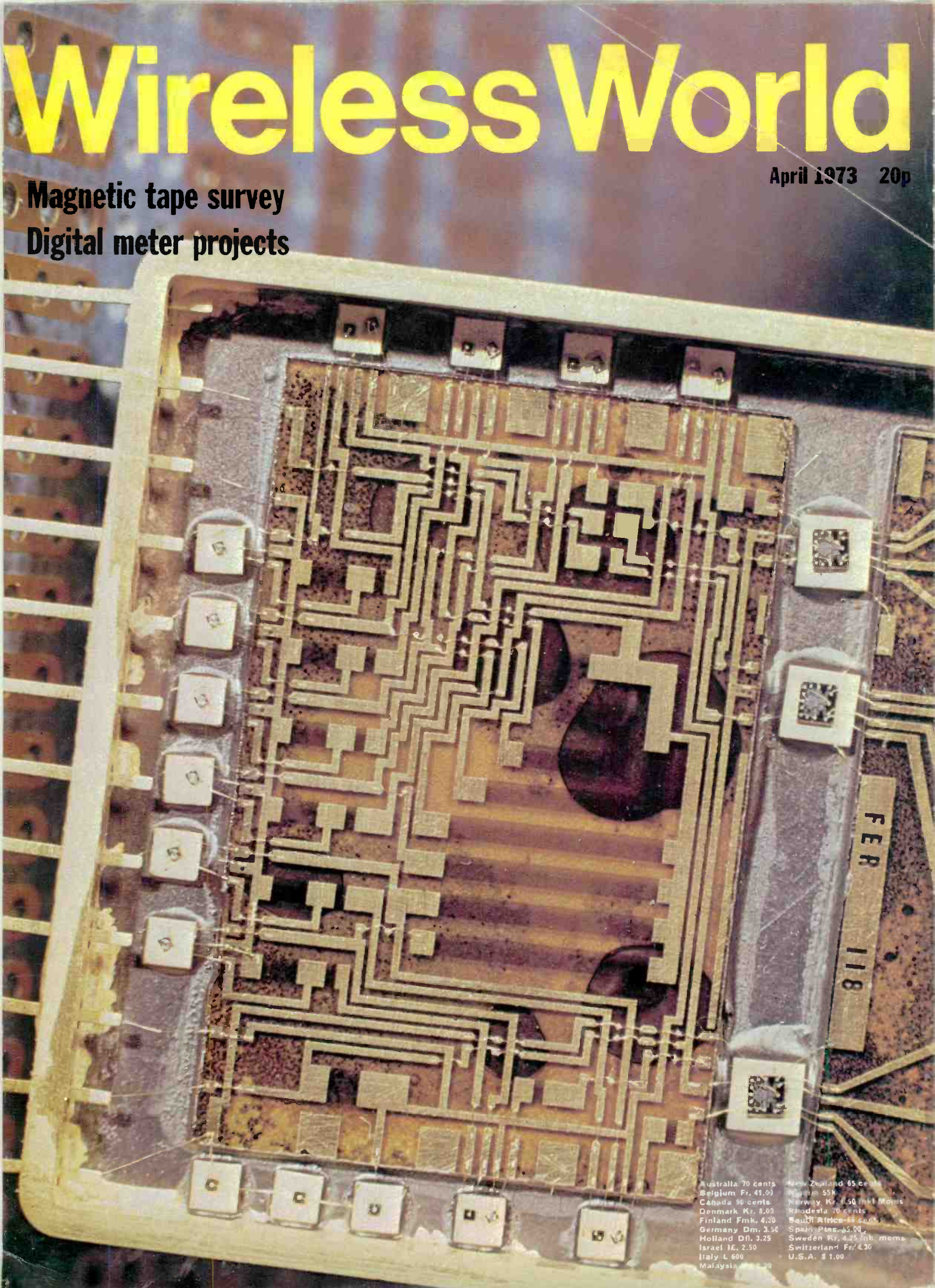

Wireless World

April 1973 20p

Magnetic tape survey
Digital meter projects

Australia 70 cents
Belgium Fr. 41.00
Canada 90 cents
Denmark Kr. 8.00
Finland Fmk. 4.30
Germany Dm. 3.50
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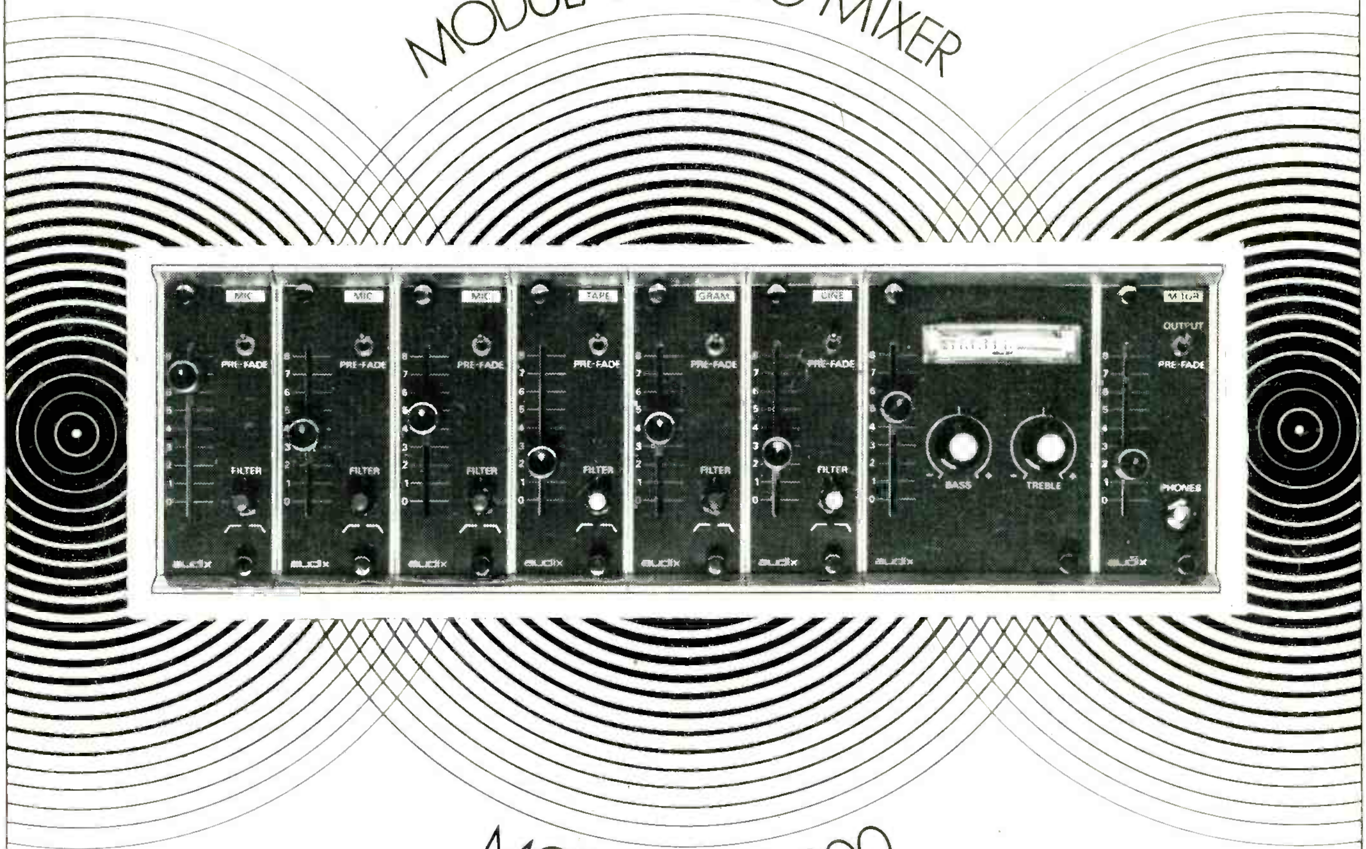
audix
SOUND SYSTEMS AND ELECTRONICS

MODULAR AUDIO MIXER



MODEL MXT-200

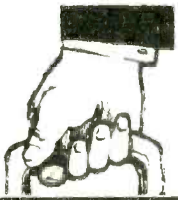
The MXT-200 is the latest addition to the range of modular audio mixing units available from Audix for public address, theatre, broadcast and recording studio applications. Designed for either mono or stereo working the MXT-200 incorporates high and low frequency filtering per channel as well as overall treble and bass tone controls. A pre-fade listen miniature toggle switch is fitted to all plug-in channels; the maximum number of inputs being 16. The wide choice of modules including output routing, monitoring facilities, P.P.M. or V.U. metering units can be fitted within rack mounting or free standing cabinets.

audix MANUFACTURERS OF SOUND SYSTEMS AND ELECTRONICS

AUDIX BB LIMITED
STANSTED · ESSEX
TELEPHONE: STANSTED 3132/3437 (STD 027-971)

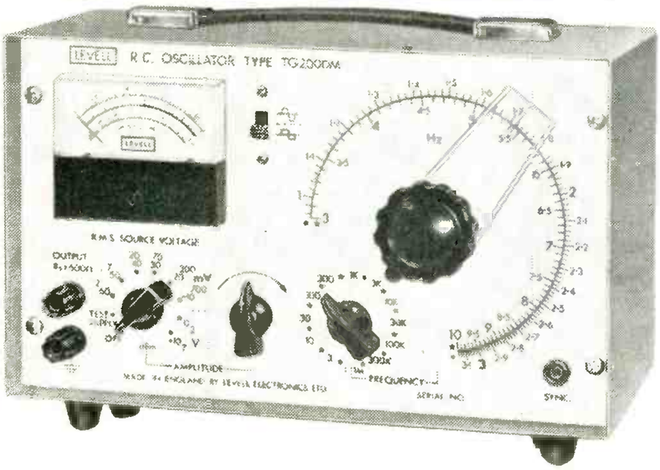
WW—005 FOR FURTHER DETAILS

LOW COST RC OSCILLATORS 1Hz TO 1MHz



LEVELL
PORTABLE INSTRUMENTS

**VISIT US ON STAND 621 AT L.E.C.S. 73
OLYMPIA, LONDON, 22-25 MAY**

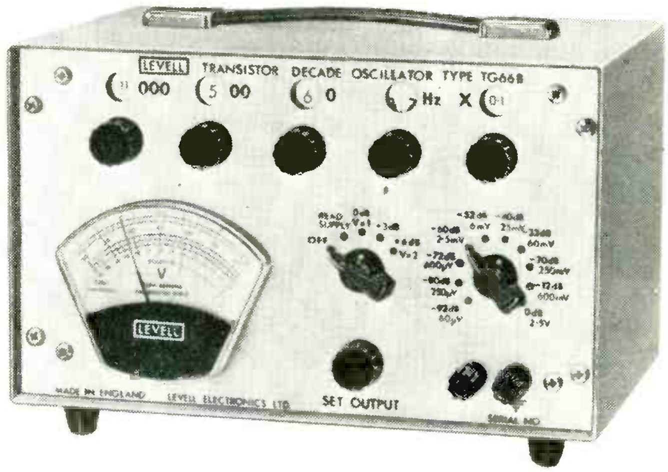


ANALOGUE

FREQUENCY	1 Hz to 1 MHz in 12 ranges. Acc. ± 2% ±0.03Hz.
SINE OUTPUT	7V r.m.s. down to <200µV with Rs = 600 Ω
DISTORTION	<0.1% to 5V, <0.2% at 7V from 10Hz to 100kHz.
SQUARE OUTPUT	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. input.
METER SCALES	0/2V, 0/7V & —14/+6dBm. on TG200M & DM only.
SIZE & WEIGHT	7″ high x 10¼″ x 5½″ deep. 10 lbs.

TG200	TG200D	TG200M	TG200DM
£42	**£45**	**£52**	**£55**
Sine O/P	Sine & Sq. O/P.	Sine O/P + meter.	Sine & Sq. O/P + meter.

NOTE: All prices subject to V.A.T.



DIGITAL

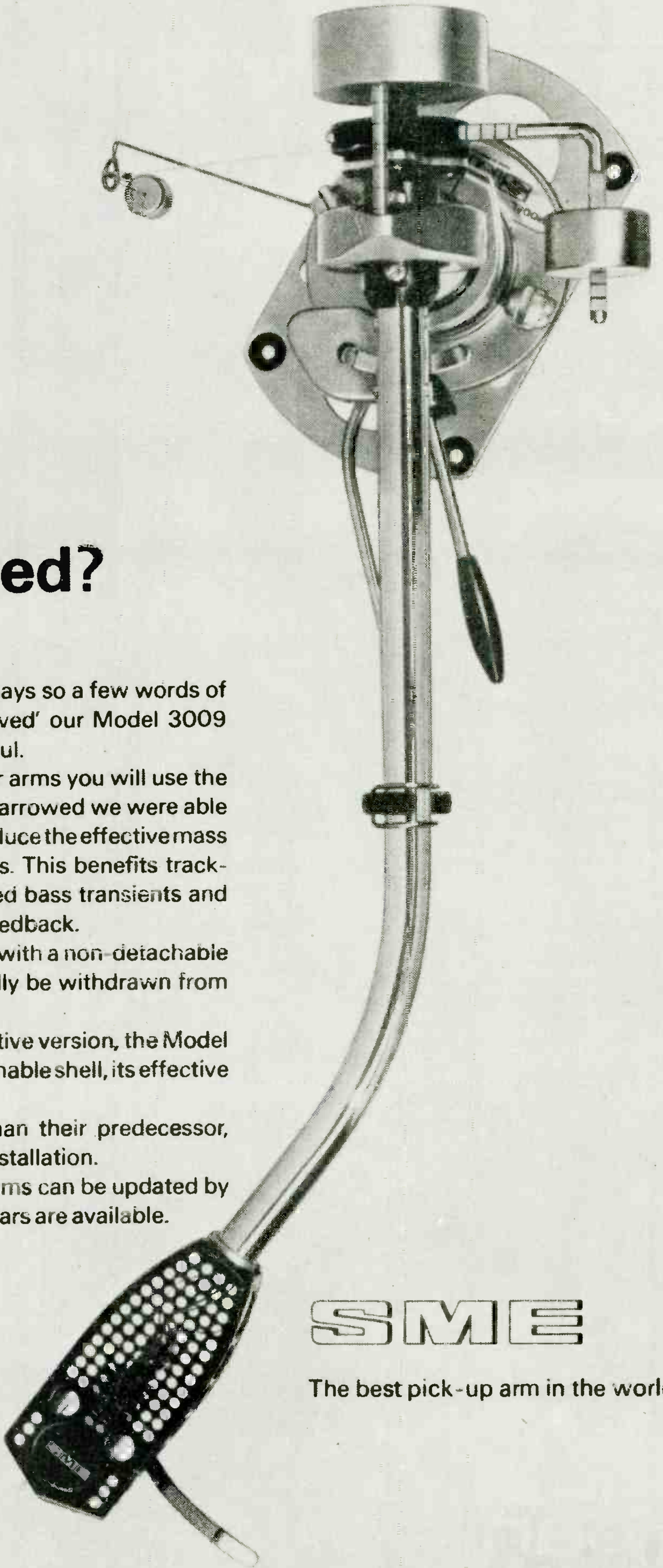
FREQUENCY	0.2Hz to 1.22MHz on four decade controls.
ACCURACY	±0.02Hz below 6Hz ±0.3% from 6Hz to 100kHz ±1% from 100 kHz to 300 kHz ±3% above 300 kHz.
SINE OUTPUT	5V r.m.s. down to 30µV with Rs = 600 Ω
DISTORTION	<0.15% from 15Hz to 15 kHz. <0.5% at 1.5Hz and 150kHz.
METER SCALES	2 Expanded voltage &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

TG66B	TG66A
£120	**£150**
Batteries only.	Mains unit & batteries incl.

Prices include batteries with 400 hour life.
Mains power units £10 extra. Leather cases £6 extra.

Send for literature covering our full range of portable instruments.

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



What is improved?

This question is put to us frequently these days so a few words of explanation as to why and how we 'improved' our Model 3009 Series II precision pick-up arms may be helpful.

We assumed that if you choose one of our arms you will use the sort of cartridge it deserves. The field thus narrowed we were able to make them more compact and above all reduce the effective mass of the standard model to a mere 5·5 grams. This benefits trackability and all round definition with improved bass transients and still lower sensitivity to external shock and feedback.

Cleaning the stylus is not really a problem with a non-detachable shell as the stylus assembly itself can usually be withdrawn from the cartridge for this purpose.

Where the facility is demanded an alternative version, the Model 3009/S2 improved is similar but has a detachable shell, its effective mass is consequently 4 grams higher.

Both models require a lot less space than their predecessor, widening their application and simplifying installation.

Following our established policy earlier arms can be updated by our Service Department from whom particulars are available.

SME

The best pick-up arm in the world

Write to SME Limited · Steyning · Sussex · England Telephone Steyning (0903) 814321

LTD/S17

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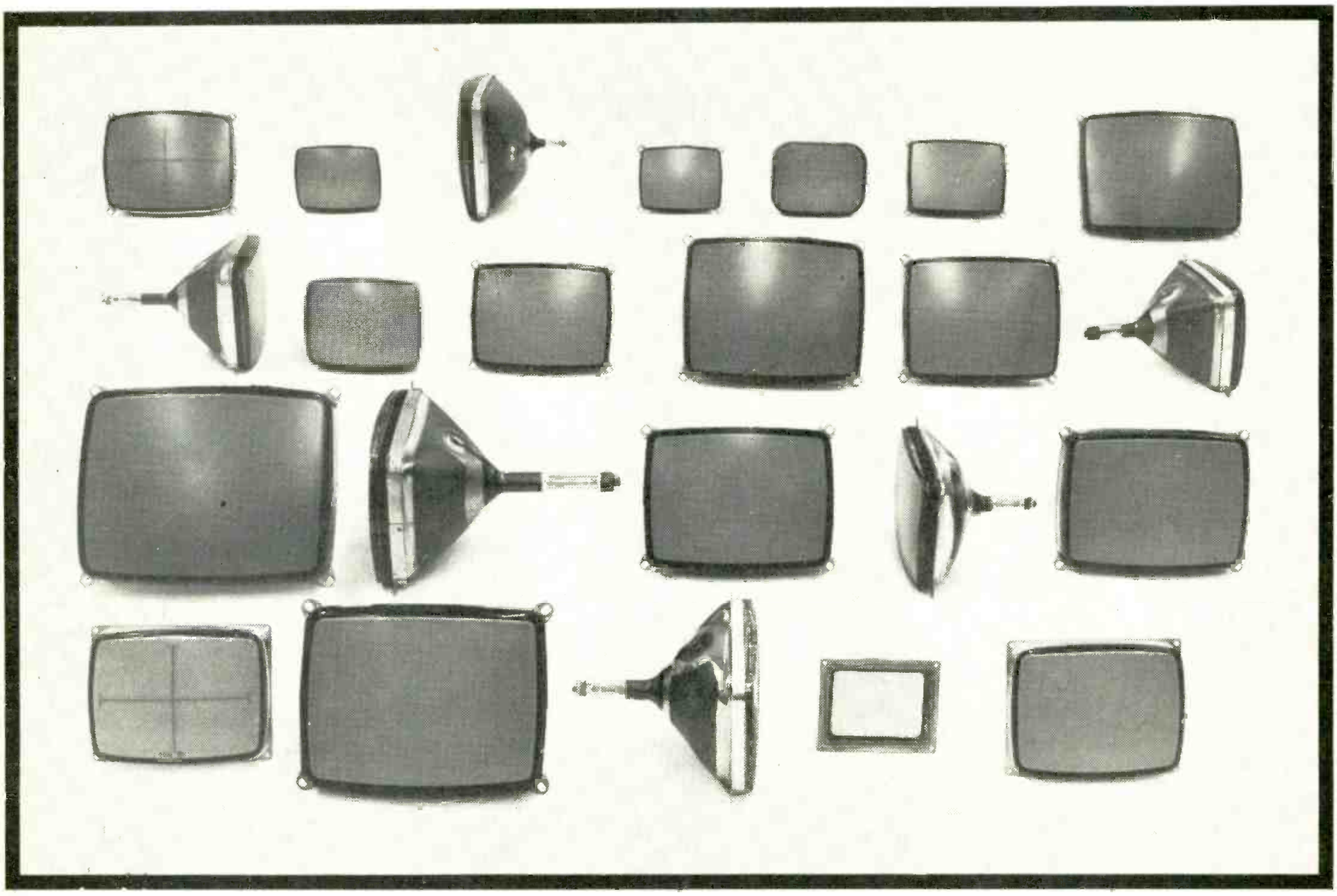
Monitor with



Whatever your monitor or data display requirement, the chances are you'll find exactly the tube you need in the Brimar range. Screen sizes from six to twenty-four inches. Deflection angles from 70° to 110°. Narrow neck for reduced deflection power or wide neck for improved resolution.

Several sizes offer the option of increased neck length for special deflection techniques. Each type comes in a selection of phosphors from the extensive Brimar range and graticules are added to order. An added bonus is the variety of implosion protection and mounting styles with which Brimar leads the field.

Thorn is the largest manufacturer of television tubes and receivers in Britain – knows more about tube design and application than anyone else in the business.
Just ring 01-804 1201 and mention our name: Brimar – it could save you a lot of trouble.

Brimar

	Unprotected	Rimguard III	Bonded Face Plate	Maximum Neck Diameter 29.4 mm	Maximum Neck Diameter 38.0 mm	Heater Voltage	Deflection Angle	Glass % Transmission	Extended Neck	Maximum Overall Length mm.
M17–12	132×99			X		6.3	70°	Clr.		236
M17–15			132×99	X		11.5	70°	Clr.		242
M28–13		228×171		X		11.5	90°	58		266
M28–131			228×171	X		11.5	90°	58		271
M31–100			257×195		X	6.3	70°	50		449
M31–101			257×195		X	6.3	70°	50		490
M31–182			257×195	X		6.3	110°	50		248.5
M31–184		257×195		X		6.3	110°	50		243
M36–141	288×216				X	6.3	70°	60		425
M36–142			288×216		X	6.3	70°	60		431
M38–100		308×229		X		11.5	90°	50		356
M38–101		308×229		X		11.5	90°	50	X	378
M38–102			308×229	X		11.5	90°	50	X	383
M38–104			308×229	X		11.5	90°	50		361
M38–110		308×229			X	6.3	90°	50		351
M38–111			308×229		X	6.3	90°	50	X	446
M38–112		308×229			X	6.3	90°	50	X	441
M50–120		394×308		X		6.3	110°	45		319
M61–120		481×375		X		6.3	110°	42		370

KEY

Rectangular Face Mounting Frame Integral Mounting Lugs

Figures denote minimum screen width and minimum screen height in mm.

BRIMAR

Thorn Radio Valves & Tubes Ltd.,
Mollison Avenue, Brimsdown,
Enfield, Middlesex EN3 7NS
Tel: 01-804 1201

THORN

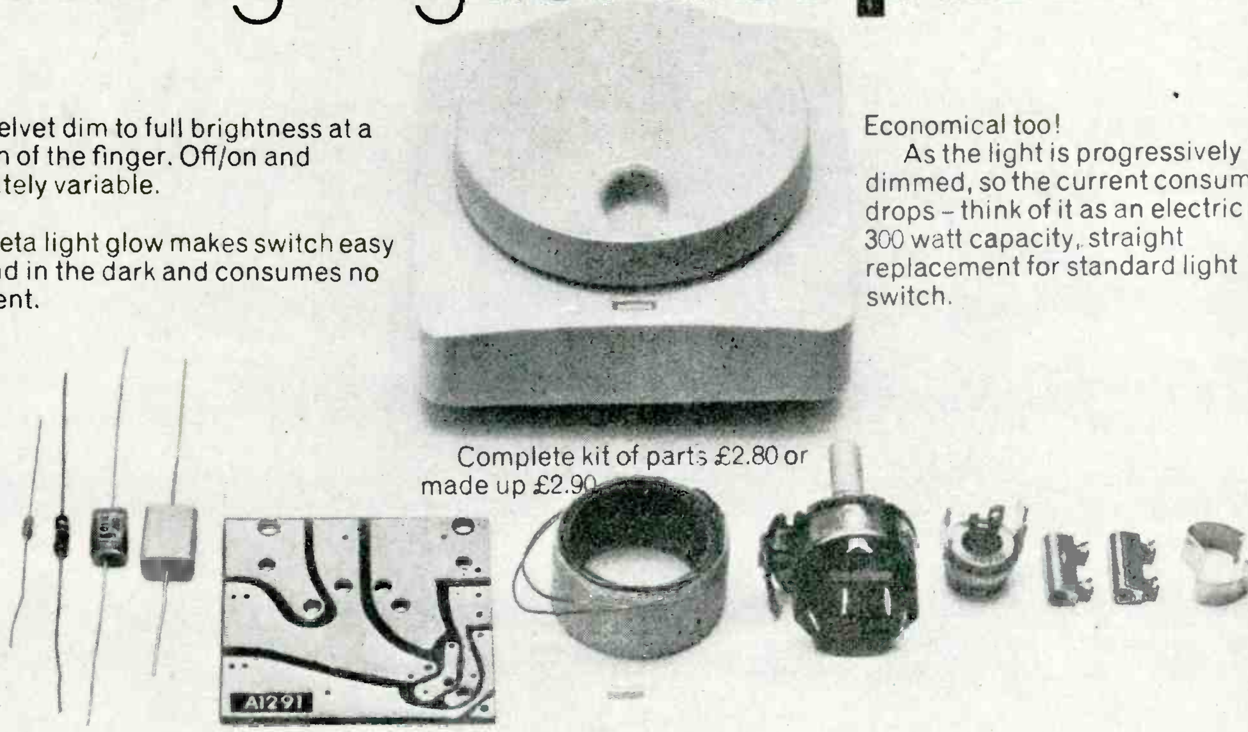
BPT9

WW—011 FOR FURTHER DETAILS

Cool lighting **for hot parties.**

Velvet dim to full brightness at a touch of the finger. Off/on and infinitely variable.

Beta light glow makes switch easy to find in the dark and consumes no current.



Economical too!

As the light is progressively dimmed, so the current consumption drops – think of it as an electric tap. 300 watt capacity, straight replacement for standard light switch.

Complete kit of parts £2.80 or made up £2.90

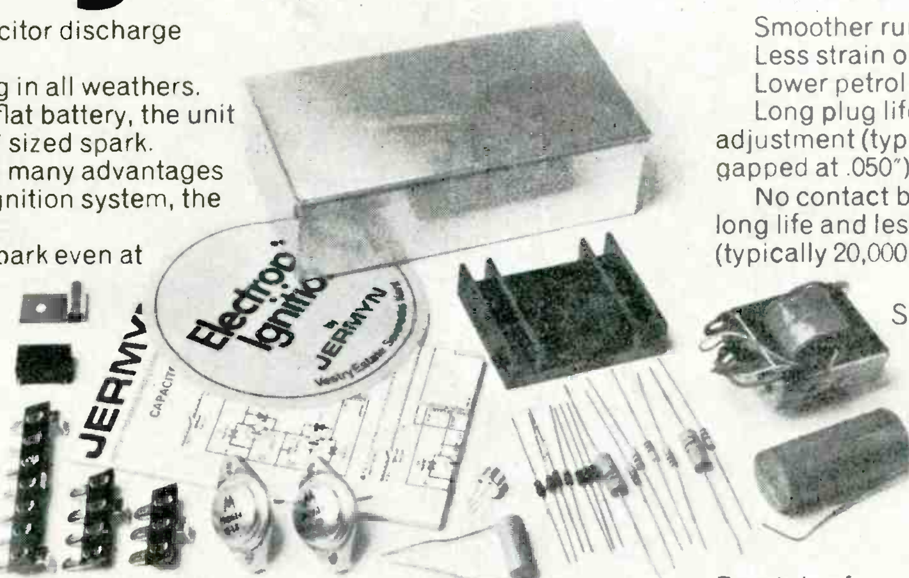
Hot Ignition for cold mornings.

The Jermyn capacitor discharge ignition system.

Instant starting in all weathers. Even with a near flat battery, the unit will produce a full sized spark.

Just one of the many advantages of an electronic ignition system, the others are:

High energy spark even at maximum revs.



Smoother running.

Less strain on battery and starter.

Lower petrol consumption.

Long plug life with infrequent adjustment (typically 20,000 miles, gapped at .050").

No contact breaker arcing giving long life and less adjustment (typically 20,000 – 25,000 miles)

STATE + or – earth when ordering.

Complete set of parts to build it yourself for only £7.75, as described in Practical Wireless and fully approved by the author.

Save 55p
Buy both for £10.00

Reprints of the two part feature are available at 25p.

To Jermyn Industries, 84 Vestry Estate, Sevenoaks, Kent.
Please despatch return of post .... light dimmer kit .... light dimmer ....
Ignition Kits .... + or – earth .... £10 pair. Enclose cheque or postal order.

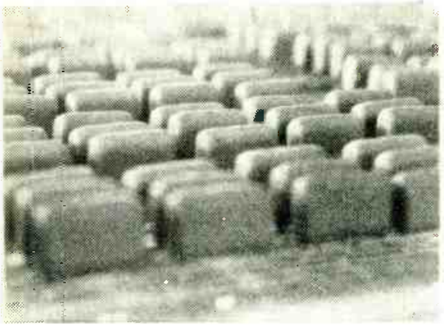
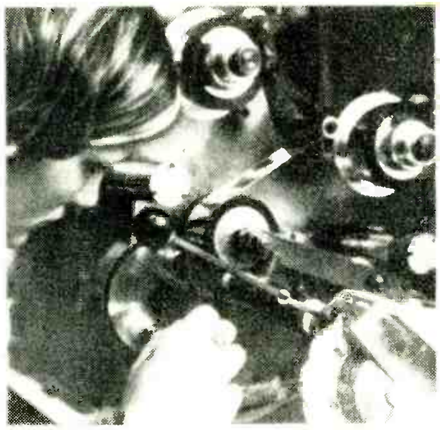
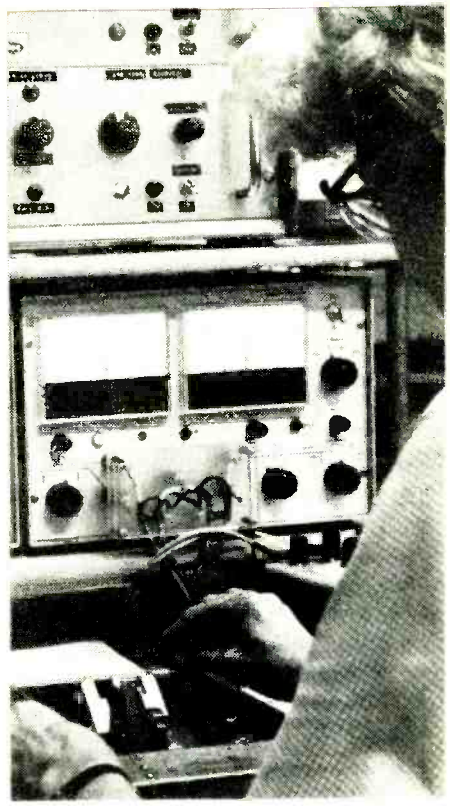
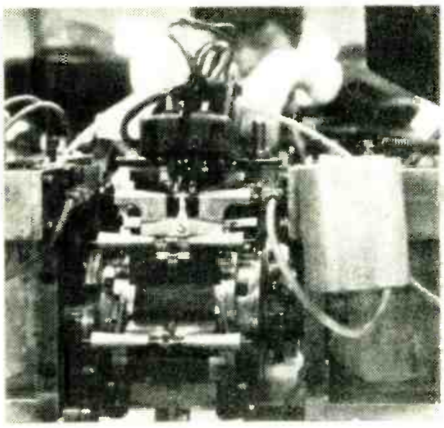
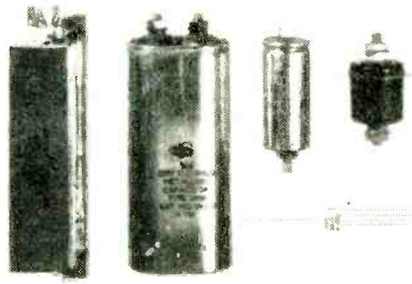
BLOCK CAPITALS

NAME ....

ADDRESS ....

JERMYN

WW—013 FOR FURTHER DETAILS

Erie metallised dielectric capacitors-more 'firsts' to their name than the rest rolled together

Erie's strength in metallised film lies in immense capability – the result of unique experience in materials and production technology, objective marketing and a total commitment to satisfying customer requirements. This, plus . . .

an enterprising spirit . . . The group has held world patents on de-metallising and handling techniques since 1945.

A string of 'firsts' includes the use of metallised paper with high temperature impregnants to give fully type-approved capacitors (with still no competitor in sight)!

We were first to develop epoxy resins as a sealing medium. First in Europe with metallised polyethylene terephthalate (P.E.T.) capacitors. First in the world with thin metallised polycarbonate film capacitors, by making our own film. First with castellated metallised paper and P.E.T. small-value types (still an exclusive process).

And in 1970, in a special custom-designed job, first with the volume production of a metallised polypropylene capacitor.

near total in-house capability . . . Particularly in metallising equipment. It means new materials and techniques can be investigated in depth. As leaders, we are invariably approached at an early stage by the material developer. The result is often a combined development programme (and more 'firsts'). It also means the speedy dispatch of customer specials – independent of outside suppliers.

unique flexibility . . . The real key to Erie's capacity to meet specific needs – particularly in long-run multi-section and feed-through units – is flexibility. Basically: design-stage discussion and a batching system specially geared to quick production line change-overs.

Full-scale Life test both on new products and on a batch sampling basis is carried out to monitor and maintain Erie's uncompromising standards. This Test House is Government approved.

To take any of the foregoing further, contact
the Advertisement Dept (DC/WW/1/73),
Erie Electronics Ltd.,
South Denes, Great Yarmouth, Norfolk.
Tel. (0493) 56122 Telex 97421

Opposite page: Setting-up plant for metallisation of plastic film dielectric.
Top left: Type 51016 capacitors awaiting oven cure.
Top centre: Winding close tolerance professional metallised polycarbonate capacitors.
Bottom left: Automatic soldering of wire terminations on metallised P.E.T.
Bottom centre: Typical examples of custom designed capacitors.
Far right: Test Station for metallised P.E.T. capacitors.

ERIE
ELECTRONICS
LIMITED

ERIE

WW—014 FOR FURTHER DETAILS

WW—015 FOR FURTHER DETAILS

A Garrard deck-
ask the man who owns one

AP76 module: this superb deck offers every modern feature you need for Hi-Fi performance. This is a genuine transcription quality deck at a moderate price
Fitted with 75/6/SM Shure cartridge.

AP96 module: the connoisseur's single playing transcription deck. It is beautifully styled with precision performance to match any Hi-Fi system.
Fitted with 75/6/SM Shure cartridge.

Make no mistake—your deck is the key unit in your Hi-Fi equipment. All the latest electronic refinements in amplifiers and speakers can be wasted if the deck is not precision-built and mechanically reliable. Ask the man who owns a Garrard. He may take it for granted—but that's the way it should be. You have no second thoughts, no regrets once you've bought Garrard. That's why the overwhelming majority of 'package deals' start with a Garrard. Hi-Fi dealers can't afford after sales problems, so they go for Garrard.
Go along with your dealer—go for Garrard.

SP25 Mk III module: this automatic single play deck offers the refinements of enthusiast Hi-Fi at a budget price.
Fitted with 75/6/SM Shure cartridge.

ZERO-100S module: the ultimate. Tangential pick-up arm virtually eliminates tracking error. The transcription turntable with the greatest combination of advanced features available today.
Fitted with M93/E Shure cartridge.

These Garrard units are supplied complete with elegantly styled bases and distinctive lift-off hinged covers, which can be closed during playing. Ready-wired for quick and easy connection to mains and amplifier.

Complete the coupon and post it now!

Please send me more details on the Garrard range of modules and decks.

Name ______________________

(Block letters)

Address ______________________

Garrard

A PLESSEY QUALITY PRODUCT

To: Garrard, Dept. WW, Newcastle Street, Swindon, Wiltshire.

WW—016 FOR FURTHER DETAILS

STAY TUNED WITH JACKSON

When you use Jackson capacitors, you know you're using tried and tested components. Jackson capacitors are made to the most exacting standards under rigorous supervision. As a result, they give perfect reliability over a very long life. What's more, you can have components custom made to suit your individual requirements.

'Our skilled personnel and bang up to date equipment are backed by 45 years of experience in the communications field. And that's your guarantee of a reliable product.

TYPE P22 AM/FM 2 GANG CAPACITOR CATALOGUE NO. 4300

Write for fully illustrated catalogue:

JACKSON BROTHERS (LONDON) LIMITED

KINGSWAY, WADDON, CROYDON, CR9 4DG. TEL: 01-681 2754/7. U.S. OFFICE: M. SWEDGAL, 258 BROADWAY, NEW YORK, N.Y. 10007. NOW! ON TELEX No. 946849.

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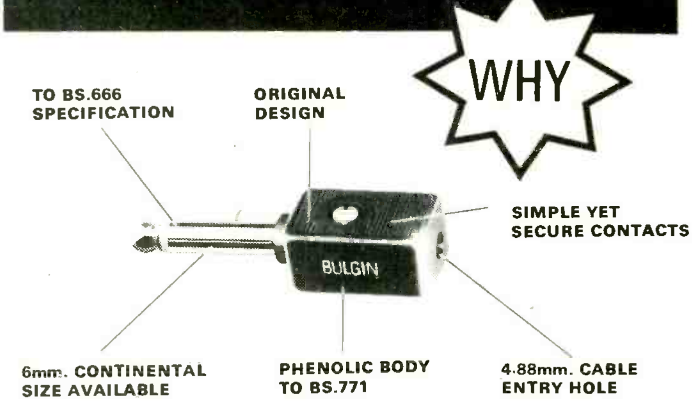
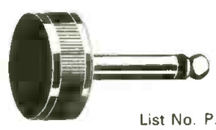
BULGIN
Can Offer You Jacks and Plugs Of Infinite Variety

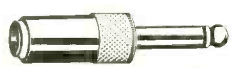


CHOICE OF 50 TYPES



List No. P.215

List No. P.505



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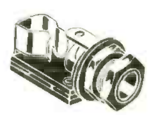
List No. P.539 (Gold)



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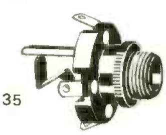
List No. J.2



List No. J.35

Also Miniature range of above available

We began making Jacks and Jack Plugs in 1929 and since that date have steadily enlarged our range which now includes a variety of designs covering all popular applications.

Many millions have been supplied to customers all over the world and have given every satisfaction.

The majority of models are made to BS.666 specification and every component part is checked for compliance to this standard before assembly. A range of miniature models are also listed.

Designs are varied; and include two pole models, which can be connected to twin or co-axial cable and three pole models. Finishes vary, covering black bakelite, frosted aluminium and both chrome or gilt plating.

Ratings for BS.666 models are 50V. max., 0.1V min., 5A max., 50W. max., Max., test voltage 250 pole-to-pole or pole-to-earth.

CUSTOMERS CAN ALWAYS RELY ON 'THE HOUSE OF BULGIN' FOR SERVICE, QUICK DESPATCH AND GUARANTEED SUPPLIES FOR YEARS TO COME

TECHNICAL LITERATURE AVAILABLE ON REQUEST, QUOTE WW/1/73

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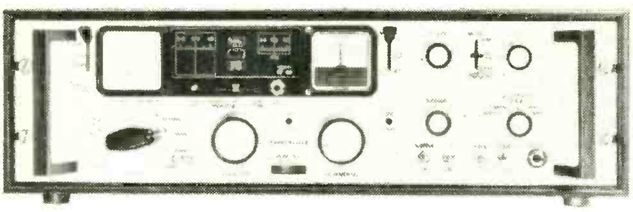
Eddystone Radio

EC958
series of receivers 10kHz to 30MHz In world-wide use



Professional high-stability receiver series for a wide variety of applications. The standard version can be used as a self-contained F.S.K. terminal, or as a dual-diversity terminal with common oscillator control. Variants are available for Lincompex terminal use, for specialized network monitoring surveillance and for marine applications.

Simplicity Reliability Economy

Your distributor's address and illustrated brochure obtainable from:

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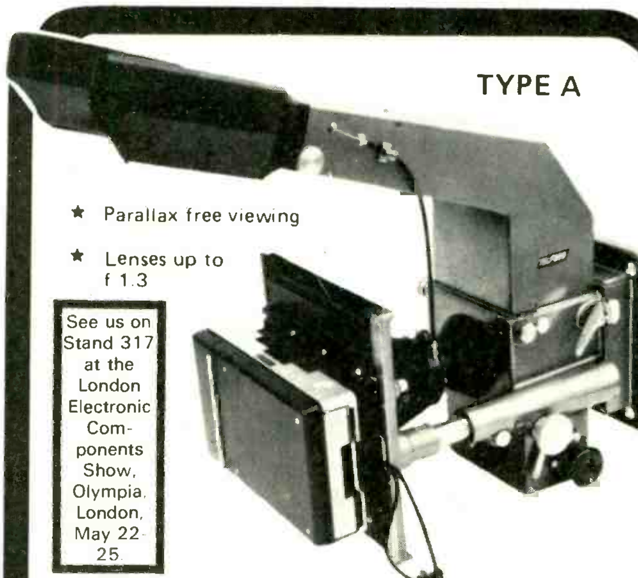
Telephone: 021-475 2231. Telex: 337081
A member of Marconi Communication Systems Limited

LTD/ED99

WW—025 FOR FURTHER DETAILS

Telford range of Oscilloscope Cameras

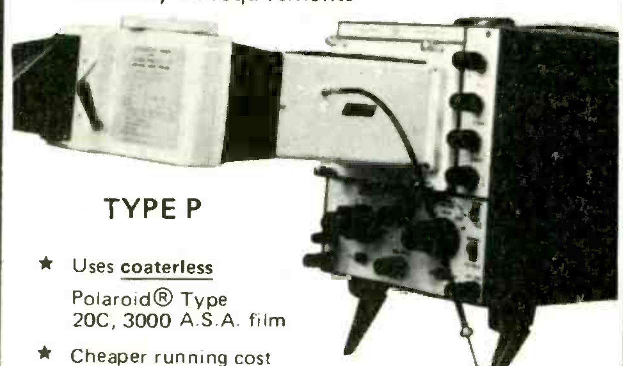
TYPE A



- ★ Parallax free viewing
- ★ Lenses up to f 1.3

See us on Stand 317 at the London Electronic Components Show, Olympia, London, May 22-25

Modular system with range of film backs, lenses, viewing systems and adaptors to meet virtually all requirements



TYPE P

- ★ Uses **coaterless** Polaroid® Type 20C, 3000 A.S.A. film
- ★ Cheaper running cost (up to 42%)
- ★ Lowest purchase price for comparable specification
- ★ Precision Dallmeyer f 4.5 lens
- ★ Inexpensive interchangeable adaptor for most popular scopes

® *Reg. Trade Mark.*

More complete details available on request from:

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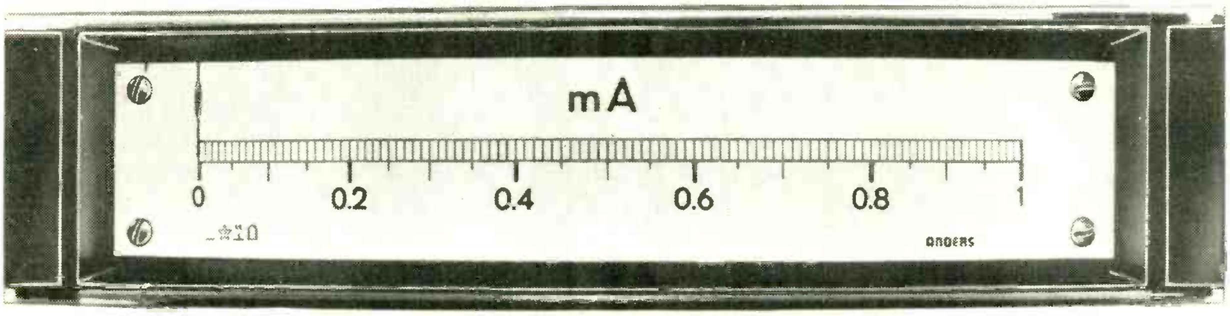
DAVALL A MEMBER COMPANY OF BENTIMA INDUSTRIES LIMITED

WW—026 FOR FURTHER DETAILS

ANDERS MEANS METERS...



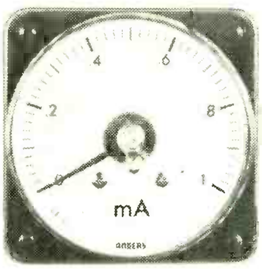
Actual size illustration *Scale length 4·3″*

PROFILE 350 EDGEWISE METER

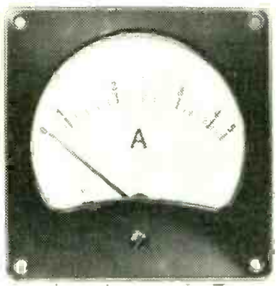
- Long scale while retaining small overall size
- Process control and electronic applications
- Easily stackable
- Horizontal/vertical use
- 60µA upward, AC/DC
- Self-shielding rugged movement

Anders provide what is probably the largest range of meters available from a single source in Europe: MC/MI, dynamometer, vibrating reed, electrostatic, etc. in over 100 case styles and sizes, a few of which are shown below.

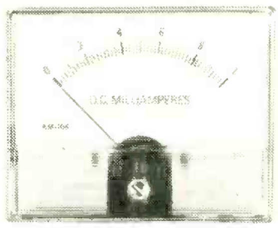
Popular models and ranges are stocked in depth while a specially equipped instrument department enables swift production of non-standard ranges and scales, to suit individual customer requirements, in large or small quantities.



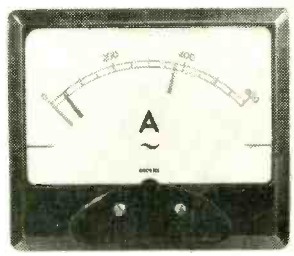
Oxford Long Scale 240°. 2 models, 5·5″, 8″ scales. DC moving coil and AC moving coil rectified.



Vulcan Moving Iron. 4 models, 1·5″, 1·8″, 2·7″, 3·7″ scales. Voltmeters, ammeters and motor starting meters.

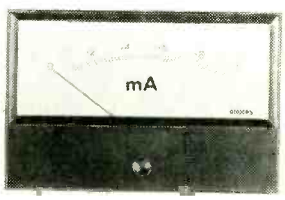


Kestrel Clear Front. 7 models, 1·3″—5·25″ scales. DC moving coil, AC moving coil rectified, AC moving iron.

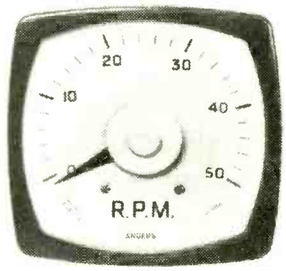


Solicontroller Moving Coil Relay. DC moving coil and AC moving coil rectified. 1 or 2 adjustable alarm controls.

Models KE1 and KE2 Miniature Edgewise Meters. Nominal scale lengths 1.2″ and 2″. Available in sensitivities from 50 microamps Moving Coil.



Regal Range 100° flattened arc. 2 models 2.5″ and 3.2″ scales. Taut band. DC moving coil and AC moving coil rectified.



Stafford Long Scale 240° 6 models, 3·5″—11·5″ scales. DC moving coil, AC moving coil rectified, AC moving iron. Also 98° scale.

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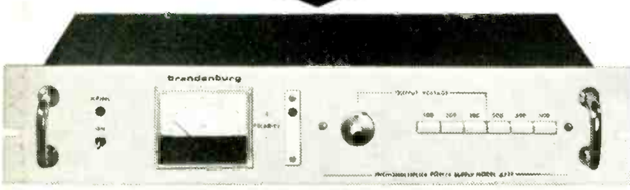

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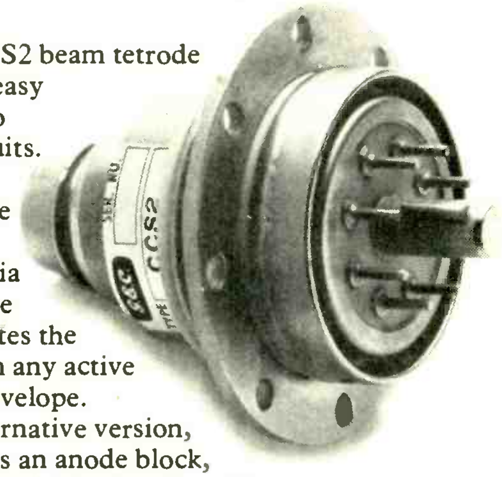

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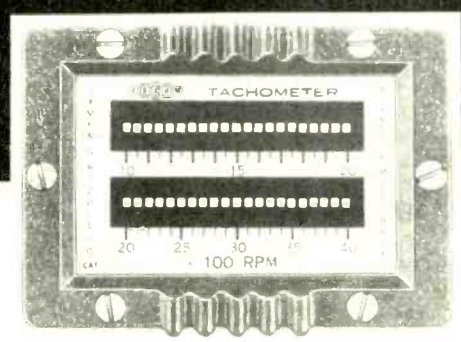

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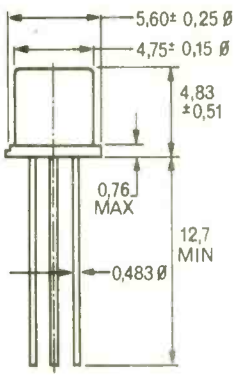

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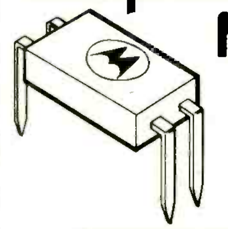

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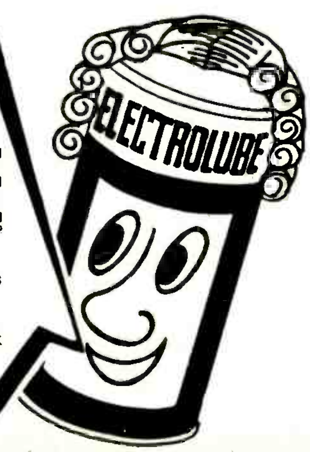

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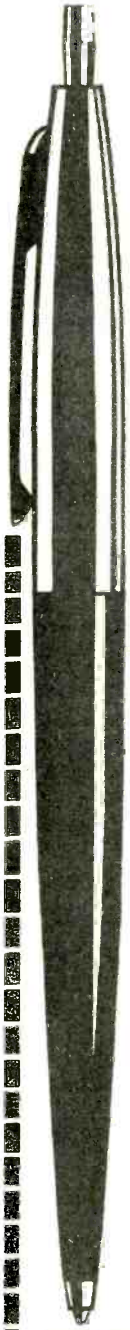

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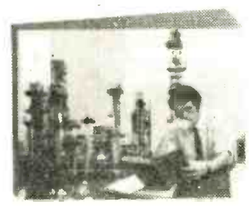

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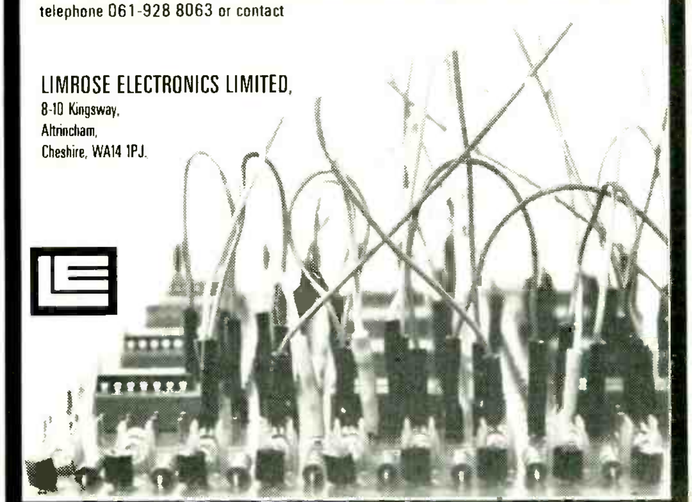

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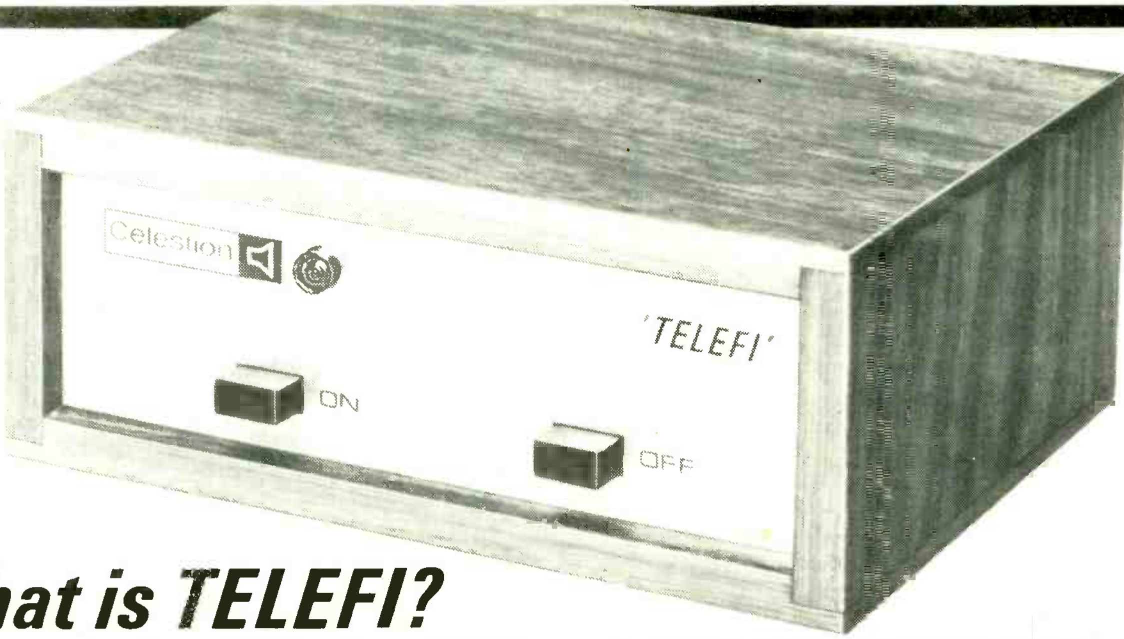

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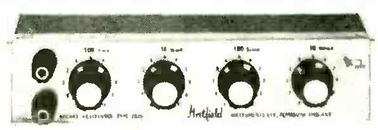

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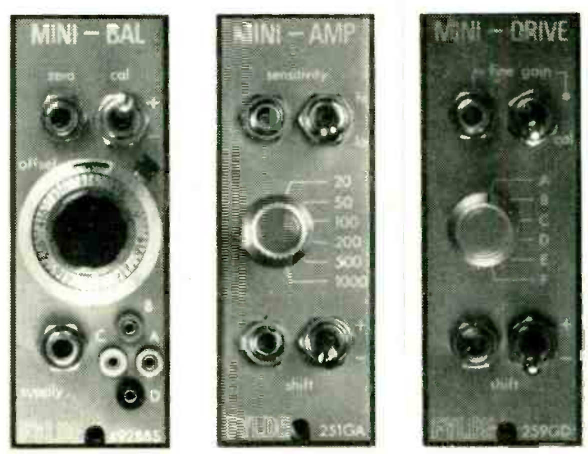

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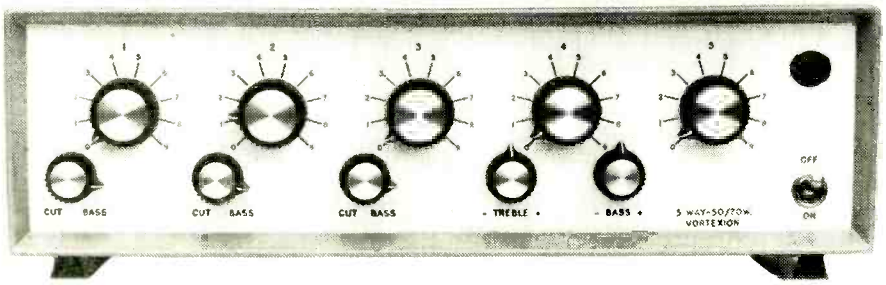

This is a high fidelity amplifier with bass cut controls on each of the three low impedance balanced line microphone stages and a high impedance (1.5 meg.) gram stage with bass and treble controls, plus the usual line or tape input. All the input stages are protected against overload by back to back low self capacity diodes and all use F.E.Ts for low noise, low intermodulation distortion and freedom from radio breakthrough.

A voltage stabilised supply is used for the pre-amplifiers making it independent of mains supply fluctuations and another stabilised supply for the driver stages is arranged to cut off when the output is overloaded or over temperature. The output is 75% efficient and 100V balanced line or 8-16 ohms output are selected by means of a rear panel switch which has a locking plate indicating the output impedance selected. The mixer section has an additional emitter follower output for driving a slave amplifier, phones or tape recorder, output .3V out on 600 ohms upwards.

50/70 WATT ALL SILICON AMPLIFIER WITH BUILT-IN 4-WAY MIXER

(0.3% intermodulation distortion) using the circuit of our 100% reliable 100 Watt Amplifier with its elaborate protection against short and overload, etc. To this is allied our latest development of F.E.T. Mixer Amplifier, again fully protected against overload and completely free from radio breakthrough. The mixer is arranged for 2-30/60Ω balanced line microphones, 1-HiZ gram input and 1-auxiliary input followed by bass and treble controls. 100 volt balanced line output or 5/15Ω and100 volt line.

100 WATT ALL SILICON AMPLIFIER

A high quality amplifier with 8 ohms-15 ohms or 100 volt line output for A.C. Mains. Protection is given for short and open circuit output over driving and over temperature. Input 0.4 V on 100K ohms.

THE 100 WATT MIXER AMPLIFIER

With specification as above is here combined with a 4 channel F.E.T. Mixer, 2-30/60Ω balanced microphone inputs, 1-HiZ gram input and 1-auxiliary input with tone controls and mounted in a standard robust stove enamelled steel case. A stabilised voltage supply feeds the tone controls and pre amps, compensating for a mains voltage drop of over 25% and the output transistor biasing compensates for a wide range of voltage and temperature. Also available in rack panel form.

CP50 AMPLIFIER

An all silcon transistor 50 watt amplifier for mains and 12 volt battery operation, charging its own battery and automatically going to battery if mains fail. Protected inputs, and overload and short circuit protected outputs for 8 ohms-15 ohms and 100 volt line. Bass and treble controls fitted. Models available with 1 gram and 2 low mic. inputs, 1 gram and 3 low mic. inputs or 4 low mic. inputs.

20/30 WATT MIXER AMPLIFIER

High fidelity all silicon model with F.E.T. input stages to reduce intermodulation distortion to a fraction of normal transistor input circuits. The response is level 20 to 20,000 cps within 2dB and over 30 times damping factor. At 20 watts output there is less than 0.2% intermodulation even over the microphone stage at full gain with the treble and bass controls set level. Standard model 1-low mic. balanced onput and HiZ gram. Outputs available 8/15 ohms OR 100 volt line.

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Can deliver its full audio power at any frequency in the range of 30 c/s—20 Kc/s ± 1 dB. Less than 0.2% distortion at 1 Kc/s. Can be used to drive mechanical devices for which power is over 120 watt on continuous sine wave. Input 1 mW 600 ohms. Output 100-120 V or 200-240 V. Additional matching transformers for other impedances are available.

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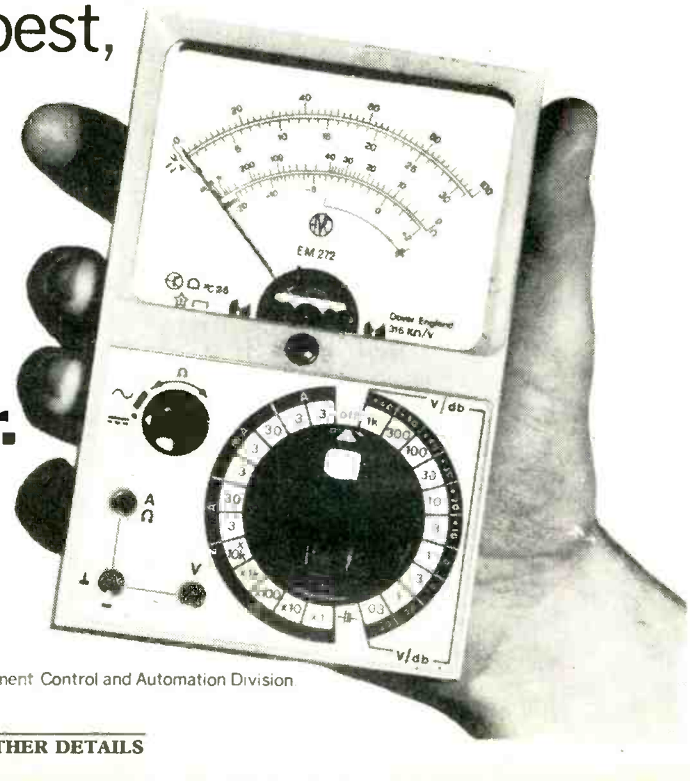

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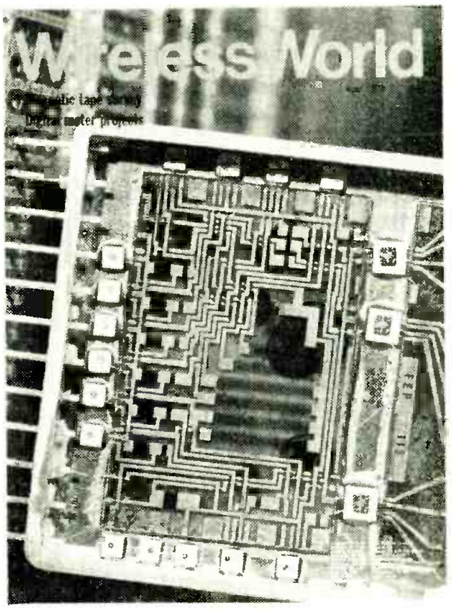
WW—068 FOR FURTHER DETAILS

Wireless World

Electronics, Television, Radio, Audio

Sixty-third year of publication **April 1973** **Volume 79 Number 1450**



This month's cover illustration is of a Ferranti thin-film hybrid microcircuit (Type FER 118) which contains six amplifiers to interface between t.t.l. and f.e.ts with fast switching times.
(photographer Paul Brierley)

Contents

We apologize for any indistinctness of printing in parts of this issue. This is due to lack of gas drying during the dispute in the gas industry.

In our next issue
(publication date April 16)

Colour telephoto system for sending colour pictures over the normal telephone networks, developed by IPC Technical & Information Services, is described.

Meterless transistor tester. Design for a portable, compact, reliable instrument capable of resolving current gain and leakage.

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Electrosil

Wireless World

The Engineer in Industry

The role of the engineer or technologist in business and the importance of engineers acquiring management techniques were stressed in recent correspondence in *The Financial Times*. Mr. B. B. Hundy, of the School of Automative Studies at the Cranfield Institute of Technology, declared that engineers and technologists play a much more important role in the direction of industrial companies in the United States, Germany and France than they do in the U.K. and that "this is reflected in the way in which they are regarded by society". Whether or not this is so may be open to discussion, but one thing is certain, as was pointed out by Sir Eric Eastwood (president) at the recent I.E.E. annual dinner, engineering and science graduates are finding it more difficult than in previous years to find employment and "there is a widespread feeling among such students of dismay and frustration . . . that they have been let down by engineering and industry".

A consequence of this is apparently a reluctance on the part of students to enter courses devoted to science and technology. At one university in S.E. England 10% of the places in the science courses are currently unfilled whereas there is increasing pressure for places in the social studies. On this particular point Sir Eric commented: "Can the nation afford to indulge the new generation of students in a wholly liberal education in which job training has no part?" He also suggested that it ought to be possible now for Britain to improve its industrial productivity "by injecting more graduate manpower, not into research and development but into the production areas of our industries". We are tempted to ask, however, is the graduate really fitted for the shop floor? In too many or our universities original research is the order of the day for engineering and science students with less and less emphasis on tutorial lectures in which the hard facts of technology applied to industrial life can be presented. Incidentally, this deification of research, as opposed to tutorial learning, is epitomized in the attitude of some professors to papers written by members of their staffs for publication. They rule that those dealing with original research must be presented to learned societies if they are to be counted as "credits" in academic life, whereas those published in public journals for sordid gain, and especially those concerned with the practical application of some technique, are apparently beyond the pale.

To get back to the question of engineers in industry and particularly their role in management. All too often the elevation of an engineer to management means that the company loses a first class engineer and appoints a bad manager. Management is now a profession for which training is needed. The answer, surely, is that there should be greater opportunities for senior engineers to take management study courses which would equip them for managerial posts. In the U.S. engineering graduates have for many years gone back to their colleges for management study courses and it is gratifying to see that this is now being encouraged in some quarters in this country.

We are not advocating a technocracy, but in this increasingly technological world we need men at the head of industry who are basically technologists.

Electronics at the Open University

"Post experience" course in electromagnetics and electronics

by K. L. Smith, Ph.D.*

The Open University is a degree awarding body, so how does electronics fit into the picture? Virtually all the Open University courses lead to the B.A. degree (there are no "B.Sc." degrees) via the same hierarchical structure of two foundation courses (1 credit each), second level courses (some 1 credit, others ½ credit), third level and so on. A student gaining 6 credits is awarded a degree. If he or she gains 8 credits, at least two at third or fourth level, the award becomes an honours degree. The study programme for each course is based on comprehensive written material backed up by television and radio broadcasts, together with regular tutorial meetings at local centres. As if to cap the course a full-time summer school is held. Students go into residence at one of the "ordinary" universities for a week, taken over for the purpose during the vacation period. By all accounts the intensity of study is remarkable.

Second level courses (and possibly others) are used for non-degree purposes and are then known as "post experience" courses. They would function as refresher studies and/or enable specialists in one field to gain knowledge of the techniques and so forth current in another. The Electromagnetics and Electronics course, code number TS282, falls into this category. A preliminary glance through the study materials for the course shows it to be very suited to the role of post experience study. I would think this is the area in which it might be very useful, especially for teachers who obtained their science degrees before the days of electronics and for the keener technician who would like to go somewhat further into the bases of his subject. But having said that, I remember a point that was put to me at the O.U. about the supply of home experiment kits and summer school residential weeks — both being limited in practice. Thus it is unlikely that the course could become a mass post experience development at the moment because of practical limitations. However, of all the students taking the course so far some 10% have been admitted as post experience members. The Electromagnetics and Electronics course is the first to have students of this status.

The course forms only one-twelfth of the work for a degree, but nevertheless it may be the first time even the mature students of the O.U. have seriously come into contact with the subject. The attitudes engendered are therefore important. As seen from the full title, more than just electronics is attempted. Traditional electromagnetism gets a say too. Perhaps this may be attempting too much in such a short course, but there is not sufficient background material in the foundation courses to allow the material to be dropped. Certainly it may also strengthen any weak props on this subject in the repertoire of an experienced technician. Inevitably it means some selection of the electronics content has to be made and one could debate the pros and cons for a long time.

* University of Kent

Engineering bias

Looking through the first four correspondence "units" is reminiscent of A-level electromagnetism. The course jumps straight into Coulomb's inverse square law, proceeds through electrostatic potential and later into magnetism. The discussion of H and B fields and magnetic circuits is quite detailed but the corresponding D field is not discussed in the electrostatic case. An engineering bias is quickly discernible. There is considerable discussion of motors and generators, transformers and the Hall effect. The mathematical content certainly requires some knowledge of elementary calculus, although it was a little quaint to see Poisson's equation in total differentials instead of partials. The required techniques are summarized in a booklet "Mathematics for Electronics", but some practice would be required before enough familiarity is achieved with the subject. Second level students are equipped with mathematical "tools"; other students (post experience) without some mathematical background could find the study a little heavy. I have often found this difficulty with full-time students on the usual science courses at university.

A rapid shift into the elementary theory of semiconductors at correspondence unit 5 carries the O.U. student into electronics.

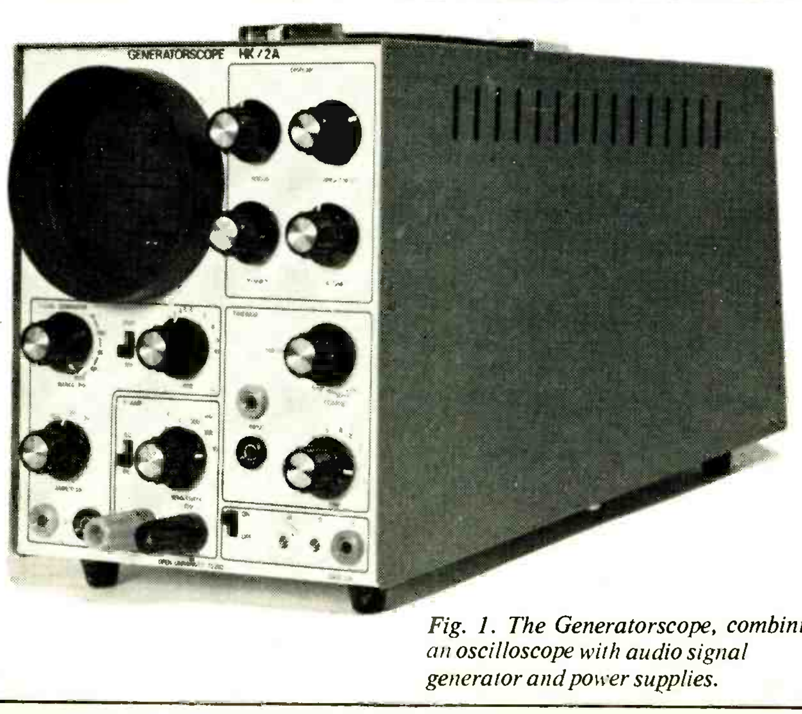


Fig. 1. The Generatorscope, combining an oscilloscope with audio signal generator and power supplies.

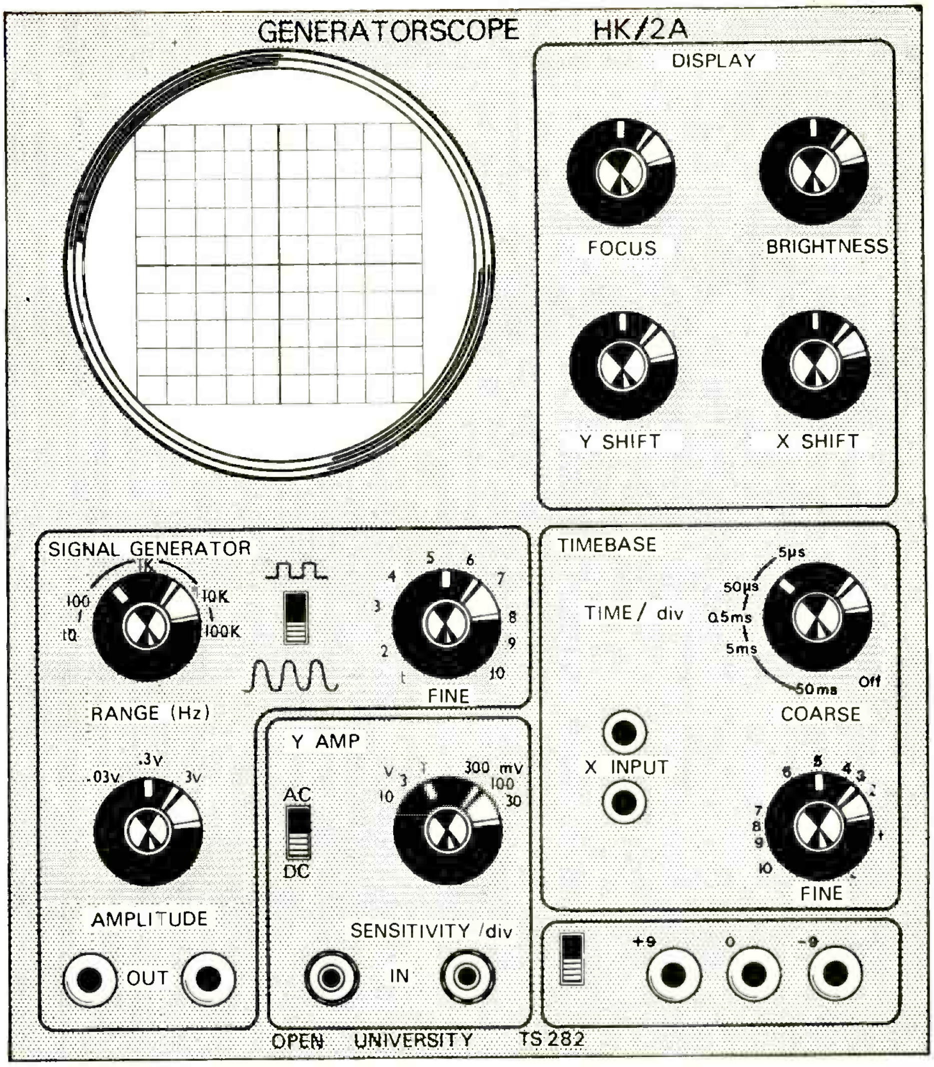


Fig. 2. Layout of the front panel of the Generatorscope.

At the end of this unit, a person studying the course should know something about bipolar and various types of field effect transistors, zener and rectifier diodes and solar cells. The remainder of the course units (17 in all) cover such topics as pulse circuits (transient response), sine wave response, large and small signal circuit analysis, measurements, and three design studies, one on a linear circuit (a power amplifier which includes an i.c. operational amplifier in the first stage), a switching circuit (an example of a time base generator), and studies of a servo system including an operational amplifier.

There is a very heavy emphasis on circuit techniques and design. Very little of the rest of electronics appears in the course. For example, thermionic emission is given a miss. This would need to be covered at some stage, considering the important applications of c.r.t.s that occur and the ion generators and electron beam systems that are employed in mass spectroscopy and electron microscopy. (Both fields require electronic engineers and technicians to be very conversant with beams in high vacua and with electron "optics".) The student is supplied with an oscilloscope, so that by adding a coil for magnetic deflection, a home experiment on the measurement of e/m for an electron could have been included, as well as an investigation of electrostatic and electromagnetic deflection of charged particles. Another omission concerns radiation, aerials, transmission lines and so on. At this point, remembering what Dr. Smol of the O.U. had said to me about the selectivity required because of study time limitations, I feel it is important to say how thorough and attractively presented the selected material is. It is the policy of the Electromagnetics and Electronics course team to introduce further courses to cover topics left out of TS282. A more advanced course on electromagnetics and one concerned with electronic devices is envisaged, but they are not yet finalized. This means that a student would find it necessary to take up more than one course to cover a broader spectrum of the subject.

Compare with full-time course

Coming now to the actual course — unique in the sense that many of the experiments are conducted at home — how does it compare with, say, a typical laboratory course at about the same level in a university or college running full-time studies? Typical first year experiments in electronics from a university course are the following sets. The first group is: the study of thermionic emission and the thermionic diode; a series of experiments on valve circuit design for amplification, feedback and oscillation; experiments on transient and sine wave response of linear (L, C, R,) circuits; semiconductor diode characteristics and design of a simple stabilized power supply; transistor characteristics; transmission lines with transient and sinusoidal signals; delay lines. Experiments in the second term include: the generation and radiation of microwaves and investigation of diffraction, reflection and other wave properties; the construction and investigation of an alloy junction diode; experiments with a transducer; the design and investigation of the performance of *RC* and transformer coupled transistor amplifiers.

Turning now to how the Open University copes with practical experience for its students, a similar range of work, different in detail of course, is found. The early work involves designing and building the d.c. ranges of a multimeter. This is used to measure currents and voltages for investigating characteristics of semiconductor diodes and photo cells. Then follows work on transient response of *RC* and *RCL* circuits and d.c. restoration experiments, leading on to sine wave response of *RC* circuits. An experiment on half-wave rectification is included in unit 9 of the course. An instrument called a Generatorscope is used to investigate the response and waveforms in these experiments (see later). Unit 9 also contains work on adding ranges to the meter. The practical work in unit 10 involves the design and construction of a series pass transistor stabilized power supply. The full design of the amplifier in units 12 and 13 and timebase circuits in units 14 and 15 is realized by practical construction and testing. An operational amplifier and servo system are investigated in unit 16.

Further experimental work is carried out at the summer school. Four experiments are undertaken, occupying about one and a half days each. The first is an accurate check and calibration of the multimeter and Generatorscope (which students take with them to the school) and measurement of harmonic distortion of the amplifier designed and built in units 12 and 13. An experiment involving properties of magnetic materials is conducted (to be changed slightly in 1974). Another piece of work involves logic design, 7-segment readout and so forth. The final experiment consists of some team work on a colour organ. It involves active filter design for four bands of frequencies and unijunction oscillator s.c.r. drivers to the coloured lamps. Altogether the practical course is a challenging and interesting collection of work which is anything but boring. Thus the O.U. is able to run a series of practical projects well up to the standard of the "orthodox" course.

The one piece of equipment which contains some novel ideas, especially as a teaching aid, is the Generatorscope

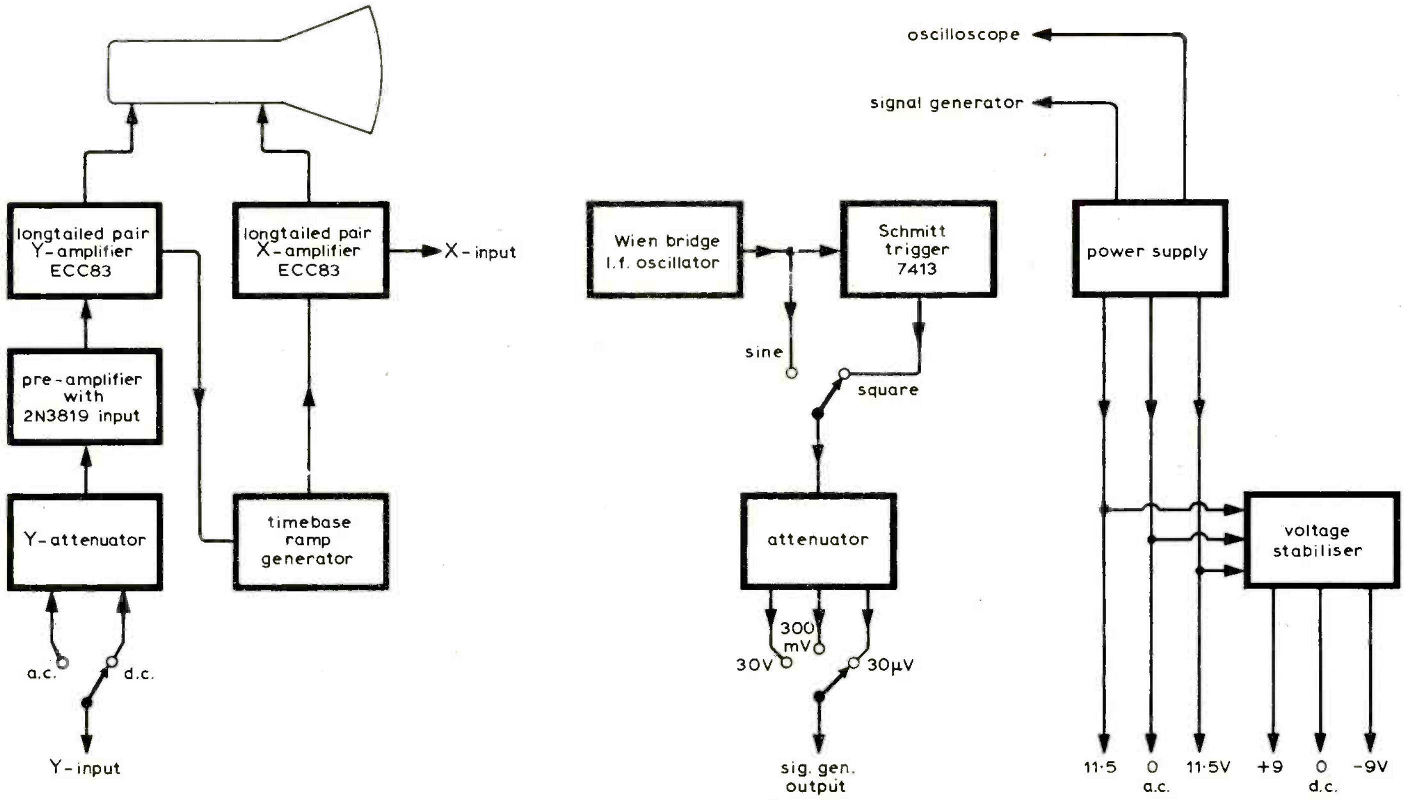


Fig.3. Block diagram of the Generatorscope, showing facilities available.

referred to above and illustrated in Fig. 1. It consists of a fairly basic oscilloscope combined with an audio sine/square wave signal generator, all in the same cabinet. Stabilized d.c. supplies are available from terminals on the panel and also unrectified low voltage a.c. is provided as an output for external rectifier/power supply experiments. Dr. Chapman of the O.U. conceived the idea of combining the instruments and the design and construction was undertaken by specialist firms in the industry to the O.U's specification. The controls, inputs and outputs are conveniently arranged on the front panel, as can be seen in Fig. 2. The circuit is a hybrid, in that double triodes are used as long tailed pairs to drive the c.r.t. deflector plates. With anode loads of 100kΩ this means the frequency response is limited, being 1MHz in fact. A Mark II version of the instrument is being designed now and will have a much improved Y amplifier performance. In addition a Mark III version seems to be already on the stocks and will have all solid state circuitry. The block diagram Fig. 3 shows the design of the whole instrument. The signal generator has four ranges by switching the capacitors in a Wien bridge oscillator circuit. The sine wave output is taken from an emitter follower fed by the output of the oscillator to an SN7413 t.t.l. Schmitt trigger i.c.

The ±9 volts d.c. from the power unit is stabilized by series transistors referenced to zenor diodes and it has short-circuit protection. It might increase the versatility of the power source to have a variable output facility, considering that both polarities are available. The availability of 11.5-0-11.5 volts a.c. is very useful for experiments on magnetic induction and on phase shifts in reactive circuits and, with the internal sine wave generator, for Lissajous figure studies. All round, the Generatorscope is a very compact, useful bench instrument likely to be of value to many users outside the Open University course. Schools, colleges and even radio amateurs might find the instrument very convenient, especially if the Y-amplifier performance is improved. Mr. Bellis, Electronics Officer in the Faculty of Technology, informs me that the instrument should be available through the Open University marketing division this year.

Wider impact

It would appear that the Open University will have an impact on the general appreciation of electronics as well as boosting the standards of technical people already working at it. If the 1,251 students who enrolled for the course last year (over 60% eventually passed, 90 with distinction) is a typical enrolment, likely to expand in future sessions, then some tens of thousands of people will have a good grounding in electronics within a decade. The first television programme went out on 28th January for the 1973 session, so if you wish to "look in" to see the kind of presentation made, switch to BBC2 at the appropriate times. The TS282 Electromagnetics and Electronics TV programmes are broadcast fortnightly on Sundays at 9.30 a.m. and Fridays at 6.40 p.m. The Open University most probably will establish more advanced courses in electronics science, as already mentioned, so that it will be a force worth watching in the future.

Thanks are due to the Open University for the help given to me during the work on this article. Acknowledgements are given for the illustrations used here, the copyright of which resides with the O.U. Opinions expressed in the text are strictly the author's of course.

Post-experience course details

Course material: 17 correspondence units; 17 television and 5 radio programmes; home experiment kit; one week residential summer school; a number of evening or Saturday tutorials; 8 computer-marked assignments and 4 tutor-marked assignments.

Course fee, including summer school: £80 (returnable deposit for home experiment kit £10).

Course begins: 2nd February 1974. Ends: 14th November 1974.

Application period: 7th May to 28th September 1973.

Note: The Electromagnetics and Electronics course may also be taken as part of an Open University B.A. degree course, but a prerequisite is that the student must first have taken one O.U. foundation course.

Further information: Post Experience Student Office, The Open University, P.O. Box 76, Bletchley, Bucks.

Digital Panel Meter

Design, operation and construction of an instrument with a solid-state display and based on an m.o.s. l.s.i. chip

by P. Bartlam, B.Sc.*

Digital panel meters provide high accuracy and reliability of measurement compared with conventional analogue instruments. This meter is based on the technologies of large scale integration and solid-state light-emitting diode displays which provide the benefits of digital operation and miniature instrument size. Resulting from co-operation between *Wireless World* and Integrated Photomatrix Ltd, who designed the d.p.m., the meter is available as a complete kit of components. The kit costs £36.75 with an extra power supply or d.c.-d.c. converter if required (see p.165). Instructions for the construction of the kit are given in the last section of this article.

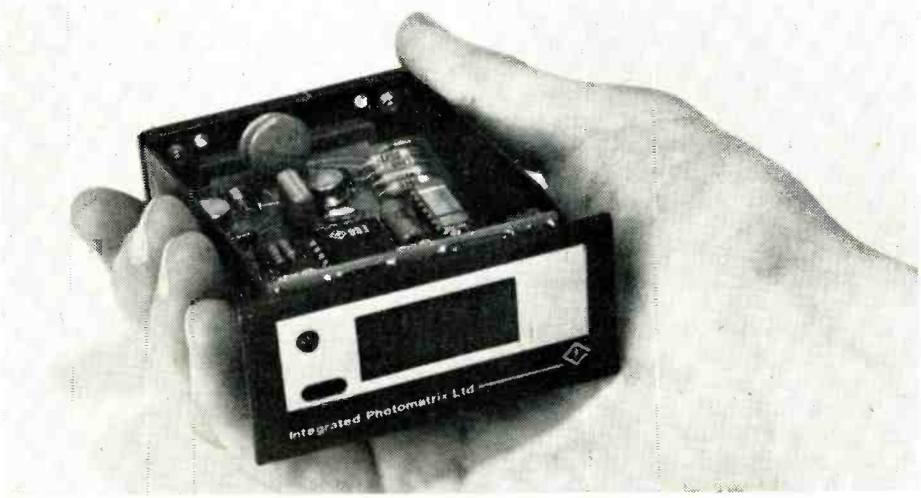
Until recently it had been impossible to design a digital panel meter comparable in size with an equivalent analogue instrument, owing largely to the fact that it was necessary to use neon tubes for the display. This, together with the large number of t.t.l. packages necessary to implement the logic, imposed a limitation on the degree of miniaturization which could be achieved. Neon tubes consume considerable power and are prone to damage due to shock and vibration. As a result of rapid developments in the fields of large scale integration and solid-state displays, this d.p.m. has been designed to overcome the basic limitations of circuit complexity, large size and high power consumption. The small dimensions of the d.p.m. are achieved using a design centred around a single m.o.s. l.s.i. logic chip type MC902 produced by Integrated Photomatrix. The d.p.m. is a single-range instrument. It occupies only 72 × 36mm of panel area, with a base area of approximately 72 × 105mm. A full list of the instrument's specifications is shown overleaf.

*Integrated Photomatrix Ltd

Panel meter i.c.

The MC902 integrated circuit is the heart of the d.p.m. and is a single silicon chip measuring 3.5 × 3mm and containing over 1000 m.o.s. transistors. The chip is encapsulated in a 28-lead d.i.l. package.

A block diagram of the chip is shown in Fig.1. It incorporates all the logic required for a four-decade-plus-one, i.e. full scale count of 19999, dual-ramp analogue to digital conversion system. The logic includes five decade counters, four binary counter stages, 20 shift register stages acting as buffer storage, 13 further shift register stages, 12 set/reset bistables and about 70 other logic gates of varying complexities. Apart from the counting logic and buffer storage the chip also incorporates automatic over-range and under-range indications, display multiplexing and all the logic for gating the analogue functions. In addition to the MC902 chip the circuitry consists essentially of an integrator, a comparator, a clock oscillator, input switches, voltage reference and the display.



Complete instrument mounted in its chassis. Four l.e.ds provide the numerical display, with a further l.e.d. (on the left) used as an over-range indicator.

Operation of the d.p.m.

A schematic diagram of the instrument is shown in Fig.2. The full scale digital reading is 1999 and thus does not use the full capability of the MC902 chip. Only the most demanding applications of extremely high accuracy would require a full scale reading of 19999 and would call for a degree of sophistication and stability in the analogue circuitry far greater than achieved by the design used here. Thus in this design the least significant decade information is not displayed.

The operation may be understood by reference to Fig. 3 which shows the waveforms for normal mode operation of the chip in a basic dual-ramp system. Normal mode in this case is for input voltages in the range 0 to + 1.999V. The meter input switching circuitry is controlled by four control signals from the MC902: (1) the input ramp control, (2) dead period control, (3) reference ramp control and (4) under-range ramp control. The input ramp period A (Fig.3) is initiated when the number contained in the main counter (one binary and four decade counters) equals zero. A logic 1 appears at the input ramp control output of the MC902 and closes the input switch for V_{in}. After integration of V_{in} for a period of 40,000 clock-timing signal pulses (i.e. a count of 20,000 in the main counter, as the main clock generator divides the clock-timing signal frequency by two), the main counter again reaches zero. The input ramp output goes to logic 0 and the reference ramp control from the MC902 becomes 1 thus disconnecting the input voltage and connecting V_{ref} to the integrator. The main counter continues to count until the comparator output becomes a 1, i.e. when the integrator output is zero. The contents of the main counter are transferred to the buffer

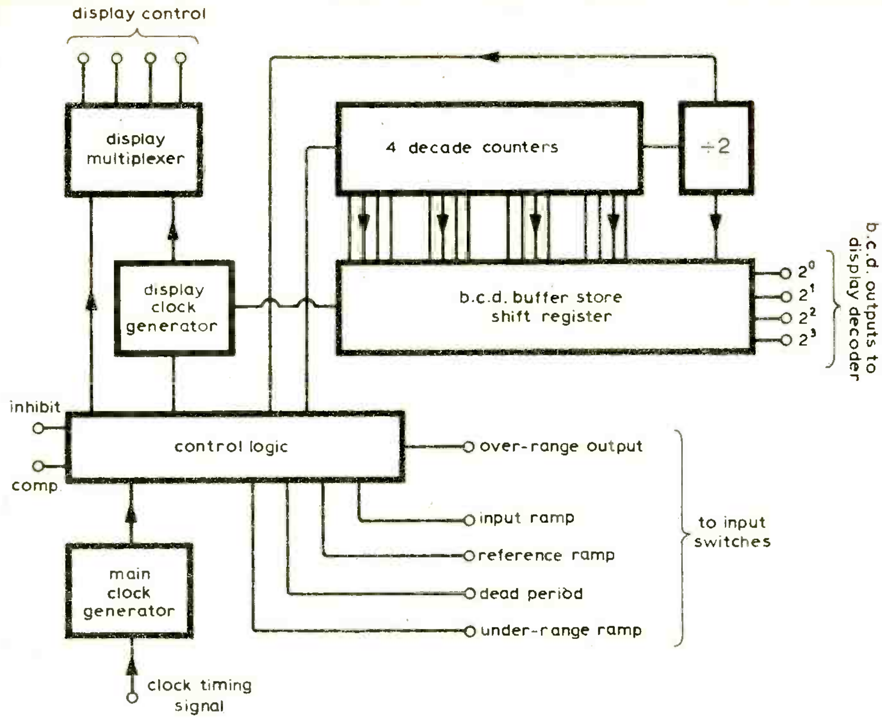


Fig. 1. Basic logic diagram of the MC902 m.o.s. l.s.i. integrated circuit which forms the heart of the design.

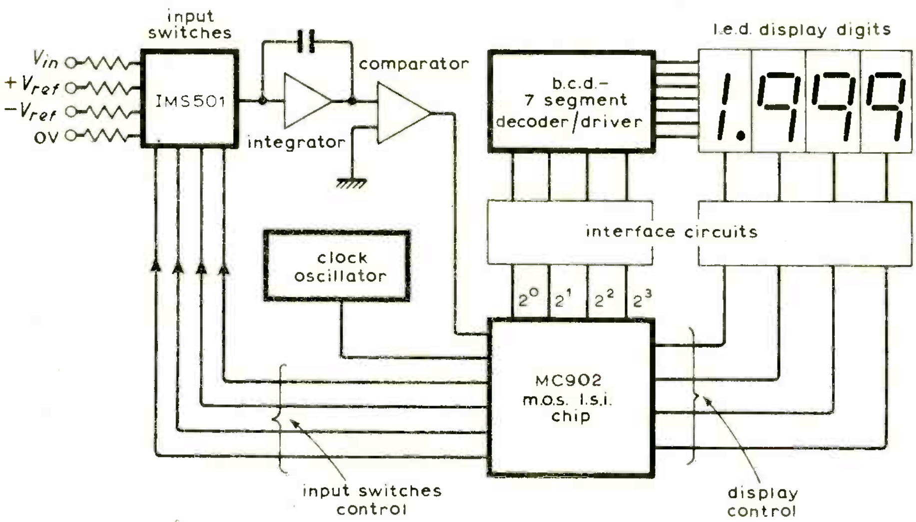


Fig. 2. Block diagram of the digital panel meter.

store. The contents of the buffer store are now directly proportional to the signal being measured, in this case V_{in}. The reference ramp control goes to 0 and the dead period control of the MC902 goes to 1 thus connecting 0V to the input of the integrator. The main counter continues counting until it reaches zero (at the end of the 40,000 clock pulses cycle) when the input ramp begins again.

The input switching is achieved using another Integrated Photomatrix m.o.s. integrated circuit the IMS501 which contains four series/shunt multiplexing switches with low leakage currents. The detailed circuitry of the input switches and the integrator is shown in Fig.4. The LM308 operational amplifier used as the basis of the integrator has characteristics of low input current and temperature drift. The potentiometer is necessary for zero calibration of the instrument. The comparator uses another integrated circuit, type LM710C. A stable reference voltage is generated from a precision temperature-compensated zener diode D_1 and stable potentiometer chain as shown in Fig. 8. The potentiometer adjustment of the reference voltage is necessary for full-scale calibration of the instrument. The main printed circuit board and display panel assembly of the d.p.m. are shown in a photograph and the relatively low number of discrete components can be clearly seen. The l.e.d. displays together with an over-range indicator l.e.d. and the display decoder driver are on a printed circuit board which mates with the main board in a mother/daughter arrangement.

Light-emitting diode display

The solid-state display comprises four gallium arsenide phosphide (GaAsP) light-emitting diode (l.e.d.) seven-segment display digits giving a bright, legible reading with 7mm high characters. The use of these l.e.d. digits has been a major contribution to the considerable reduction in size of this d.p.m. The configuration and electrical connections of the

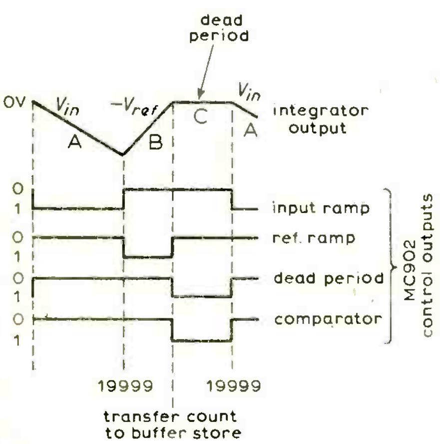


Fig. 3. Waveforms for normal mode operation, in this instance described for input voltages in the range 0 to +1.999V.

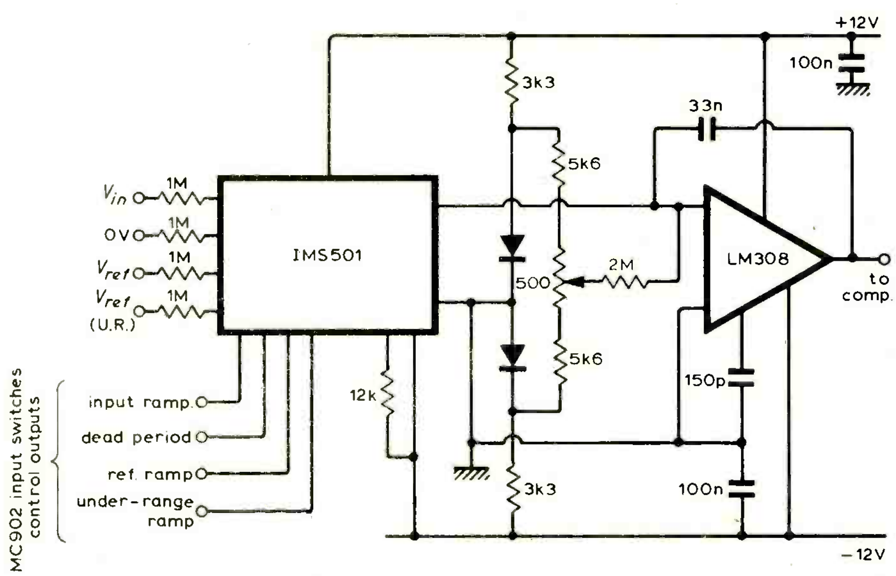


Fig. 4. Circuit of the input switches and integrator.

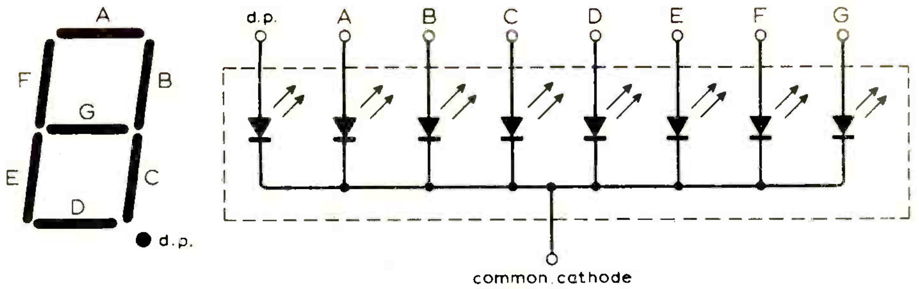


Fig.5. Configuration and connections of the l.e.ds in one digit.

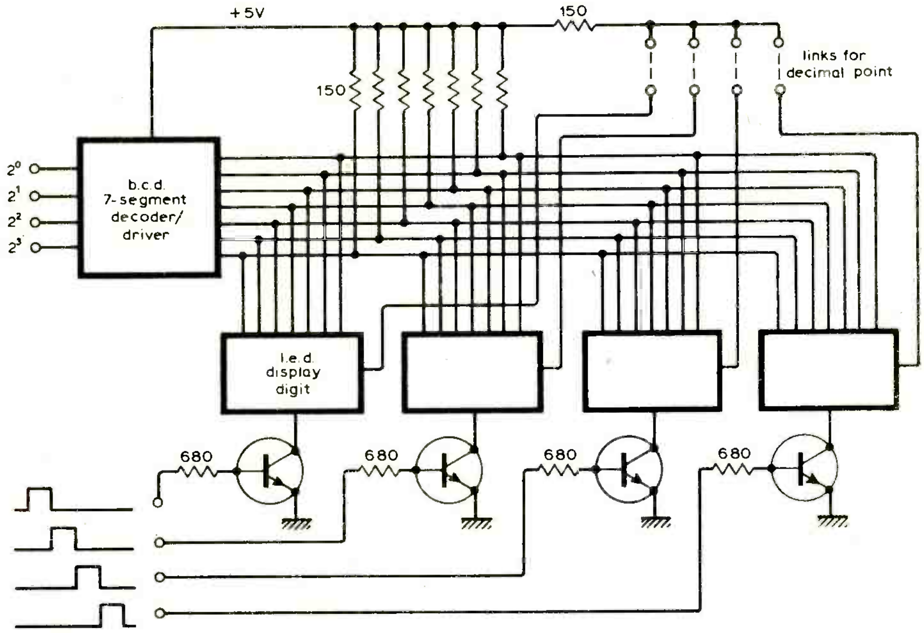


Fig.6. Multiplexing of the displays, achieved by a switching transistor in the common cathode of an l.e.d.

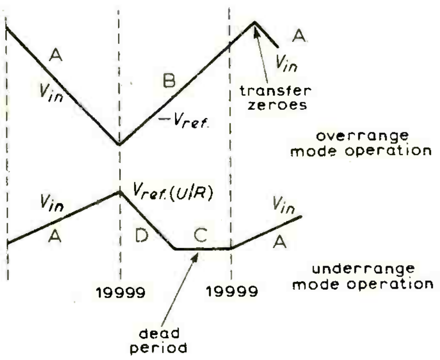


Fig. 7. Waveforms for over-range and under-range operation.

Specifications	
Full scale range	+1.999V, single polarity, programmable decimal point
Accuracy	±0.1% reading ±1 digit
Operating temperature range	0° to 60°C
Storage temperature range	−25° to +80°C
Temperature co efficient (0° to 40°C)	±0.1mV/°C
Input impedance	1MΩ
Input bias current <	10nA
Reading rate	5 per sec.
Overload protection	±100V
Inhibit/hold facility	a facility is provided to hold a reading by earthing one input connection
Power supply	+5V, ±12V
Power dissipation	3W
Supply and input connector	8-way edge connector 0.15in pitch
Display	7-segment l.e.d.. 0.25in character height. Overrange indicated by "0000" and flashing panel indicator. Reverse polarity is indicated by "0000" flashing repetitively at a low rate

How to obtain the kit

From Integrated Photomatrix Ltd., The Grove Trading Estate, Dorchester, Dorset.
Price D.P.M. kit — £33.00 + £3.75 v.a.t., p. & p.
Optional power supply kit — £7.50 + £1.25 v.a.t., p. & p.
Optional d.c.-d.c. converter (5V input) — £10.00 + £1.00 v.a.t., p. & p.
Value added tax calculated for 10%
Delivery time — 7 to 10 days

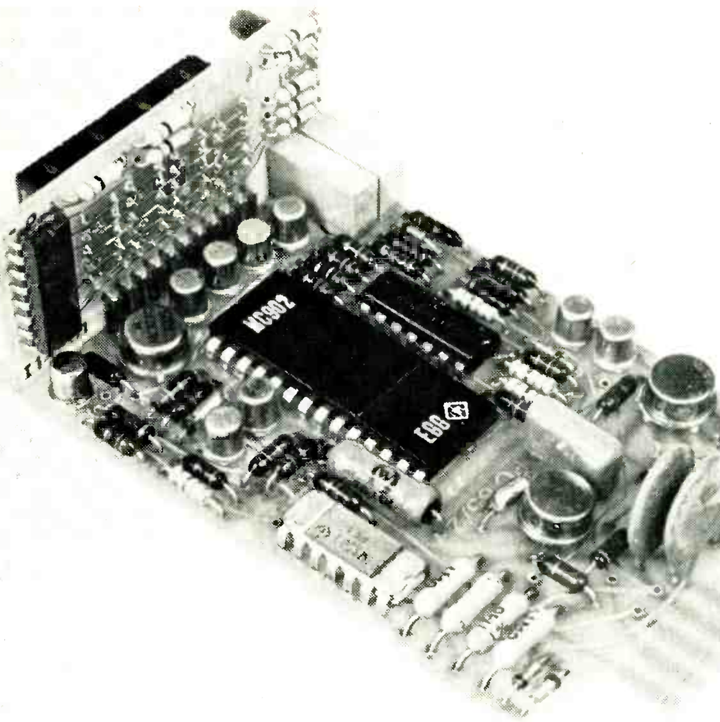
segments of an l.e.d. digit are shown in Fig. 5. The introduction of l.e.ds resulted from the discovery that some semiconductor compounds had properties which enabled them to emit light from a biased p-n junction. Their construction is such that they are able to withstand severe environmental conditions and in addition are not subject to sudden failure, while they have extremely fast response and rise-times. The use of these solid-state digits for the display function has resulted in an extremely compact, rugged unit, which may be used in many applications as a replacement for analogue panel meters particularly where size, weight, accuracy, reliability and low power consumption are important.

The binary-coded decimal (b.c.d.) information from the MC902 chip is serially clocked out of the buffer store onto four output lines representing the four bits of b.c.d. data for each character, i.e. parallel b.c.d. data, serial by character. The data is clocked out at a 20kHz rate, i.e. 50μs per character, and it is necessary to multiplex the displays such that the correct l.e.d. digit is turned on synchronously with the corresponding b.c.d. data. The multiplexing is carried out so quickly that all the displays appear to be continuously illuminated. As only one l.e.d. digit is on at a particular time, only one b.c.d.-to-seven-segment decoder driver is necessary. However, as each digit is only illuminated for 1/5 of a complete readout cycle it is necessary to drive the segments with a higher current when multiplexed than when operated statically, in order to achieve equivalent brightness; this imposes a stringent requirement on the output stages of the decoder driver and the Signetics type 8T06NB device is used for its high current sink capability. The display multiplexing circuitry is shown in Fig.6. The 150 Ω resistors define the l.e.d. current and the location of the decimal point is selected by programming links. The multiplexing of the digits is achieved by switching n-p-n transistors in the common cathode of the l.e.d. Interface circuits consisting of r.t.l. integrated circuits are used to drive the decoder driver and the multiplexing transistors, as the MC902 integrated circuit cannot supply enough current to drive them directly.

The l.e.d. digits and a panel indicator l.e.d. which is used to indicate over-range (not as power supply indicator incidentally) are mounted on one side of the board such that when assembled in the case they locate through apertures in the front panel. Other components, including the decoder driver and eight resistors, are mounted on the opposite side of the board. A wire link may be soldered in any of four positions to select the desired decimal point.

Over-range and under-range operation

Normal operation of the d.p.m. has been described for input voltages within the range 0 to +1.999V. The MC902 inte-



Component layout on the main printed circuit and the rear of the display panel p.c. board. The two boards are constructed separately and then slotted together by means of metal tacts.

Components list

Resistors

1, 2, 3, 4-1M 1%	21-10k
5-4.7k	22-3.3k
6-2.2k	23-8.2k
7-680	24-390
8-2.2k 1%	25, 26-680
9-1k 1%	27-100k
10-12k	28-680
11, 12-3.3k	29-33
13, 14-5.6k 1%	30, 31-150
15-2M 1%	32, 33, 34, 35-680
16, 17-2.2k	36, 37, 38, 39-150
18-560	40, 41, 42-150
19-2.2k	43, 44-500
20-3.3k	

Capacitors

1-0.033μ	4-68p
2-150p	5, 6-0.1μ
3-680p	

Diodes

1-1N823	8-BZY88C6V2
2 to 7-1N4148	9-BZY88C3V3

Transistors

1, 2-BC107	4 to 9-BC107
3-BCY70	

Integrated circuits

1-IMS501	5-MC827G
2-LM308H	6-MC824P
3-LM710C	7-N8T06B
4-MC902	

Light emitting diodes

1 to 4-FND70	5-MV5023

grated circuit automatically gives an indication of under-range, i.e. negative voltages, and over-range, i.e. greater than 1.999V. In both conditions a reading of "0000" is displayed; the reading is flashed on and off at a low rate to indicate under-range whereas over-range is indicated by a static display of "0000". Additionally, the over-range output signal from the MC902 goes to a logic 1 in the over-range condition and is used to illuminate a panel mounted indicator l.e.d.

The ramp waveforms for under-range and over-range operation are shown in Fig. 7. In the under-range condition, i.e. when the input voltage is negative, the ramp generated by integration of the input voltage is of opposite polarity to the normal ramp and when the counter reaches the full count of 19999 the comparator output is at a logic 1; the under-range ramp output becomes a 1 and closes the input switch for V_{ref} (u.r.) which is a reference voltage of opposite polarity to the normal V_{ref}. The reference voltage is derived by a resistor chain from the positive voltage rail, the actual voltage being non-critical as the function is merely to ensure that the ramp integrates back to 0V. At the start of the reference ramp period the number "00000" is transferred to the buffer store and the display control outputs are flashed by pulsing at about 10Hz giving a bold visual flashing on the displays. When the comparator output becomes 0 the dead period begins as in the normal mode operation.

In the over-range condition of an input voltage greater than +1.999 volts the counter in the MC902 reaches a full scale count of "19999" during the reference ramp period before the ramp has returned to zero and thus before the comparator output becomes 1. This condition causes "00000" to be transferred to the buffer store and the over-range control output to become a 1. This output is used to flash an l.e.d. panel indicator which, combined with the "0000" reading on the display, will show that the input voltage is too great.

Inhibit/hold facility

An additional feature incorporated on the MC902 l.s.i. chip is an inhibit function. The operation of this is such that when a logic 1 is applied to the meter inhibit input then the d.p.m. operation is halted in the next dead period. The last reading of the counter is thus retained in the buffer store and the effect is to hold a reading for as long as the inhibit input is at a logic 1. Normal operation is resumed the next time the main counter reaches zero after the inhibit input returns to a 0. On the instrument the inhibit/hold facility is achieved by connecting a pin on the edge connector to 0V.

Construction

Read this section completely before constructing the d.p.m. All that is necessary is to solder the components in place on the two p.c. boards. These boards — the main circuit board and the display panel — can then be slotted together and the complete circuitry mounted in its chassis by means of two screws.

Use an earthed soldering iron. For the narrowly spaced tracks and solder points on the display panel, a bit diameter of 1 to 2mm will be necessary. Other tools should include a pair of sharp wire strippers or clippers to trim the component leads to their correct length, a pair of narrow nose pliers and a straight edge, e.g. a metal ruler, to align the connection pins of the dual-in-line packages for easy insertion. Multicore solder is suitable and should preferably be 22 s.w.g.

The order in which components are soldered is not critical but the following is a guideline to avoid any possible problems. Referring to Fig. 10, solder the 11 Varicon connector contacts along the front edge of the board — soldering the staked side of the contacts to the underside of the board.

Solder the resistors and capacitors to the main p.c. board, except the two potentiometers R_{43} and R_{44}, and capacitors C_5 and C_6 which protrude and may hinder the insertion of Tr_5 and IC_2. Component leads should be trimmed so that the ends are just through to the reverse side of the p.c. board. If they are the correct length they will be fixed by a touch of the iron. Solder the diodes in place. The nine transistors should be fitted using the mounting pads provided with the flat side of each pad flush with a transistor. Integrated circuits IC_2, IC_3 and IC_5 can be mounted — using a mounting pad again for IC_3. Capacitors C_5, C_6 and resistors R_{43} and R_{44} should now be fitted. Finally, the dual-in-line packages IC_1, IC_6 and IC_4 (in that order) can be soldered in place using the straight edge to align the pins. These three i.cs could be soldered to the board first, to make fitting easier but damage may occur during subsequent handling of the board. Two holes in the p.c. board are redundant when IC_4 is positioned (there are 28 pins and 30 holes). The unused holes are positioned towards the rear end of the board. All the other "vacant" holes on the board are plated through to make connections between tracks on opposite sides of the printed circuit. To mount the transistors the correct way round, tag marks corresponding with those on the transistor cases have been marked on the board. Similarly for the integrated circuits, an identifying mark on the board corresponds with a pin mark on the i.c.

The next step is to solder components to the display panel. The 11 Varicon connector contacts should be soldered in place on the "staked" side of the contacts. Solder eight 150Ω resistors in place on the back of the panel and also IC_7, referring to Fig. 11. The indicator l.e.d. and four display l.e.ds can be soldered to the front of the panel as shown in Fig. 12. Care should be taken to ensure that the display l.e.ds are assembled in line and square to the board. This can be achieved by soldering two diagonally opposite connections of each l.e.d. Make sure they are all correctly aligned and then

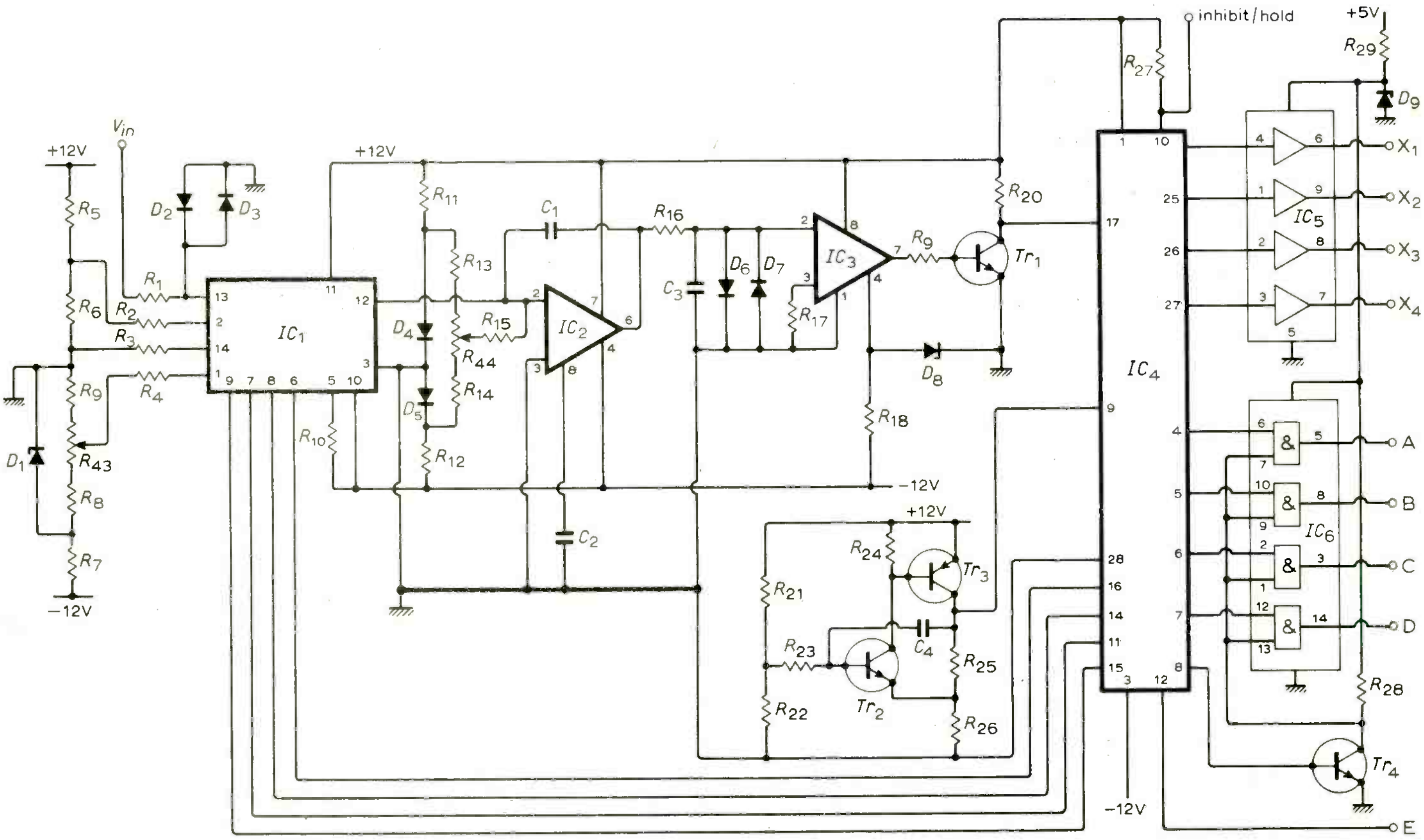


Fig. 8. Circuit diagram of the "processing" section of the d.p.m. This provides the b.c.d. and multiplexing signals for the display circuitry.

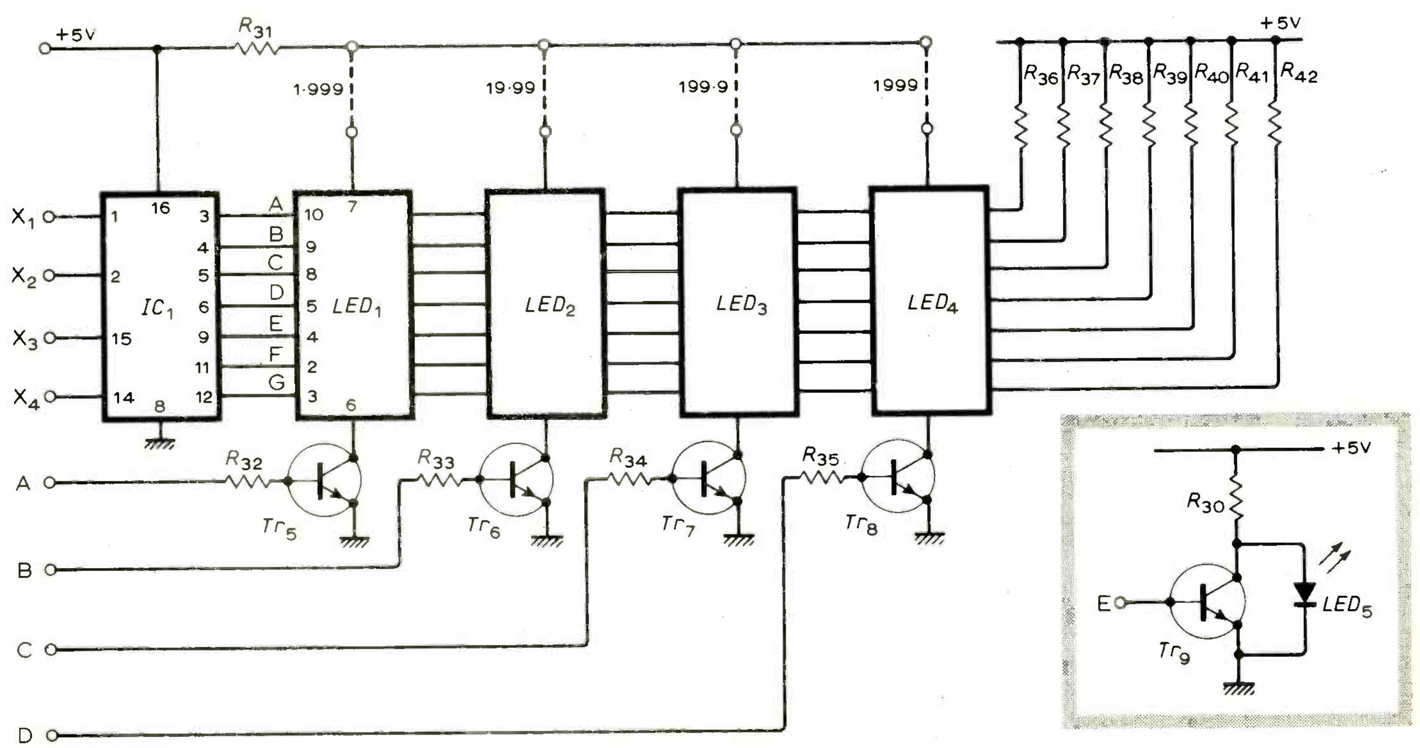


Fig. 9. Circuit of the display l.e.ds and their drivers. Also shown is the circuit for the over-range indicator (inset).

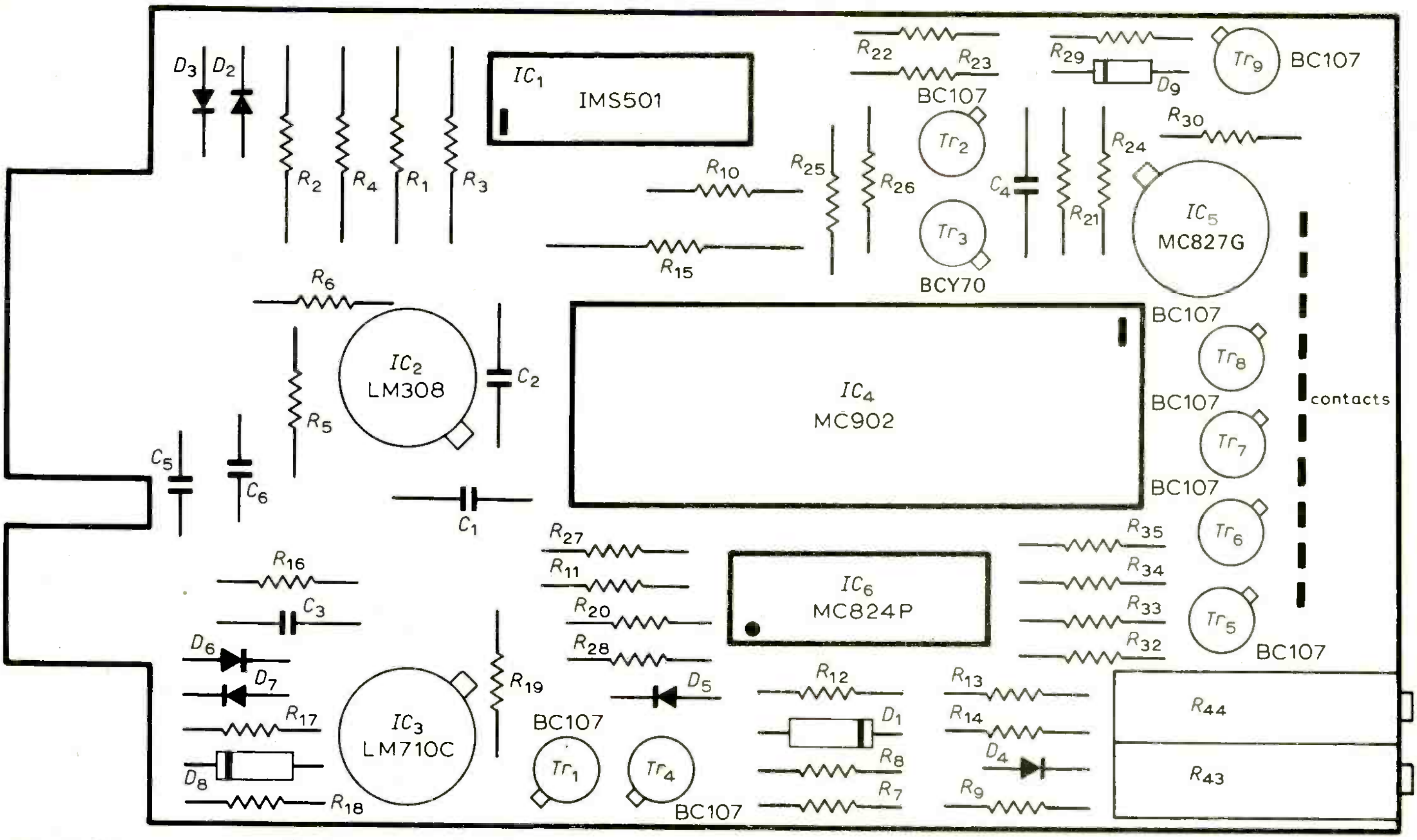


Fig. 10. Component layout on the main p.c. board.

solder the remaining pins when this is found to be so. Note that the orientation grooves must be towards the top of the p.c.b., i.e. away from the edge contacts.

The decimal point position can be programmed as required by tinned copper-wire links soldered in any of four positions shown in Fig. 11.

Link position	Full scale
1	1.999
2	19.99
3	199.9
4	1999

Check all joints carefully, using a magnifying glass if possible, in case bridging shorts have occurred between adjacent tracks. The two boards can now be slotted together and the power supplies connected.

Identifying letters are marked on the connector for external power supplies and input. Pin connections are as follows:

A-V_{in}
B-inhibit/hold
C-+5V
D-−12V
E-OV
F-keyway
H-no connection
J-+12V

If, after construction, it is necessary to desolder any components, a special desoldering instrument of the suction type should be used.

Two steps are required in setting up. Adjust R_{44}, so that the display reading is "0000" for zero input (input terminals shorted). The reference voltage is then adjusted by R_{43} for full scale calibration using a standard cell source to provide a known reference reading on the display.

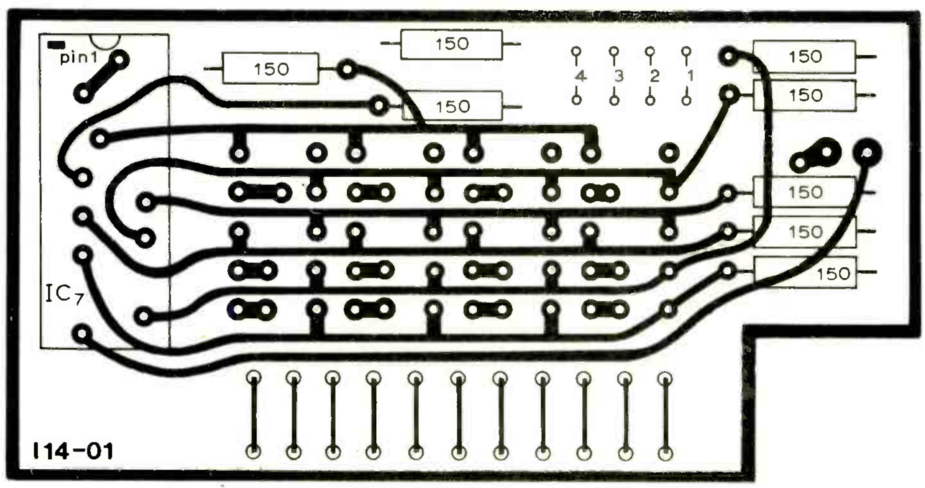


Fig. 11. Component layout and connecting tracks on the rear of the display p.c. board.

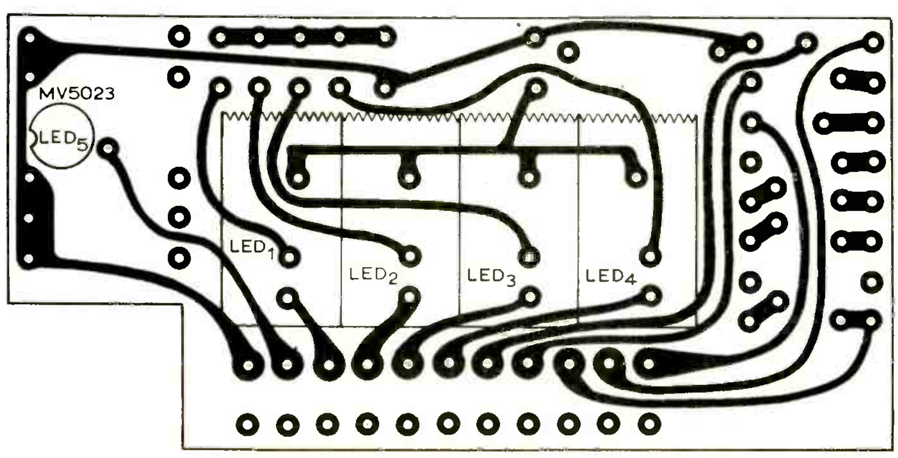


Fig. 12. Component layout and connecting tracks on the front of the display p.c. board.

The Semiconductor Story

4: Large scale intentions. Conclusion of a series of articles commemorating the 25th anniversary of the transistor

by K. J. Dean, M.Sc., Ph.D., and G. White†, M.Phil., B.Sc.*

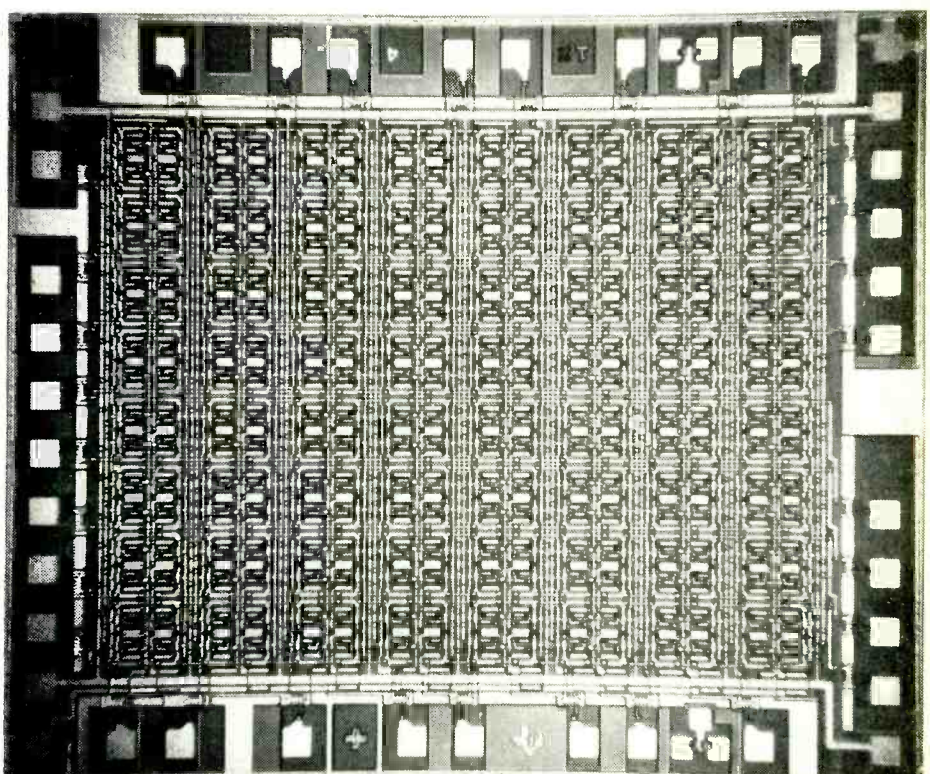
Since 1945 the industrial society in which we live has been one where technological change has been the normal state of affairs. It is not easy to plan such changes; indeed there has been very little worthwhile market and technological forecasting. Our national research establishments have been involved in bringing changes about, but it does not seem to have been a part of their role or that of industry to formulate clear research and development goals based on market assessment. To a surprising extent the semiconductor industry has been a victim of circumstances rather than their master. Its fortunes were founded on the arms race and further encouraged by the U.S. space programme. Again we have seen that military confrontation seems necessary to bring about major scientific developments. (There must surely be some other way.) Defence contracts helped establish large production plants when yield efficiencies were small, so that increasing skill and consequent falling production costs brought overproduction and "dumping". Fierce competition resulted in casualties despite the larger market which became available. A situation was arising which, though so clearly visible in retrospect, no one appeared to notice then.

Larger chips

As the move to put more electronics on a single chip got under way even greater attention was paid to the problems of increasing yield. There are, perhaps, three golden rules if high yields are to be achieved but, like all such rules, they are easier to state than to implement.

First, the processing should be simple The main difficulty here is with gold doping which is a particularly critical process necessary because charge-storage takes place in the lowest concentration area of doping, which is usually in the collector region of the transistor. Gold doping decreases life-time and so reduces charge-storage. However, this effect can also be mitigated by a diode between collector and base, so that the overdrive current goes through this anti-bottoming diode rather than the collector region. Unfortunately, if a silicon junction diode is used it has the same forward characteristics as the silicon junction transistor which it is trying to speed up. This difficulty was overcome by using the Shottky barrier diode formed by aluminium on the silicon, which has a knee voltage of 0.3V instead of 0.5V for a silicon junction diode. The use of Shottky diodes to clamp a transistor was originally developed by Texas in 1964. In some devices the storage is in the base region. In this case, a second emitter is provided for the transistor on the chip and connected to a Shottky diode to remove the charge. Devices where speed is obtained from Shottky diodes are compatible on the same chip with linear circuits whereas gold doped circuits are not. They are also compatible in the same system, but not the same chip, with similar designs for gates, but which use gold doping. An example of this is the Texas 74 series which has been second-sourced by a number of other manufacturers.

Secondly, the number of stages in the process must be kept small. But as the circuits which industry require become more sophisticated, such as gates with good speed-power ratio and high fan-in and fan-out and capability for wired-OR connections, so the number of stages tends to rise. There are for example typically three masks needed for a single transistor, eight for a t.t.l. gate and ten for some linear amplifiers. Only five masks are needed for m.o.s. gates but here speed problems exist, particularly where m.o.s. gates are interfaced to external connection. The yield of a single diffusion is inversely proportional to the area of the chip. That of a transistor or integrated circuit with n diffusions is proportional to the yield for a single diffusion raised to the power of n. Thus the yield for planar transistors with three diffusions must be extremely high



Dual 64-bit shift register first available commercially in the U.K. in 1967 and typical of the state-of-the-art at that time. (photo: Texas Instruments)

*South East London Technical College.
†Twickenham College of Technology.

before worthwhile yields can be expected from five- or eight-mask integrated circuits often 100 or more times the surface area of single devices. If a large enough system can be put on a chip the interfacing problems are less but even then an m.o.s. system is usually slower than a comparable bipolar one, and in some circumstances this is important. Further, such a solution infringes Law 3.

The third law is to keep the chip area small; but this discussion is all about increasing chip size. Scoring heavily here is m.o.s., since the devices are self-isolating. In any case, one should take care to see that isolation diffusion, sometimes known as "lands", is minimized. One process which leads to smaller devices is ion implantation. Here dopant impurities are implanted by ion bombardment rather than by diffusion. The process is compatible with planar technology and gives good control of junction profile but it is more expensive than diffusion since it depends on vacuum technology and the use of high energy accelerators.

Thus we have seen that with these three "laws" there are ways by which they can at least be bent, if not broken. The extent to which they can be bent and there still be a profitable yield is a measure of a company's success with the technical problems. Thus typical chip sizes for m.s.i. (medium scale integration) is 2mm square for bipolar t.t.l. with about 40 gates on a chip of this size. Somewhat larger m.s.i. chips can be made if m.o.s. gates are involved, perhaps 4mm × 3mm with about 500 gates irregularly connected or, say, 1024 bits of random access memory. the latter being, of course, regularly connected.

New planar processes

Now it can be seen that m.o.s. circuits are simpler and hence cheaper to produce; also they represent higher circuit packing densities than bipolar gates but in terms of performance m.o.s. is often at a disadvantage. Therefore, in 1970 manufacturers began to investigate bipolar processes which seemed to offer prospect of being competitive with m.o.s. For example there was the c.d.i. process (collector diffusion isolation) developed first at Bell Labs and then by Ferranti, the Isoplanar process of Fairchild, the Process IV which was suggested at Plessey's research centre at Caswell, and the Dutch Locos process developed by Philips. All of these were compatible with circuits which could operate in excess of 1.5GHz and all of them had the advantage of using less surface area than earlier processes. The c.d.i. system, for example, started with a slice of 10 to 20 Ω.cm p-type silicon into which n^+-layers were diffused. These were later to be the collectors of transistors formed in a 1 Ω.cm p-type epitaxial layer put down on top of them. Then n^+ diffusions were made through the epitaxial layer to make contact with the now buried n^+ layers laid down at first. These not only acted as collector contacts but isolated the area within as in the photograph of the Ferranti c.d.i. chip. In this base area the n^+ emitter diffusion is made, as well as any second emitter for a Shottky diode. After the oxide has been deposited and holes cut in it to gain access to the electrodes, silicon is grown in the holes to the same level as the oxide, thus giving a flat surface.

Other developments

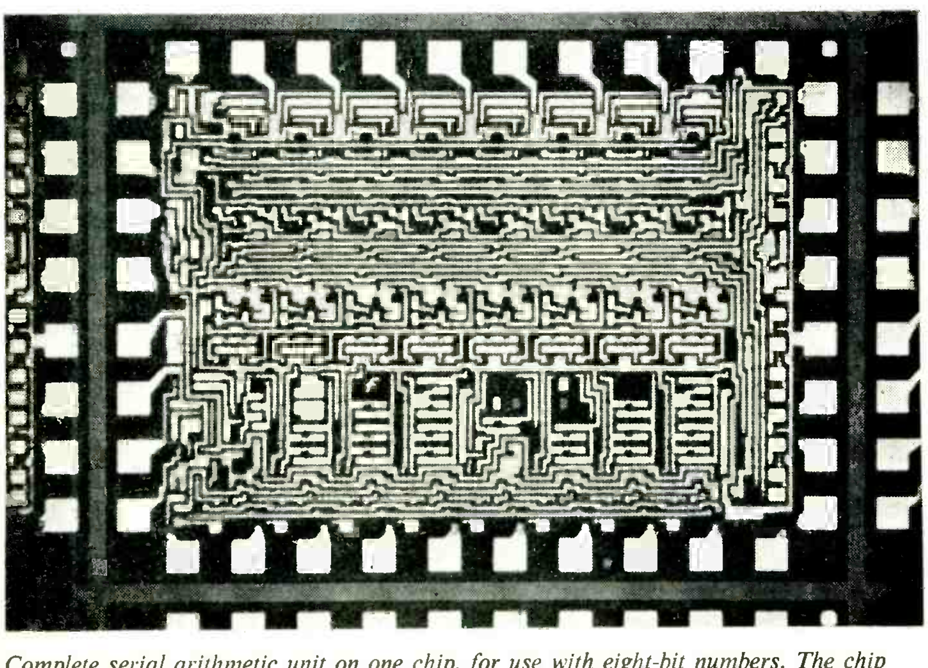
If any semiconductor manufacturer is asked about possible developments he will immediately reply that computer memories, read only and random access types are obvious areas of development. To-day a r.o.m. (read only memory) of about 4 kilobits can be made and this will probably be extended to 32 kilobits in the near future. Random access memories will also be of similar size. Complete processors are being made for the hand calculator market. These are m.o.s. chips since their slow speed is no disadvantage for manual operation. This is a growth area at the moment and prices of hand calculators are falling rapidly. This industry in which the Swiss once had a sizeable share is now dominated by Japan but often with U.S.-designed m.o.s. chips. It is whispered that the Swiss have made careful surveys before joining the competition and have decided that it is now too late to compete. Certainly they have had no indigenous computer industry to help develop their small semiconductor facilities.

What is needed now is to find markets other than in computing. Some possible ones are in communications and in various domestic industries — entertainment, cars and white goods. In telecommunications the first electronic telephone exchange to use integrated circuits was the London empress (01-603) exchange which has 10,000 i.cs. The telephone network will become increasingly digital. It is expected that by 1990 all additions to the network will be digital ones, but 17 years is a long time to wait when you are selling silicon chips. Not only will solid state crossovers be used in electronic exchanges but there is clearly a market potential, maybe for our ailing computer industry, in data processors for telephone exchanges. How often is the engaged tone heard when the number is not engaged; it is the route which is fully committed. Exchange processors are needed to effect re-routing depending on the traffic being carried at that time by a number of exchanges. Visual solid state elements are another area where a start has been made. Plessey had a much publicized chip in 1966 which carried a matrix of 10 × 10 photodiodes. Perhaps we shall see a larger and more closely packed matrix with their Process IV before long, and so bring us a step nearer to replacing vidicons, or at least for document reading.

Bell Labs have been working on picture 'phones for some time using m.s.i. chips which supply data to update a store only where picture content is changing, but this is no short-term research project. We are more likely to see low speed facsimile, perhaps augmenting or replacing the national telex network, before this.

British Rail have a large financial commitment in the development of high speed trains. As speeds become higher, say 200 m.p.h., one can no longer rely on the driver to make appropriate decisions in the much smaller time he has available to him, so that here again integrated circuits will find markets in a central processor and its associated control systems.

The white goods market offers prospects for circuits to control washing machines and similar equipment. The automobile market in which four million cars are made in Europe each year has a potential of perhaps £30 per car for electronics, to control ignition and petrol injection and to sample various

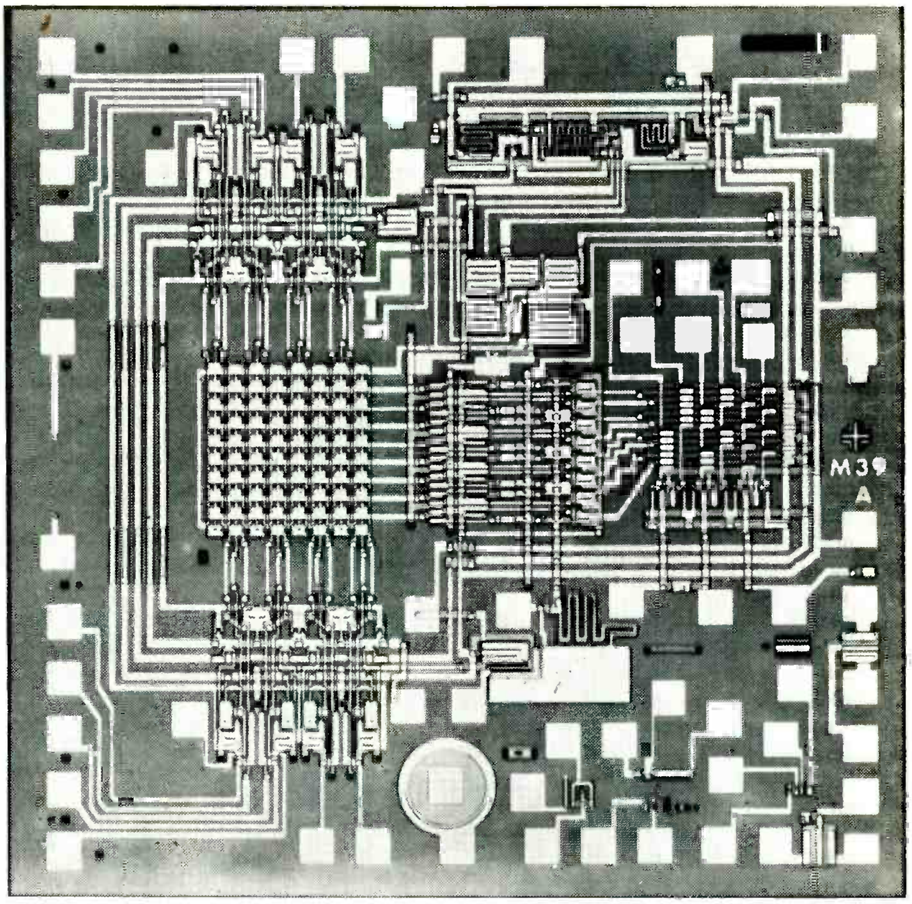


Complete serial arithmetic unit on one chip, for use with eight-bit numbers. The chip consists of 200 m.o.s. gates and was designed in the U.S.A. by Fairchild and marketed in the U.K. in 1968. (photo: S.G.S. (United Kingdom)) transducers so as to indicate a fault or warn of any dangerous condition, even of speeding. This represents an enormous market which is virtually untapped to-day. When cars are advertised as "solid state controlled" and the price of hand calculators makes slide rules obsolete, the semiconductor industry will be freed from the tyranny of computing.

What of l.s.i?

In 1968 manufacturers like Texas were proposing to make 2in slices, diffused to comprise the gates of a single system, that is, using a slice as a single integrated circuit. It was then suggested that these slices would be probe-tested and a discretionary wiring applied so as to avoid or short out faulty devices. But individual probe testing on this scale is expensive: in fact the size of chips may ultimately be limited, not by the technological skill with which they can be manufactured but by the time taken to carry out testing, to interpret the tests, and the cost of testing. This is especially true when the chip logic is of a non-repetitive nature.

There is however a problem which is more fundamental, even than this. What is there that is sufficiently complex or so large in terms of circuitry that it warrants the use of a single chip of this size and which at the same time is of such a general nature that it will sell in such quantity, perhaps to a variety of users, to make it an economic proposition? Unless this can be satisfactorily answered l.s.i. cannot be really viable. There are of course some "answers" which might be considered. Random access and associative memories for computers, use so many interconnections between cell locations, for addressing and so forth, that it is desirable to avoid the inter-chip connections which would occur using m.s.i. chips as sub-sections of the memory and joining the sections by printed circuit boards. Also, when processors need to be of small physical size and speed is not an important parameter, as with hand calculators, a single chip has advantages such as minimal wiring and servicing costs. Nevertheless there are but few cases where a convincing argument can be put up, to show that it is not good enough to use beam lead i.cs interconnected as a hybrid system on a thick film substrate. Genuine arguments are in short supply: it is not enough to have large scale intentions.



This chip carries a non-volatile m.n.o.s. 64-bit memory (left-centre) with p-channel m.o.s. decoding circuits which require a 40V signal to drive the memory cells. The storage time for which the memory can be retained in the event of power supply failure and which can be measured in days, months or even years, is a function of the thickness of the oxide and nitride layers. (photo: The Plessey Company)

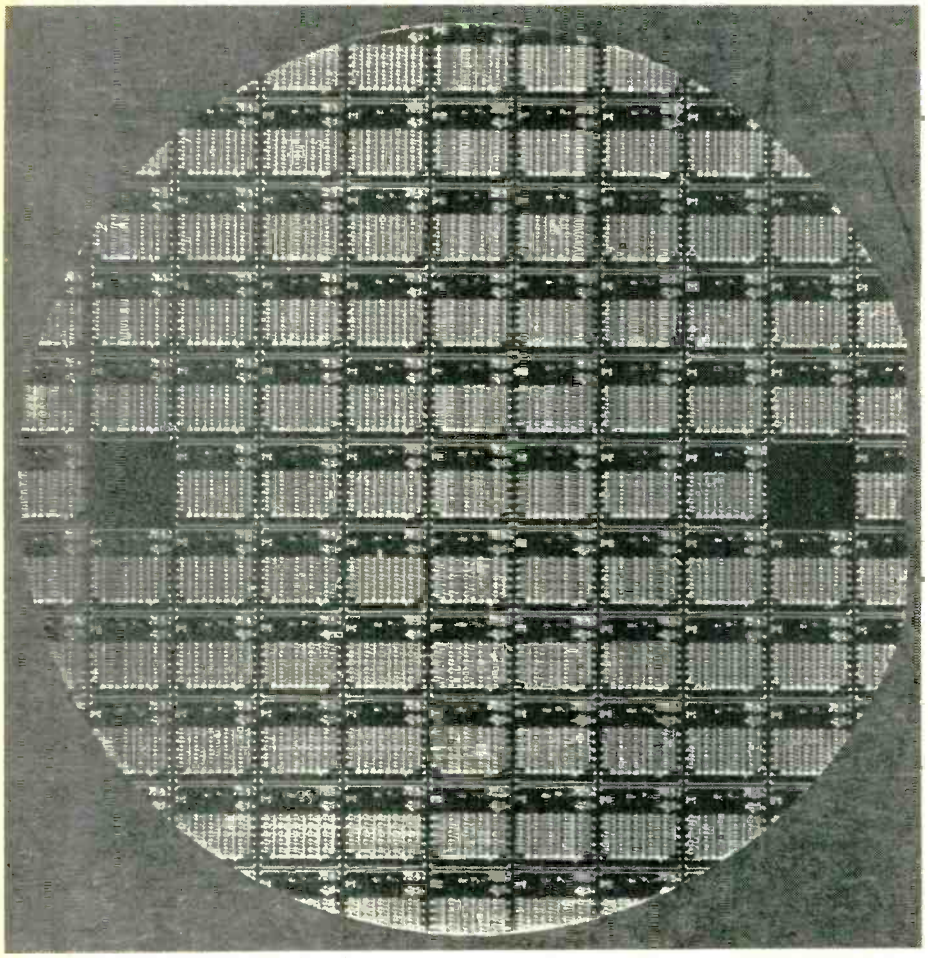
Manpower

Now let us look at some of the significant trends regarding people, prices and prospects. In 1966 the Manpower Research Unit of the Department of Employment (then the Ministry of Labour) carried out a study of the electronics industry, published by H.M.S.O. in 1967, to forecast labour requirements in detail to 1970 and more generally beyond that. It claimed to pinpoint the major growth areas of employment. It forecast for the period 1965–1970 over 50% increase in the jobs available for wiremen and production workers, 41% increase for testers, 35% for scientists and technologists and 32% for technicians. So far as longer term trends were concerned it called for more technicians and for them to have higher qualifications. It did however observe that semiconductor manufacture "would become still more capital-intensive". The predictions were not believed, for negligible support was given by industry to our technical colleges to increase the number of trained technicians by the large figure of one third. There were even cases in 1971 of withdrawal of industrial support for some block release and sandwich students. As for the scientists, it was recently stated that in 1971 only the chemical industry had more unemployed Ph.Ds than electronics. The period 1969-1971 has seen a massive cutback in the computer manufacturing and electronics industries — takeovers, closures, redundancy — and very few in the semiconductor sector making a profit. Perhaps manpower prediction, like weather forecasting, is an area in which we still have much to learn.

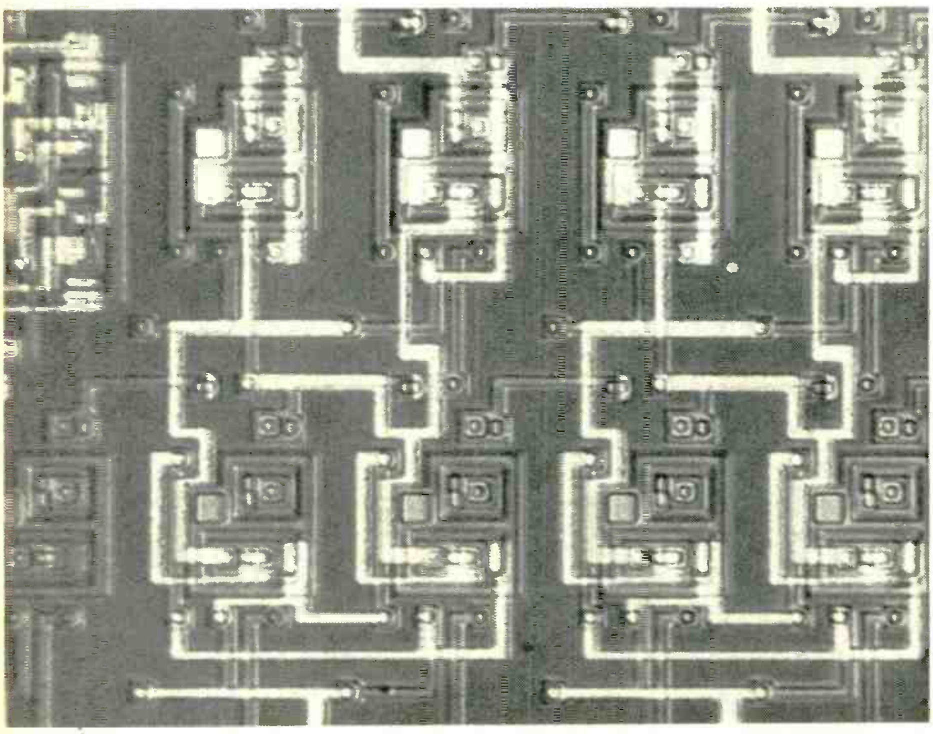
Price erosion

One of the recurrent themes of this series of articles has been the constantly falling price of semiconductors in a society where practically every other commodity was continually costing more. In part this is the result of learning about the processes involved so that production yields have increased. But commercial pressures have also had an important part in forcing prices down. It has been suggested that the combined effect of learning and competition on the price of a device is linearly related to the total quantity which has been manufactured. By examining, for example, the U.S. price of an integrated circuit first produced in 1963 for \$30, it can be seen that there has been a price fall of 30% each time the total quantity from the start of production is doubled. Neither does this apply solely to integrated circuits. Germanium diodes, for instance, which were amongst the earliest of semiconductor devices, were originally sold for £1 each. Today their quantity price is 2p and still falling. Although these figures are typical there have been cases where the rate of fall is much greater than this. In early 1969 t.t.l. gates cost 75p, 28p at the end of 1969 and 8p a year later. This was the result of dumping, giving price falls in excess of the learning process, so that prices were so low that U.K. manufacturers could not make and sell devices at these prices either then or in the foreseeable future. Even taking the whole i.c. and transistor scene into account it seems unlikely that more than one or two companies can do much more than break even. Why then continue to compete?

Some have not continued, but the average growth of the electronics industry since World War II has been about 12%



Silicon slice with over 60 chips each about 5mm square. The circuit was commercially available from Ferranti in late 1972 and contains the components of a 200-gate uncommitted logic array and is an example of the use of c.d.i.



Left shows one chip of the 60-chip 200-gate uncommitted logic array produced by the c.d.i. process. Right shows a detail of this chip. The function which the chip performs, analogue or digital or both, is selected by the metalization pattern employed, so that only one mask is involved in changes of function. Supply-line connections within the chip are made, not by the aluminium pattern, but through the silicon.

so that it has doubled in size every six years, whereas the target for national growth has been only 3%. This is one incentive to continue. Whether one believes that there is a national need to retain an independent manufacturing capability depends on the way in which one views the British trading role abroad and at home. However it should be remembered that in 1964, 90% of the U.S. semiconductor industry's output was for military applications, in 1968 the figure was 53% and even in 1970 it was as high as 37%. If our relations with the U.S.A. should ever be strained this source of "raw circuit material" for sophisticated electronics equipment might run more thinly.

It has been said that since the U.K. computer industry is effectively a second-sourcing industry (IBM has over 80% of the world's computer market) the U.K. i.c. market can never be more than a second-sourcing industry. This may well be, but at least it provides an alternative for emergencies, which is what second-sourcing is all about. Further, the developments already described may go some way to loosening the ties between semiconductor and computer manufacture by providing other major outlets for the industry.

Market potential

The accompanying table gives some indication of the areas in which the active device side of the electronics industry has grown. The bare statement, sometimes heard, that the sales of thermionic valves still outstrip those of semiconductors can be seen to fall into that class of lies we call statistics when it is noticed that major valve sales today are of colour television tubes and professional valves such as transmitting valves. Thus the sales of i.cs and transistors are about four times those of receiving valves and are bound to continue to increase as the maintenance market for valve equipment decreases. The apparent setback revealed by the 1971 figures seems rather larger in the table than the true result because ITT, who have approximately 15% of the semiconductor market, have amongst others now withdrawn from V.A.S.C.A. In future, the figures from the Electronic Components Board will include imports from companies such as Motorola and R.C.A. who do not manufacture in the U.K. and General Instrument Microelectronics who are now manufacturing at Glenrothes. Thus the figures for 1972 and subsequent years will not be strictly representative of either British-owned companies or British-made semiconductors.

The annual statistical survey of the electronics industry, published by the U.K. Electronics Economic Development Committee (H.M.S.O., September 1972) dealt more generally with the whole electronics industry employing 446,600 people, a slight drop on 1970's figures. The report which is for the year 1971 said that over 50% of them were employed in S.E. England, the area, understandably, with the greatest unemployment figures for electronics. The survey claimed an 80% growth for the industry in 1971 compared with 21% in 1970. Whilst these figures do not appear to take into account the erosion of the value of the pound, they point out that the reduced rate of growth was most apparent in the capital equipment sector, which includes computer production. The decline of the home demand for computers resulted in a fall of 8% in sales of this type of equipment, thus giving further support for seeking new outlets for microelectronics, such as the colour television market where the growth rate was 72%. That particular level of development obviously cannot continue for long, but it shows what can be achieved in some sectors of the market.

It may well be asked if these sales figures are of interest to readers. Surely whether we are manufacturers of devices or electronic instrumentation, or are industrial or domestic users, or educators, or just have the interest of the success of our country at heart — because our own interests are linked with it — the fortunes of the semiconductor industry matter to us. When we feel the full impact of going into Europe this will be even more vital. The exports from West Germany, for example, are some 70% greater than Britain's and their imports are one third of the total E.E.C. imports. What are our prospects then?

They are in fact very good, especially if recent surveys are any better than former ones. The survey carried out by Mackintosh Consultants for the Department of Trade and Industry in 1971 in the context of the difficulties the industry has been facing, puts the U.K. integrated circuit market at £100 million by 1980 that is an increase of six times over the 1970 figure of £16.5 million quoted in the table, and the m.o.s. share of this at £20 million. Quantum Science Corporation of New York recently forecast a growth rate of 14% per annum for the U.S. market, but both sets of consultants comment that there is not likely to be any diminution of the competitive market forces in the foreseeable future, or to put it more crudely, no one is content to let anyone else have a slice when there is the remotest chance of grabbing it all for himself. And this at a time when it is so difficult to keep unemployment levels down. We must turn a capital-intensive industry, likely to become more so, into one which is certainly intensive of those recently lacking human values.

So there it is: more rough water ahead, more risks for both employer and employee, but high prizes for the far-sighted. It happens, though, that to a great extent we are all in the same boat: let us hope we do not get sea-sick on the way.

Acknowledgement

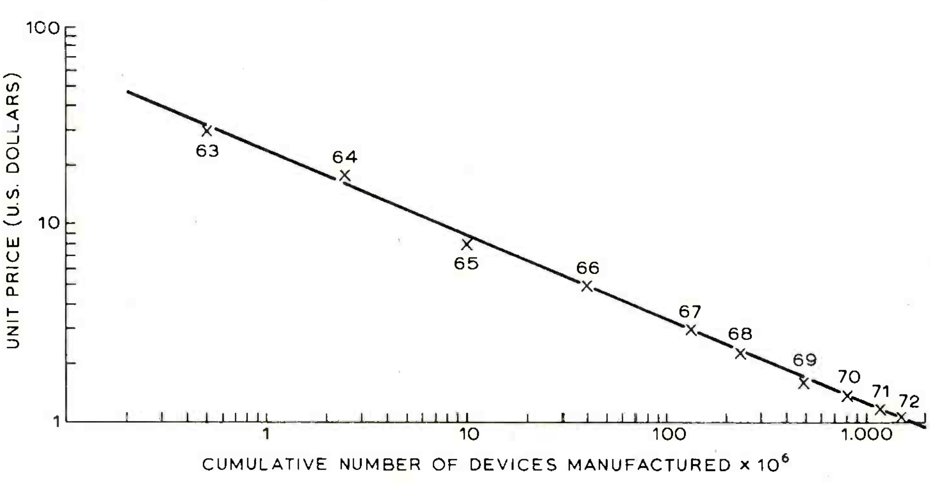
The authors would like to thank their many friends in the semiconductor industry and in Government departments who have racked their files (and their memories) for past detail, and who have been prepared to speak freely about the present and the future.

Sales figures for the U.K. electronics industry.

The figures refer to U.K. based manufacturing plant. Hence T.I. and S.G.S. are included but not Fairchild. The figures were provided by the Electronic Components Board which includes B.V.A., V.A.S.C.A. and R.E.C.M.F. All figures are in millions of pounds sterling and are not corrected for the changing value of the pound.

year	receiving valves	television tubes		professional valves and tubes	discrete semiconductors	integrated circuits
		monochrome	colour			
1955	10.2	10.8	—	—	—	—
1960	14.7	13.9	—	11.6	—	—
1965	13.1	12.8	—	20.1	28.1	—
1970	13.8	17.3	23.0	23.8	46.2	16.5
1971	11.9	16.2	31.7	25.2	34.0*	10.4*

*The figures for 1971 do not include I.T.T.

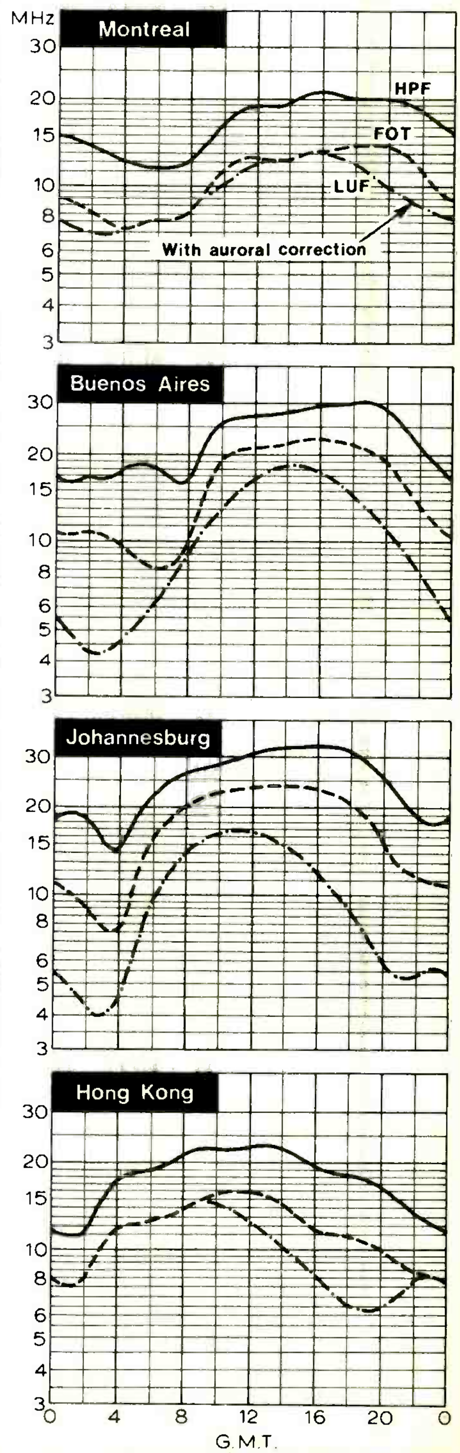


Relationship between the unit price in U.S. dollars and the cumulative number of devices manufactured between the years 1963 and 1972.

H.F. Predictions — April

The mean sunspot number for March was around 38 and this should decrease by two during each month following.

With reducing solar activity propagation disturbances will become less frequent and less intense but tend to last for longer periods. Advance forecasting of these periods, based on a solar rotation, as seen from the earth, of 27 to 29 days, should now become more reliable. There was an unusually prolonged period of nine disturbed days at the end of February which indicates a recurrence over April 17 to 24 and possibly on the first and last few days of the month. The least likely disturbed period is from April 9 to 14.



News of the Month

Cable highway into the home

More than 6,000 new houses will be equipped by the Post Office during the next 12 months with twin-cable systems carrying telephone service and "piped" radio and TV programmes. The twin cables will also form a highway into the home for telecommunication systems of the future.

Five housing developments — at Washington, County Durham; Irvine, Ayrshire; Craigavon, Northern Ireland; Milton Keynes, Buckinghamshire; and Brackla, South Wales — are being equipped with underground cable systems which enable householders simply to plug in for television or radio programmes. Although the cable systems, which are installed while houses are being built, can be used immediately for telephone, television or radio services they will play a key role in bringing other services into the home. For example, viewphone conversations, access to computer data and possibly remote meter-reading could all travel easily on these new communication "highways".

Over the next 20 years the Post Office expects to extend the service to more than 200,000 new homes nationally. By far the biggest single development is Milton Keynes, where nearly 3,000 homes will be connected to the system by March 1974. Eventually the Post Office will provide the service to 100,000 homes there. No longer handling just telephone calls, local telephone exchanges will operate as a local communications centre handling other services, such as television and radio. Key exchanges at Milton Keynes, Craigavon, Irvine, Washington and Brackla will have masts to receive television and radio programmes and equipment for boosting incoming signals and distributing programmes by cable to houses throughout the areas they serve.

Laser-computer system measures air pollution

A rapid method of identifying pollutant gases in the air has been devised by a Bell Laboratories scientist. A laser and an electronic computer have been combined in a system for detecting and measuring concentrations of pollutant gases. Identification and analysis of pollutants is a first step toward their control.

Capable of identifying concentrations of gases as low as 1 part in 10^{12}, the laser-computer system has a far greater sensitivity than most of the present regulatory standards in the U.S.A. require.

An established laboratory technique — gas spectroscopy is based on the phenomenon of different gases absorbing light at different wavelengths. Thus, specific gases leave their "fingerprints" on laser light at specific wavelengths. The amount of light absorbed shows the amount of pollutant in the air. The computer, which is about the size of a small home stereo receiver and uses the kind of electronic components common in hand-held calculators, controls the laser, tuning it through the absorbing wavelengths of various pollutant gases. Samples of air being analysed are held in a chamber called an opto-acoustic absorption cell.

The laser beam is directed into the absorption cell. Light energy absorbed by a gas increases the temperature and pressure of air in the cell in direct proportion to the quantity of gas. A sensitive microphone in the cell detects the increase in pressure and converts it to an electrical signal which is fed to the computer. The computer matches the signal with "fingerprint" data stored in its memory and identifies the pollutant.

For a feasibility demonstration in the laboratory, the system has been used to identify five different gases simultaneously. However, it can be programmed to handle up to about twenty.

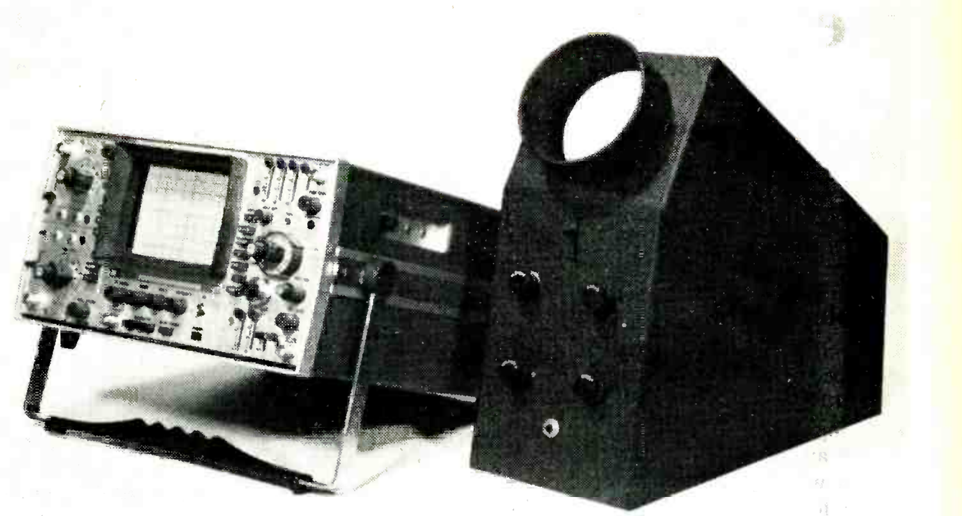
Redifon Omega Navigator, installed on board M.V. Orbita of the Pacific Steam Navigation Co., will provide position fixes accurate to within approximately one mile throughout ocean passages and coastal waters.

Holographic computer memory

A holographic optical computer memory able to perform the data processing operations of write, store, read, and erase has been developed and demonstrated by RCA at its Princeton laboratories in the U.S.A. The experimental optical system employs a laser, liquid crystals, electro-acoustic deflectors, and holograms stored on thermoplastics. It could be the forerunner of a new generation of memories equal in capacity to, but 1,000 times faster than, present large disc systems. In addition to their capacity and speed, future holographic memories could be more reliable and perhaps less expensive per data bit than mechanical systems at present used to store and process large quantities of information.

The memory utilizes the ability of holograms to store large quantities of data in a small space, and upon the speed at which light from a laser can be deflected and modulated. The memory stores data in holograms formed by a laser beam on a thermoplastic storage medium. *En route* to the storage medium, the beam strikes liquid crystal cells, which can be controlled electronically to scatter light or to be transparent. The cells introduce digital information into the laser beam in the form of tiny areas that are dark (where the cells are scattering) and light (where they are transparent). This pattern of darkness and light, recorded in the hologram, corresponds to the "zeros" and "ones" of the binary code.

Once the data is stored in the hologram, it can be retrieved by passing the laser beam through the hologram. The beam projects the holographic information on to a light sensitive array which "reads" the optical data and converts it into electronic signals. The laser beam, in both writing and reading the data, is directed by electro-acoustic deflectors. In the experimental holographic memory, the array is connected to a panel of lights to determine if the data has been stored and read out correctly. To erase the data in a holgram, heat is applied to the thermoplastic storage medium. A new hologram with new information can then be written in its place.



Pictured on the right is an early Cossor oscilloscope, believed to be only the second portable model made, which has been donated to the Science Museum by O. S. Puckle. Designated the Cossor Portable Mains Oscillograph Type No. 3247, it was manufactured in 1933, selling price was £20. Alongside is one of the latest Cossor 'scopes.

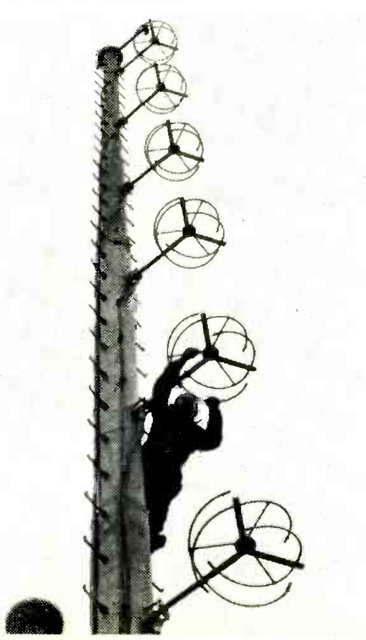
Electronic traffic control

A vehicle detection system has been designed in Morgantown, West Virginia, U.S.A. using proximity switches for sensing purposes. These proximity switches, from the British firm Elliott Relays, have sensing distances that can be adjusted up to 12 inches and can sense the presence of vehicles as they travel along a given track. The information obtained is then processed by a central computer to prevent collisions between the vehicles by retaining a specified distance between them. The scheme functions by installing proximity sensors along the route at strategic points, from where they can monitor vehicle presence on adjoining track sections or blocks. When a minimum predetermined spacing between vehicles is reached, the central computer initiates either car braking or system shutdown. Failure of a channel in the system will indicate a "vehicle present" condition to the computer for that channel, thus initiating system shutdown and fault location.

The system comprises three basic components: the sensor assemblies located at various intervals along the guideway, the electronic assembly that provides the information for the central computer, and a magnet assembly that is mounted on the moving vehicle. No adjustment is required after the initial installation unless replacement of an electronic assembly or sensor becomes necessary.

It is possible to avoid using the magnet assembly by using the vehicle structure for the target. But, in this particular application the magnet assembly is used because of the existence of high ambient magnetic interference that could actuate existing vehicle detection systems. The magnet assembly is attached to the vehicle and provides a magnetic field to actuate the sensor in the road bed. It is oriented on the vehicle with its longitudinal axis parallel to the direction of travel and is perpendicular to the fields generated by the power rails which can interfere with the detector operation. The sensors are located typically every 300 feet in the roadbed so that the longitudinal axis is also parallel to the direction of vehicle travel.

Transmitting aerial system for one of Britain's first commercial radio stations is pictured here during its check-out programme at the EMI aerial test site at Hayes, Middlesex. Two v.h.f. aerials have been specified for London and Birmingham utilizing circular polarization techniques.



High-speed mobile message-switching

Said to be the first mobile, computerized message-switching system in Europe is to be produced by Marconi Space and Defence Systems Ltd for the Ministry of Defence. The contract follows successful British Army tactical field trials with an experimental system which was designed by the Signals Research and Development Establishment in collaboration with the Company.

Code-named TARIF (Telegraph Automatic Routeing In the Field), the computer-based system will speed-up distribution of telegraph messages and will permit substantial manpower savings in operation. It will be capable of handling 5,000 messages a day on up to 48 lines simultaneously, with a typical "cross-office" handling time of one second per message. It is designed to replace the existing "torn tape" manual system which is slow, laborious and unreliable under heavy traffic conditions. TARIF is based on the GEC 920B military digital computer, backed with high-speed magnetic drum storage. Incoming messages are automatically forwarded in response to a coded message heading, or are stored for onward transmission when the recipient's line is clear.

Viewphone for surgical operations

An experimental viewphone being developed by Post Office scientists has been used to assist in the care of patients during surgery. Engineers from the Post Office's Research Department at Dollis Hill, helped by staff from London Telecommunications Region, provided a viewphone link between the operating theatre in St Peter's Hospital, Covent Garden, and the Research Department of Anaesthetics of the Royal College of Surgeons half a mile away at Lincoln's Inn Fields.

Patients undergoing operations at St Peter's are already linked over a telephone line to the R.C.S. where a computer has been used to monitor the patients' responses to anaesthetics and their general condition.

In a new experiment the viewphone was used on two full days of surgery to enable specialists at the R.C.S. to follow the progress of operations, to see the actual administration of anaesthetics, and to relate the patient's response to them with information such as heartbeat, brain waves and blood-flow, fed into the computer over the telephone data link.

Professor J. P. Payne, Head of the

Research Department of Anaesthetics, also carried out successful experiments with the examination of X-ray photographs by viewphone. He displayed a number of plates to a colleague who, over the viewphone, correctly diagnosed the conditions shown on the X-rays. Picture definition was good enough to pick out lesions in an X-ray. Viewphones are still at an early stage of development and unlikely to become available to the public for some time.

Industrial Security

Computer security, low-light television, the detection of eavesdropping devices and perimeter protection techniques were among the topics of a recent seminar programme in London arranged by Buckmaster and Page Ltd, Industrial Security Consultants, under the title "The total planning concept of industrial security". The two-day seminar was designed to provoke discussion and ideas from a team of people whose main preoccupation is with security and the senior members of their organizations who are exposed to security risk. The programme was essentially practical and used case studies to provide examples of situations where security protection was found to be necessary. A variety of electronic and other devices were demonstrated and explained including microwave and ultrasonic equipment.

Telecom awards

For the sixteenth successive year the Telecommunication Engineering & Manufacturing Association has made awards to employees of member companies of the association who were successful in the annual competition for technologists and technicians. In the technologist class the first prize (£50) went to Kevin M. Kelly (S.T. Labs) for his paper "The Doppler microwave landing system" and the second (£25 each) to Derek N. Glanville (S.T. Labs) for "The spectrum of round-off noise in a digital filter" and Philip F. Robinson (Marconi) for "Development and manufacture of a mains transient recorder". In the technician class the first prize (£50) winner was Roger Faulks (S.T.C.) for "Model automatic location store". The second prize (£20) went to David J. Mackay (Marconi) for "Selective calling in mobile radio". The awards were presented at the annual T.E.M.A. dinner on March 7th.

Inspecting aerial systems

The National Federation of Aerial Contractors is currently making plans whereby members' installations will be regularly inspected at random, and any new company applying for membership will also have its work inspected. Faulty workmanship will be reported to a standards committee. In this way, the federation hopes to assist in narrowing the field of viewer complaints.

Briefly

Record anniversary

This year marks the 75th anniversary of EMI's international recording activities which started in 1898 with the Gramophone Company, EMI's oldest subsidiary.

Sony colour TV

Sony is to start production of colour TV sets in the U.K. within the next year.

Japan Electronics Show

The Electronic Engineering Association is to sponsor the British participation at the Japan Electronics Show in Osaka from 1st to 7th October.

Finale

From the *Chiltern Carrier* — a newsletter of the Chiltern amateur radio club: famous last words — "just feel this transformer"!

Sixty Years Ago

Our advertisement for April, 1913, as it appeared in the publication *Work*. The reproduction was sent to us by a reader, Mr S. W. Saunders, of Exeter.


:: THE ::

Wireless World

which will appear on the 1st of April, and will contain the first of a series of articles which have been specially . . . prepared with a view of . . .

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Announcements

A series of lectures on **r.f. electrical measurement** practice is to be delivered at a residential vacation school at the University of Surrey organized by the Science Education and Management Division of the Institution of Electrical Engineers, Savoy Place, London WC2R 0BL.

"Minicomputers in Instrumentation and Control — 73" is the title of a short course and exhibition to be held from 30th May to 1st June at the Polytechnic of Central London, 115 New Cavendish Street, London W1M 8JS. The course is aimed at scientists, engineers and managers.

The University of Essex has announced the receipt of £51,655 of **research grants.** £33,000 is from the Wolfson Foundation to support the electronics centre for introducing electronics to non-electronic industries, and £913 from Standard Telephones and Cables Ltd is an extension of the existing grant for theoretical work on a filter synthesis topic.

The **Technical Help to Exporters** service of British Standards Institution, Maylands Avenue, Hemel Hempstead, Herts, has produced a digest detailing the technical regulations applicable to the radio interference suppression of electrical equipment and installations imported into Denmark. The publication is entitled "TD.1013 Denmark radio interference suppression".

A new plug-in unit, the 3121 single **timebase,** has been developed by Cossor Electronics Ltd., The Pinnacles, Elizabeth Way, Harlow, Essex, for use in the company's model 3100 plug-in oscilloscope system.

The United Africa Co. has changed its name to UAC International. As a result, the subsidiary company **Unamec Ltd,** P.O. Box 1, United Africa House, Blackfriars Road, London SE1 9UG has become the Unamec Division of UAC International.

The **Vero Electronics Group,** Industrial Estate, Chandlers Ford, Hants SO5 3ZR, have expanded their activities by the opening of an Equipment Division formed to market a range of wire-wrap tools, bits and sleeves manufactured by the American O.K. Machine and Tool Corporation.

Banbury Electronics, Swansea and Fenwick Electronics Glasgow, are marketing the range of counter/timers and other instruments from **Radio Control Specialists Ltd,** National Works, Bath Road, Hounslow, TW4 7EE.

Datac Ltd, The Polygon, Bowden, Altrincham, Cheshire, have been appointed agents for the **Mullard Mosaic Printer.**

Transworld Scientific Ltd have become the U.K. distributor for the **power transistor range** manufactured by Kertron Inc., Florida, U.S.A.

The Oxford Instrument Co. and the Superconducting Magnet Systems Activity of B.O.C. Ltd, have announced an agreement to merge their **cryogenic and cryomagnetic systems** operations. B.O.C. will purchase a minority share interest in Oxford Instruments and all activities will be consolidated at Oxford Instruments, Osney Mead, Oxford.

An order for **seismographic recording equipment** has been placed with Racal-Thermionic Ltd, Shore Road, Hythe, Southampton, Hants SO4 6ZH, by the Italian Government. The order, worth over £30,000, is for equipment which will form part of a chain of earth tremor detection stations sited along the length of the Italian peninsula.

Digital Multimeter

2. Circuit operation

by D. E. O'N. Waddington, M.I.E.R.E.

In Part 1 of this article I showed that the instrument falls naturally into seven blocks (see Fig. 1) with the power supply forming an eighth. In practice it is convenient to rearrange some of these blocks so that they fit onto six circuit boards as shown in Fig. 2. Boards 1, 2 and 3 form the basic digital display section while boards 4, 5 and 6 provide the various functions.

Power supply

The power requirements for this instrument are fairly modest. Firstly the supply voltage for the counter, logic and display is 5 volts, accurate to within ±5%, which means that some form of voltage stabilization must be used, as the mains voltage is not sufficiently stable. The current requirement is of the order of 500mA so that one of the integrated voltage regulators such as the National semiconductors type LM309K can be used. The advantage of using an integrated power regulator here is that it comes in a TO3 package with three connections only—input, output and common—and it requires no setting up. A large-value reservoir capacitor is necessary across the output of the bridge rectifier to ensure that the voltage drop across the regulator is sufficient to prevent the circuit from going out of regulation. This regulator also supplies the power necessary for Block 4 so that, if the only functions required are counter and timer, this is the only section of the power supply which need be built.

Blocks 5 and 6, voltmeter and resistance/capacitance meter respectively, need higher voltages for adequate operation, and, as operational amplifiers are used, it was also necessary to provide a negative rail. Therefore, the supplies for these sections are plus and minus 12 volts, which must be stabilized as they provide current feeds for the various voltage reference diodes used in the voltage and component measurements. The current requirement here is fairly low, about 50mA. It did not seem worth while to use integrated voltage regulators for these rails as, generally speaking, these devices have a common negative rail which would necessitate an extra winding on the mains transformer. An additional factor against their use was the fact that no suitable preset voltage regulators were available at a reasonable price at the time when I did the design.

The circuit which I used is very conventional, and is shown in Fig. 3. The centre tap of the mains transformer secondary is used as the common or earth rail and two full-wave rectifiers using D_1, D_2, D_3 and D_4 provide the necessary unregulated positive and negative rails. The positive rail is stabilized using a conventional "emitter-follower" type stabilizer. The reference voltage is derived from the zener diode, D_5, which was chosen to have a temperature coefficient complementary to that of the emitter/base junction of the transistor Tr_1. While this does not necessarily give perfect cancellation of temperature effects, the temperature coefficient of this sort of combination can be very good[1]. Additional smoothing has been included in the feed to the collector of Tr_1 to reduce ripple at the output. The negative rail stabilizer is also fairly conventional, and uses the stabilized positive rail as a reference and a long-tailed pair as the comparator to reduce temperature effects. No over-load protection circuits have been included as, except for accidents during testing and setting up, it is unlikely that either of these rails will be short-circuited.

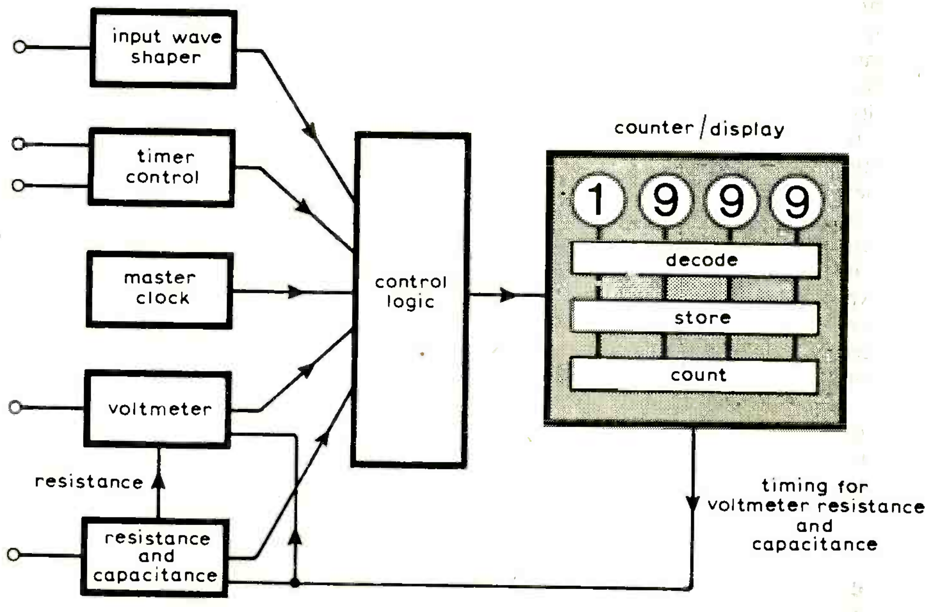


Fig. 1. Block diagram.

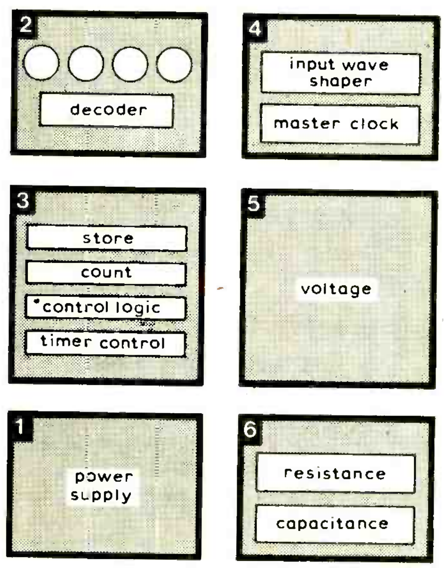


Fig. 2. Block diagram rearranged to show the parts of the circuit which are grouped together for construction.

Decoder/display

The design of this section depended largely upon the type of display device chosen. Traditionally, gas discharge numerical indicator tubes have been used. These have the disadvantage that they require a power supply of the order of 150 volts, which is inconvenient with transistor circuits, and I therefore decided to use a low voltage indicator. Light emitting diode and liquid crystal displays are still too expensive for general use so that I chose the seven-segment incandescent filament displays made by Fuji. These are very convenient to use as their leads are on the same 0.1in matrix as the integrated circuits and, as they require only 8mA per segment to give an adequately bright display, they are very suitable for use with the t.t.l., b.c.d.-to-seven-segment decoder SN7447. The display consists of four of these indicators. Three of them are driven by the decoders but the fourth is driven by a transistor, as it only needs to indicate "1" or "0". In practice it is most economical to keep the "1" permanently lit and to use a single transistor to feed the 4 segments needed to convert it to "0" as required. The input circuit to this transistor, Tr_{10}, is arranged so that it looks like a d.t.l. gate, making it compatible with the t.t.l. gate which drives it. Decimal points, albeit a little oddly positioned, are included in these display devices.

The diagram of this board is given in Fig. 4. I do not call it a circuit diagram as the true circuit diagrams of the integrated circuits are so vast that they would take up too much space. At the same time they would add little of value to the user so we must put up with diagrams which are a cross between block diagrams and circuit diagrams. The layout of this circuit is not critical and it can be mounted to display the numerals conveniently.

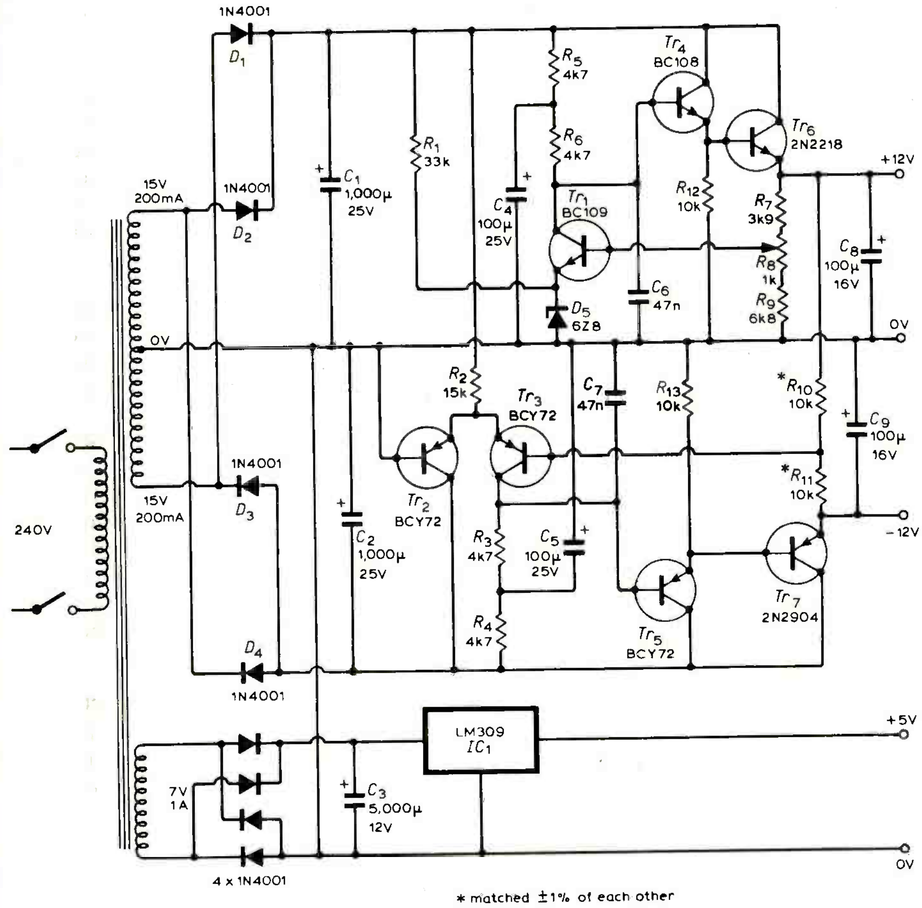


Fig. 3. Power supply and stabilizer circuit.

Counter store, control logic and time control

Counter store. In order to give the 1999 display capability needed for the instrument, the counter must divide by 2000. However, a further divide by two is necessary to drive the voltmeter and capacitance meter so that the total division required is 4000. Fig. 5(b) shows that this division is achieved by using three decade dividers type SN7490 followed by a dual JK flip-flop type SN7473. The b.c.d. outputs from the decade dividers are fed to three four-bit latches type SN7475, which act as the memory for the three least significant digits of the counter. The memory

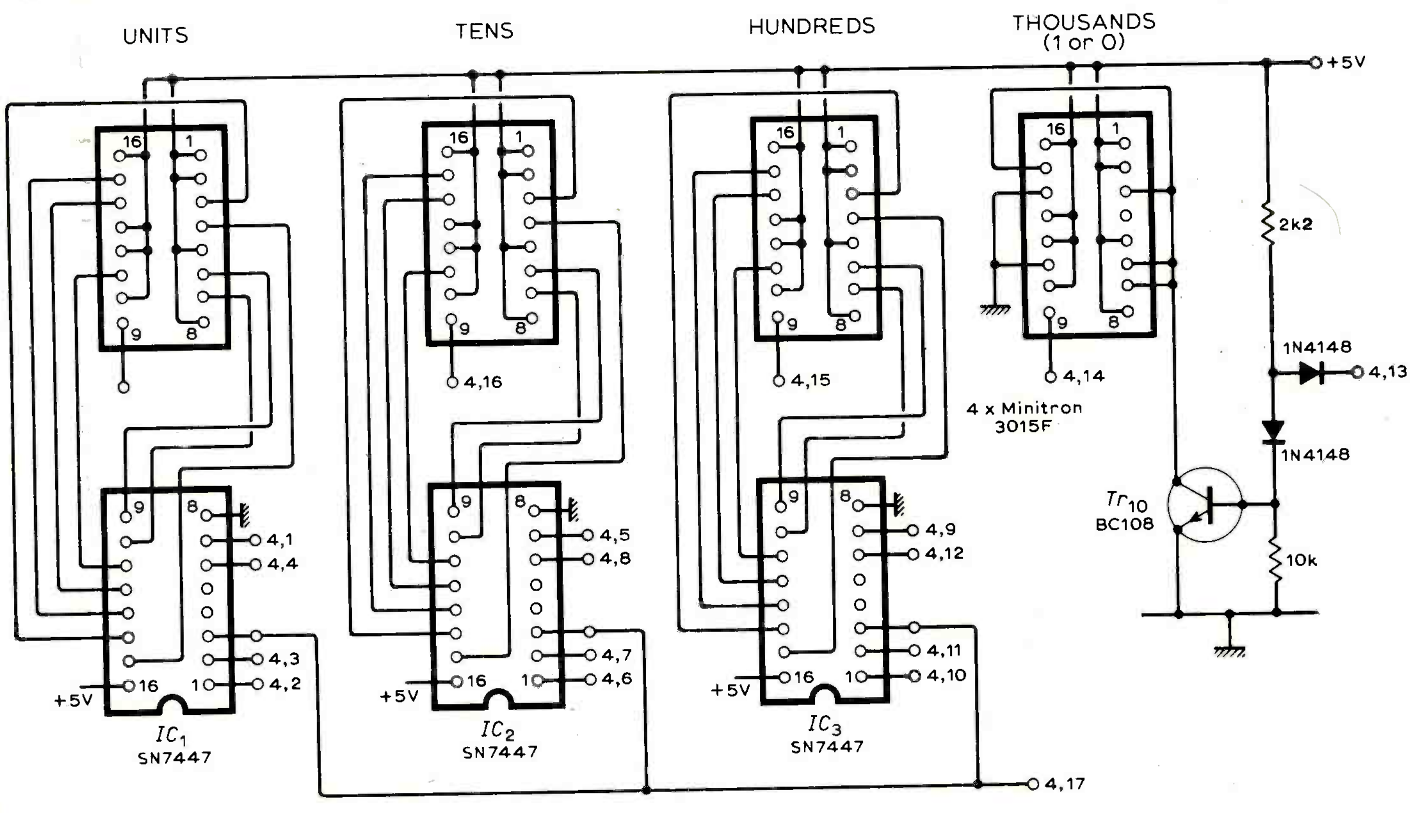


Fig. 4. Decoder/display diagram.

for the most significant digit is a one-bit latch made from a quad two-input gate SN7400. This latch consists of two switches IC_{14a} and IC_{14b} feeding IC_{14c} and IC_{14d} which are cross-coupled to form an RS (set-reset) flip-flop. When the command input is high gates IC_{14a} and IC_{14b} are enabled so that the outputs from the RS flip-flops follow the inputs. When the command input goes low, the switches are disabled and the RS flip-flop retains the state which was present at the instant when the transition occurred. The command inputs to $IC_{11,12,13,14}$ are driven by the gates in IC_5, which in turn receive their inputs either from the voltmeter/capacitance meter or from the pulse generating chain Tr_2 to Tr_5.

Control logic. This section performs the switching functions illustrated in Figs. 1, 2 and 3 of Part 1 of the article. Logic gates have been used here as they allow the switching to be achieved simply by switching the control inputs to "1", gate enabled, or "0", gate disabled. In this way the switching can be done at d.c., so that there is no necessity to take signals back and forth between the front panel and the circuit board. The input to the count gate IC_{4a} comes from IC_{1a} (input from wave shaper for frequency counting) or IC_{1b} (input from master clock for time, period or voltage/resistance/capacitance measurements). Similarly the input to the count-gate controller IC_{4b} comes from the divide-by-two IC_3, from either IC_{1c} or IC_{1d}. The output from IC_{4b} also feeds the control-pulse generating chain Tr_2, Tr_3, Tr_4 and Tr_5 which works as follows.

The output from IC_{4b} in Fig. 5 is normally high so that the 22pF capacitor C_1 is fully charged. When this output goes low, the base of Tr_2 is taken negative by the charge on C_1, Tr_2 thereby being switched off. This capacitor now discharges through the 10kΩ resistor R_8 and at a time approximately equal to $0.7CR$, Tr_2 will switch on again causing a similar switching action to take place at Tr_3. This, in turn, will be followed by Tr_4 and finally Tr_5. The reason for using four of these differentiators instead of the two which are obviously necessary is that there are delays in each gate. Separating the pulses by a controlled interval ensures that the circuit has "settled" before each instruction (i.e. "Store" or "Reset") is given.

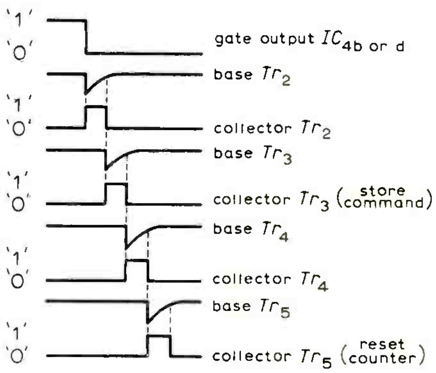


Fig. 5(a). Timing waveforms generated by the control circuit.

Timer control. This circuit has been arranged so that, once the "run" and "stop" inputs have been connected to earth, neither will operate again until the circuit has been reset. By doing this the effects of any multiple contacts, such as bounce in switches, can be eliminated. The circuit works as follows: When the "Prime" switch is momentarily closed, the RS flip-flops $IC_{2a,b}$ and $IC_{2c,d}$ are set so that the output of IC_{2a} is at 0 and IC_{2d} at 1. The 0 causes the output of IC_{4c} to be at 1, IC_{4d} at 0 and thus no pulses from the master clock can get through the count gate IC_{4a}. When the "run" input is earthed, the RS flip-flop $IC_{2a,b}$ changes state so that the output at IC_{2a} goes to 1, enables the count gate IC_{4a} and the counter starts counting clock pulses. When the "stop" input is earthed, the output at IC_2 goes to 0, disabling the count gate and thus stopping the counter. The output of IC_{4d} also goes to 0, triggering the timing chain described above.

In order to permit the "wired-OR" function to be implemented, IC_1 and IC_4 use "free collector" gates type SN7403. However, d.t.l. gates such as the μA946 can be used here in which case the 1kΩ pull-up resistor can be omitted. However, in order to allow C_1 to charge up quickly, the pull-up resistor on the output of IC_{4d} should be retained.

Input wave shaper and master clock

Input wave shaper. The circuit of the input wave shaper is shown in Fig. 6. This has been designed to accept a wide range of

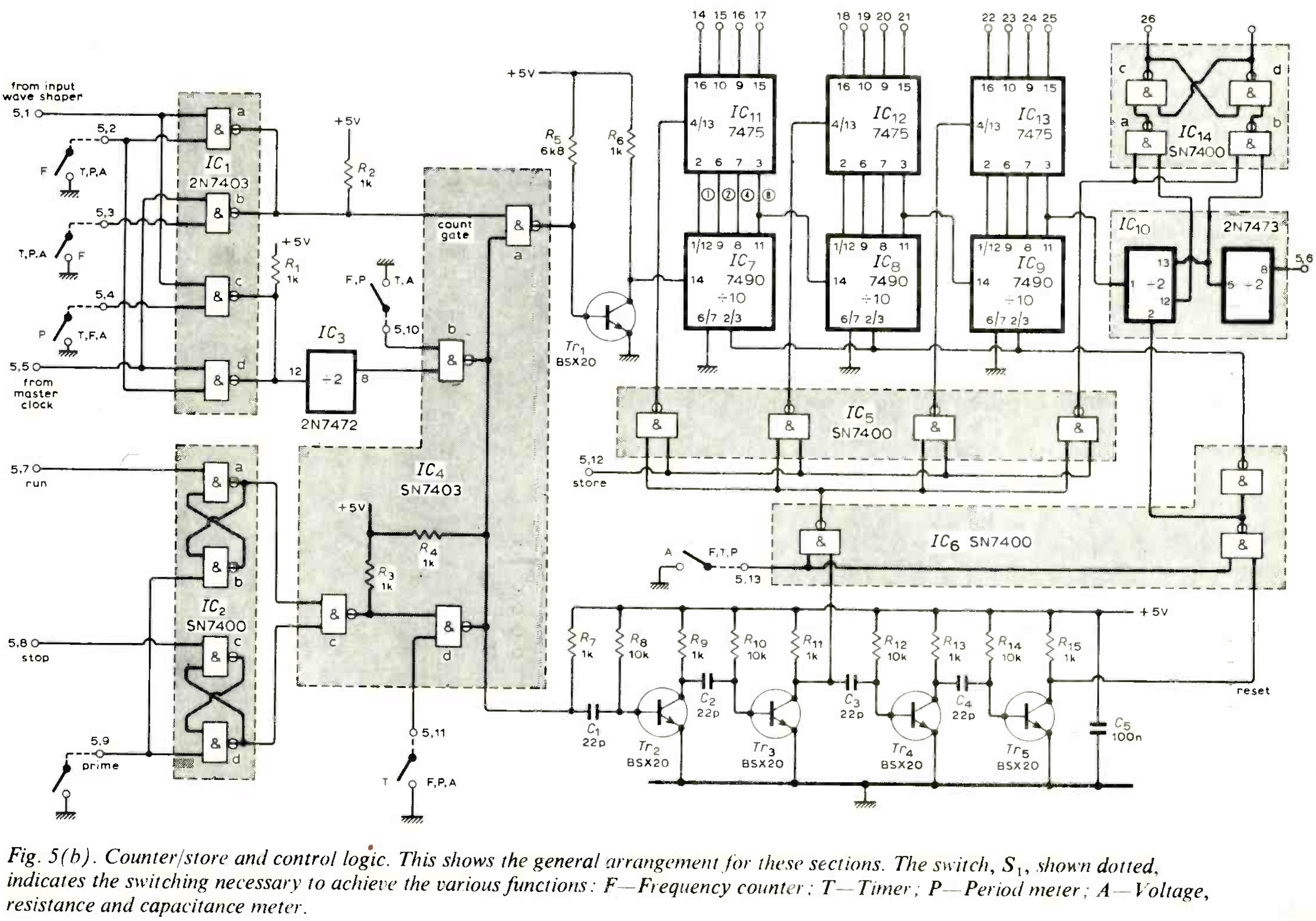


Fig. 5(b). Counter/store and control logic. This shows the general arrangement for these sections. The switch, S_1, shown dotted, indicates the switching necessary to achieve the various functions: F—Frequency counter; T—Timer; P—Period meter; A—Voltage, resistance and capacitance meter.

input voltages, 20mV to 100V, so that it was necessary to include some form of limiting as near to the input as possible. This obviates the necessity for gain control but it has the disadvantage that the input resistance varies with input level. The variation however, should not pose any real problems as, for inputs below 600mV peaks, the resistance is of the order of a megohm and, above this level, it never falls below 100 kilohms. The high-frequency response of this arrangement could be improved, if required, by connecting a small capacitor in parallel with the 100kΩ resistor but it is difficult to assess the exact value needed. The input amplifier consists of three transistors Tr_1, Tr_2 and Tr_3. The a.c. gain is set at 100 by the emitter resistor R_3 and the shunt feedback resistor R_5, and the d.c. conditions are set by the overall feedback *via* the 1MΩ resistor R_2. The output from the collector of Tr_3 is fed directly to the Schmitt trigger Tr_4 and Tr_5. In order to control the shape of the waveform to be counted, the output from the trigger is differentiated and amplified by Tr_6. The pulse width at the output will be approximately 170ns so that the highest frequency which can be counted will be limited to about 5MHz.

Master clock. In the circuit of the master clock, shown in Fig. 7, it will be noted that both the master clock and the input wave shaper run off the +5 volt rail so that, if only the counter/timer functions are required, the plus and minus 12 volt sections of the power supply can be omitted.

As the master clock provides the standard for all the time and frequency measurements the accuracy of these is critically dependent upon this section. Accordingly a crystal-controlled oscillator is used to provide the basic standard. Crystals cannot be accepted as absolute standards, however; their resonant frequencies can be "pulled" by external components, and frequencies are temperature dependent, a deficiency which can be overcome to a large extent by the use of temperature-controlled ovens. More insidiously, frequencies also drift with time. Extreme stability was not, however, considered essential for this application so that a fairly wide choice of crystals was available. I chose a 100kHz, 5° X-cut crystal type QM120F, with a parabolic temperature characteristic, the zero temperature coefficient point of which is between 12° and 22°C and, as a result, the temperature coefficient is near its lowest point at room temperature. The ageing rate of this crystal is of the order of 5 parts in 10^6 per annum.

The crystal is operated in the series resonant mode, coupling the output at the collector of Tr_1 to the base of Tr_2. The amplitude of the positive feedback to the base of Tr_1 is held substantially constant by the limiting effect of the diode D_1 and the base/emitter diode of Tr_3. The frequency is adjustable over a range of $\pm$10Hz by means of C_1 so that, provided that suitable test gear is available, the frequency may be set precisely. However, if no setting-up equipment is available, selecting this value of the parallel combination of C_1 and C_2 to be 50pF will give a frequency of 100kHz $\pm$3Hz or an accuracy of 3 parts in 10^5. The output, which is taken from the collector of Tr_3, has a rectangular waveform and is suitable for feeding direct to the logic gates and frequency divider chain. If the counter functions of the instrument are not needed, the frequency-divider chain can be omitted and this output is then fed directly to the input of the counter chain (base of Tr_1, Fig. 5). Normally, however, this output is fed to the frequency-divider chain which consists of five decade dividers connected in cascade thus providing output frequencies of 100kHz, 10kHz, 1kHz, 100Hz, 10Hz and 1Hz. Each frequency output is fed to one input of a two-input gate, the outputs of the gates being connected together to give a "wired-OR" function. The other input to each gate is fed from an individual inverter. Grounding the input to an inverter causes its output to go high, thus enabling the gate to which it is connected and selecting the appropriate frequency to be fed to the output. As a result, the six frequencies can be selected by a single-pole six position switch which connects the appropriate inverter inputs to ground. It should not be necessary to hold the ungrounded inverter inputs high as there should not be enough electrical noise within the instrument to cause errors. For this frequency selection I used three quad two-input gates type μA946 as they can be used to give the "wired-OR" function without additional resistors. However, if pull-up resistors are added to the circuit, open collector t.t.l. gates type SN7403 can be used.

Voltmeter

The principles of the dual ramp voltmeter have been discussed in Part 1 of this article. In practice, however, things are slightly more complicated as it is necessary to provide range switching, rectification and polarity indication, as well as analogue-to-digital conversion.

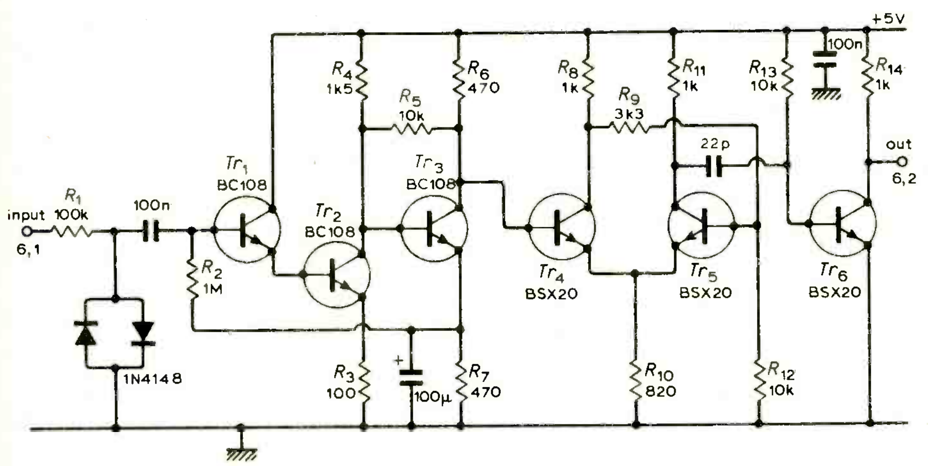


Fig. 6. Input wave shaper.

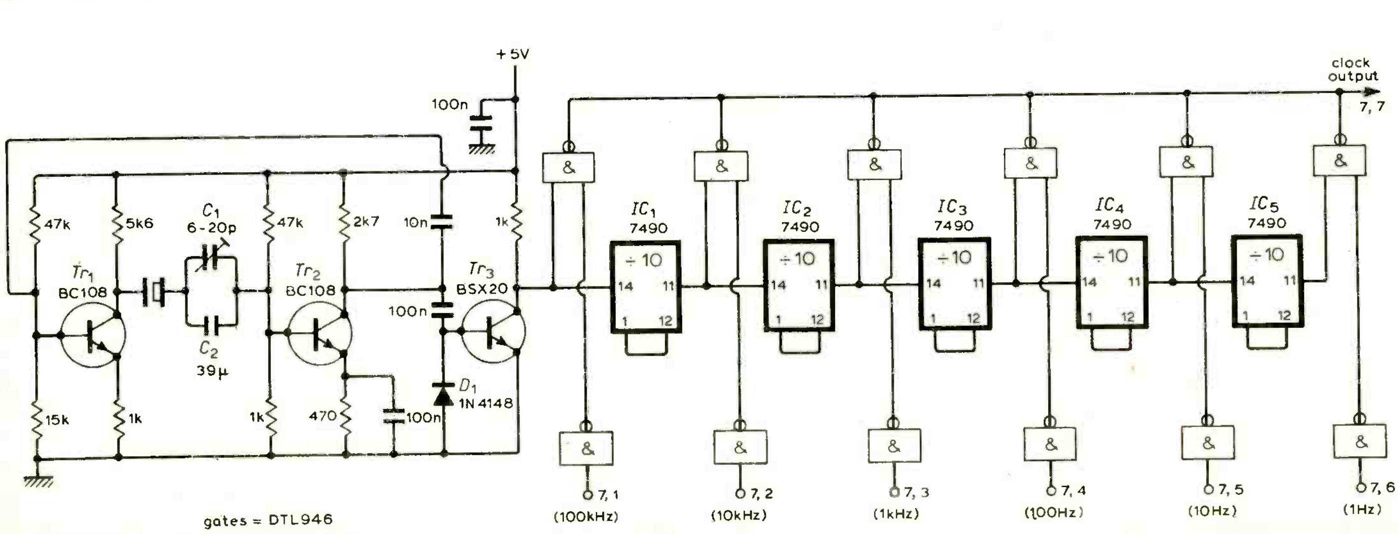


Fig. 7. Master clock and divider chain.

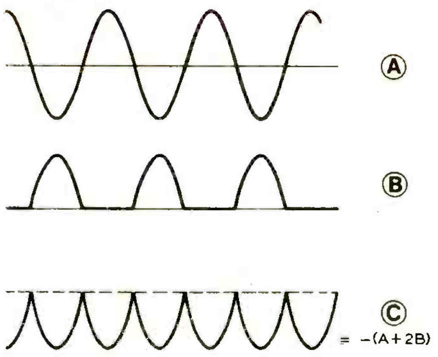


Fig. 8(a). Rectifier waveforms.

The input attenuation is divided into two sections; a 10:1 switch of amplifier gain by negative feedback, and a 100:1 attenuator at the input to the amplifier. The a.v./d.v. switch at the input (see Fig. 8) has been included to compensate for the fact that average-reading voltmeters are normally calibrated in r.m.s. so that a factor of 1.11:1 has to be allowed for. This also makes it possible to switch an isolating capacitor in series with the input when measuring alternating voltage. In order to achieve a high input resistance, a differential pair of f.e.ts is used to feed an operational amplifier type μA741, the gain being stabilized by negative feedback. In order to reduce lead lengths, I found it convenient to build this section on the back of the voltage range selector switch.

The output from the input amplifier is fed to a circuit which is sometimes called an "absolute value rectifier" because it gives an output which is effectively equal to the modulus of the input signal. In more familiar terms, it is a full-wave rectifier that works down to d.v. The action is as follows:

If a sine wave (A) is applied to the input as in Fig. 8(a), the signal at B will consist of a half-wave rectified waveform (B) having the same peak amplitude as A but inverted in phase. These two signals are added at the input of the amplifier IC_3 in the ratio 2:1 so

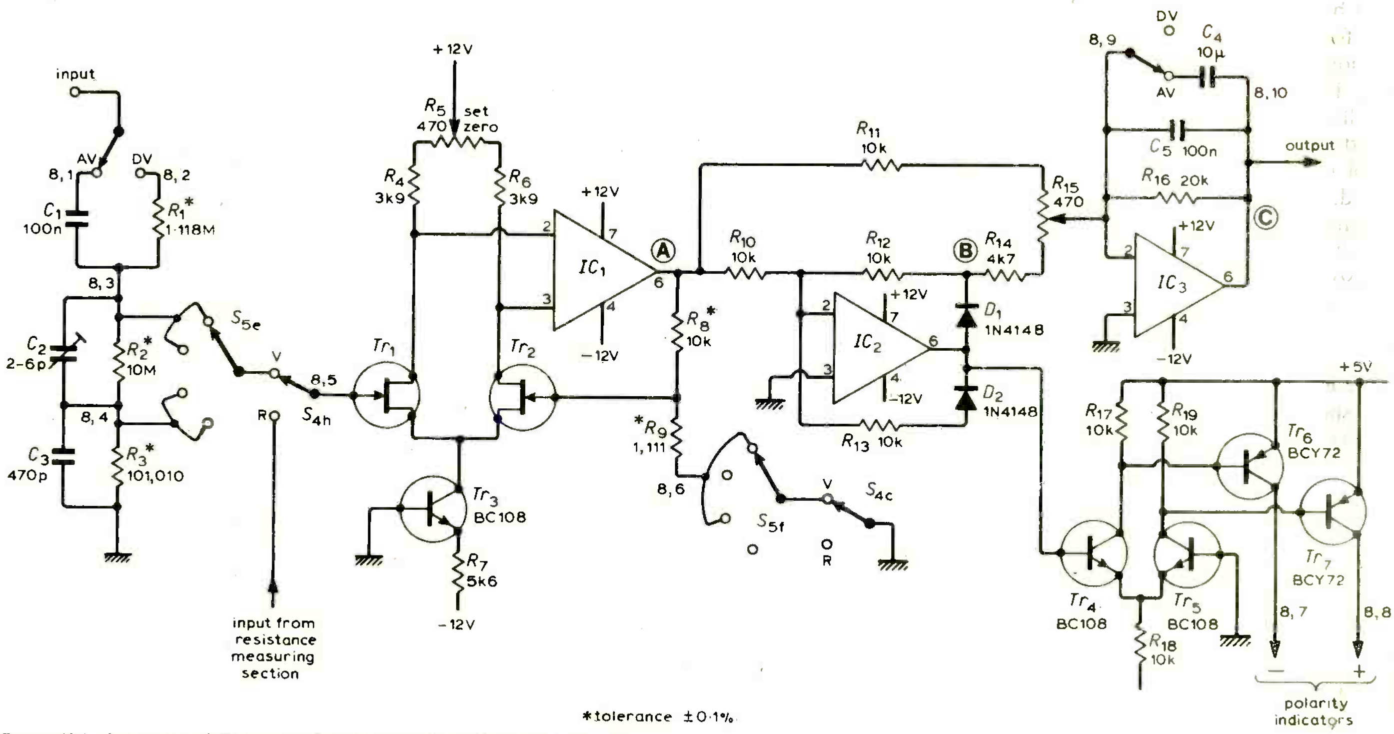


Fig. 8(b). Input amplifier, rectifier and polarity indicator circuit.

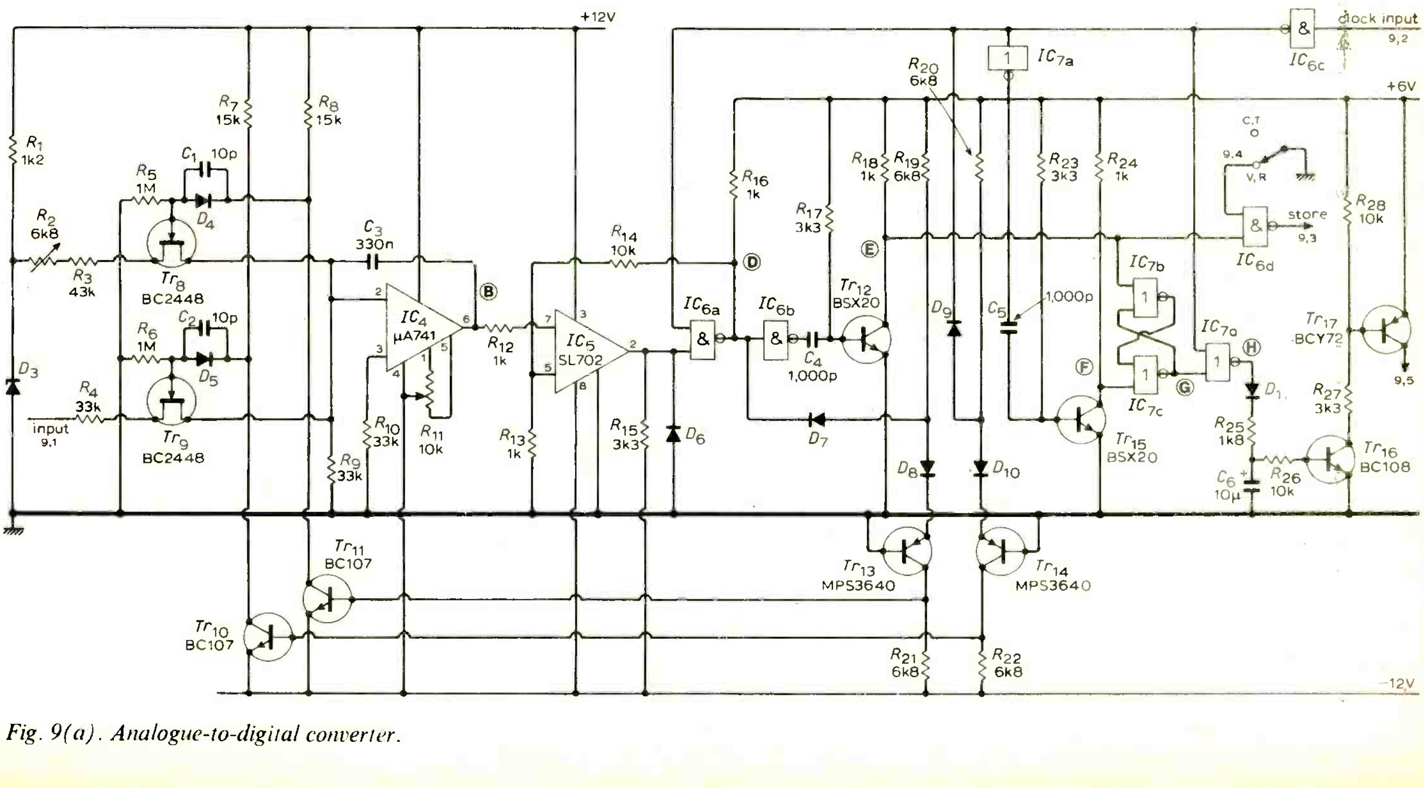


Fig. 9(a). Analogue-to-digital converter.

that the output (C) is a full-wave rectified version of the input. Thus the output at C will be negative regardless of the input polarity. The 470Ω variable resistor R_{15} is used to ensure that A and B are added in the correct proportions. A Signetics type N5556V integrated circuit is used for IC_2 as it has a better slew rate than the μA741C and thus gives a better frequency response. The output from pin 6 of IC_2 is used to drive a comparator Tr_4/Tr_5 which switches the polarity indicators. With a direct voltage input, only one polarity indicator will light at a time but with a.v. both will light giving an indication that the input is alternating.

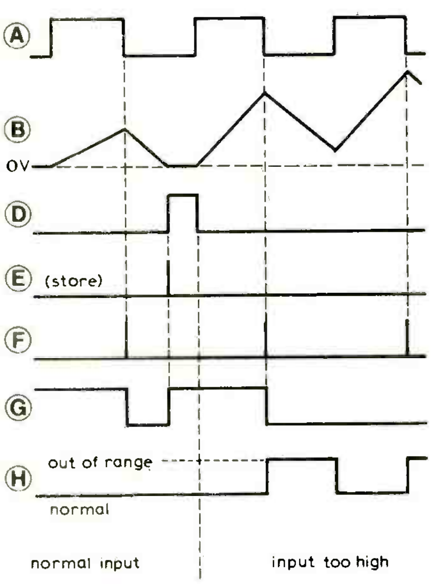


Fig. 9(b). Operation of the "out of range" indicator.

A capacitor is connected between the input and output of IC_3 so as to give a low pass filter effect. When the instrument is switched to a.v. the value of this capacitor is increased to 10μF to provide smoothing. Of necessity, this increases the time necessary for the reading to settle.

The analogue-to-digital converter section is shown in Fig. 9(a), where the three-position switch shown in Fig. 4 (Part 1) is replaced by two f.e.t. switches Tr_8 and Tr_9, the third position of the switch being provided by the 33kΩ earth return resistor, R_9, when both f.e.ts are turned off. The reference voltage is provided by a low-temperature coefficient zener diode, D_3. The absolute voltage of this zener is unimportant as its effective value can be set by adjusting the 6.8kΩ variable resistor R_2. In order to prevent oscillations occurring at the instant when the output from the integrator IC_4 reaches zero, the comparator IC_5 has been made to act as a Schmitt trigger by positive feedback from the gate IC_{6a}. The timing input to this gate had to be included to enable the zero of the instrument to be set and overrides the backlash which is essential to the operation of the Schmitt trigger, so ensuring that the comparator works as a zero-crossing detector. The "store" command is derived by differentiating the output of IC_{6b} and amplifying it using Tr_{12}.

The gates of IC_7 are used to give the out-of-range indication as follows:

The RS flip-flop in Fig. 9(a) is set by pulse F in Fig. 9(b) which is generated by differentiating the falling edge of the clock input. It is then reset by the "store" pulse E so that IC_{7d} is again disabled and when the clock goes positive once more there is no output at H. However, if E does not arrive in time (i.e. the input voltage is too high), both inputs to IC_{7d} go low so that its output, H, goes high. This turns on Tr_{16} and thus causes the overload lamp to light. The capacitor C_1 acts as a pulse stretcher so as to keep the lamp alight even though the output at H does not remain high continuously during the overload period but switches on and off at the clock rate. "NOR" gates have been used in this section to reduce the package count. Had "NAND" gates been used, it would have been necessary to put inverters in series with the inputs to the RS flip-flop.

Resistance/capacitance

The resistance measuring circuit, shown in Fig. 10, uses the main voltmeter circuit with the input attenuator disconnected and the gain of the input amplifier set to ×1, together with a constant-current source which can be switched to give four different values of current, 1μA (1MΩ), 10μA (100kΩ), 100μA (10kΩ) and 1mA (1kΩ). The simplest possible circuit was used here: a transistor with its base tied to a reference voltage and switched resistors in series with its emitter. The reference voltage is provided by a 4.7V zener diode, chosen because its temperature coefficient tracks that of the base/emitter voltage of a transistor fairly closely. The transistor chosen is a BC252, a p-n-p transistor with a very high beta even at low values of collector current. For resistance measurement, the input of the f.e.t. voltmeter and amplifier is connected directly to the collector of the current source transistor. The resistance to be measured is then connected between this junction and earth, and the voltmeter reads the voltage drop across the resistor. The voltage range and the

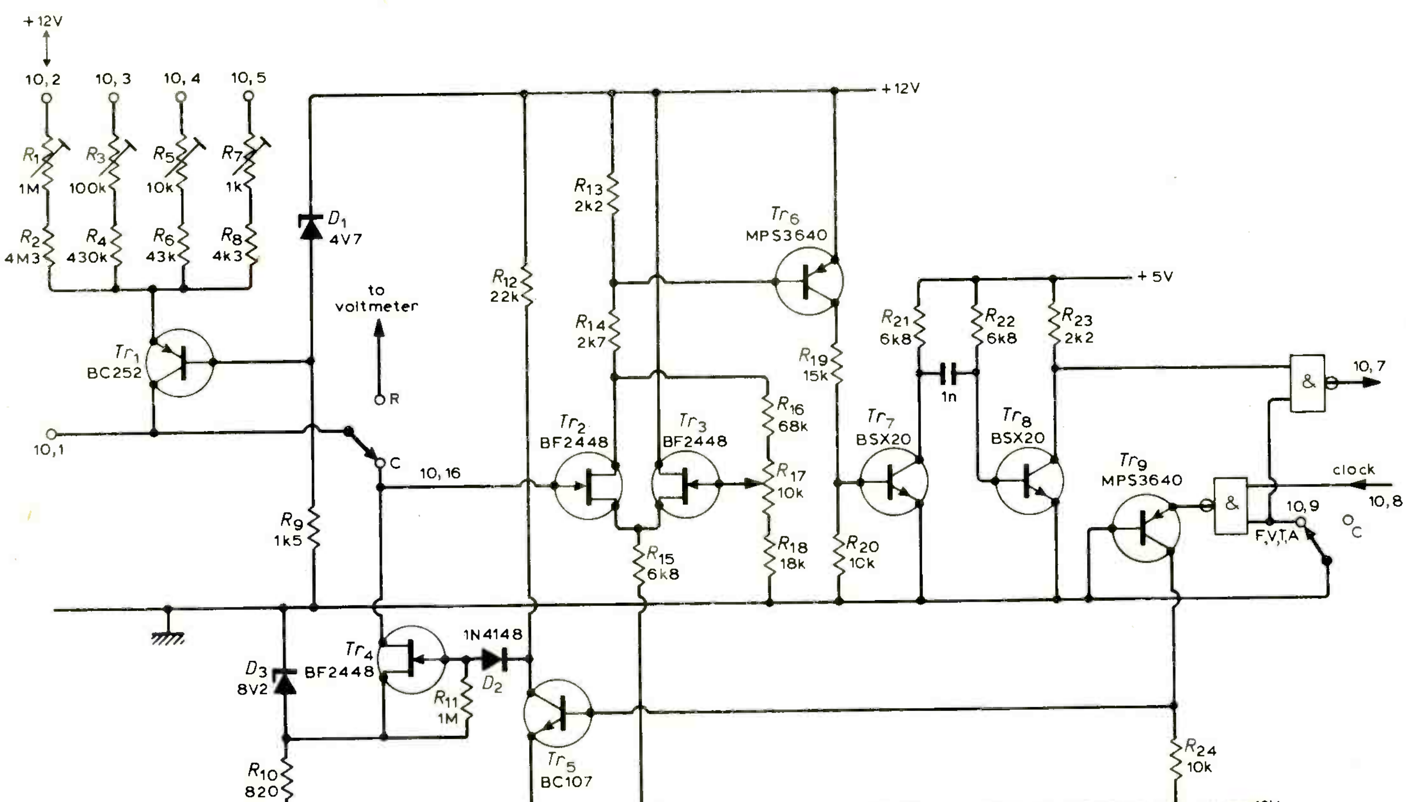


Fig. 10. Capacitance/resistance measuring circuit.

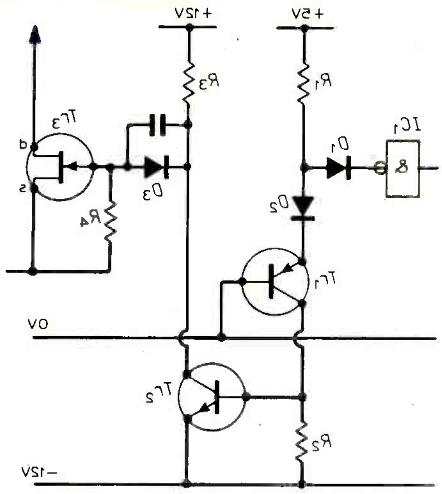


Fig. 11. Method of driving f.e.t. switches from 5V lines.

current through the resistor have been chosen so that the instrument reads resistance directly. As the input resistance of the f.e.t. amplifier is greater than 100 megohms, it does not affect the accuracy to any great extent.

Capacitance meter. This uses the same current source as the resistance measuring circuit. With a 1μA charging current, the voltage drop across a 2000pF capacitor will reach 10V in 20ms. As the time required for the counter to reach full scale is 20ms, the comparator is arranged so that it detects when the voltage across the capacitor reaches 10 volts. With only plus and minus 12-volt lines this 10 volt requirement could have been awkward. However, by making the initial charge on the capacitor -8.2V, a voltage developed across the zener diode D_2, the positive excursion of the voltage across the capacitor need only be 1.8 volts. This is suitable to feed to the input of Tr_2 which is cross coupled with Tr_3 to form a Schmitt trigger circuit. F.e.ts are used here as their high input impedance does not load the capacitor. The back-lash in the trigger circuit does not affect the accuracy of the measurement as the comparator only detects the transition as the voltage across the capacitor goes positive. The discharge of the capacitor is effected by switching Tr_4 on. The output from the trigger circuit is amplified by Tr_6 before it is differentiated and limited by Tr_7. The gates are used to switch the clock input and the output of this section on or off as required.

F.e.t. switches. In both the voltmeter and capacitance meter, use is made of f.e.t. switches. In order that these switches should work adequately, two conditions must be satisfied: when the switch is "on" the input signal must never reach sufficient amplitude to start to turn the switch off and conversely, when the switch is off the signal amplitude must not be sufficient to turn it on! Therefore, to ensure that the switch operates correctly, the input signal to the switch should be as small as practical and the switching signal to the gate of the f.e.t. should be as large as possible, in this case 24 volts peak-to-peak. In the voltmeter section the signal swing is minimized by placing the f.e.ts at the "virtual earth" point of the integrator. In the capacitance meter, the f.e.t. is connected so that the voltage developed across it cannot affect the switching. In both cases, the switching control voltage at the gate is made to switch between the positive and negative rails. In order to do this it is necessary to translate the voltage from the logic circuits (0 and +5V) to a suitable level. This is done as shown in Fig. 11. When the output from the gate IC_1 is low, D_1 is turned on so that the base/emitter junction of Tr_1 is reverse-biased and Tr_1 is turned off, turning Tr_2 off so that its collector "goes" to the positive rail. This turns the f.e.t. Tr_3 on. When the output from IC_1 goes high, D_1 is reverse-biased and a current determined by the value of R_1 flows into the emitter of Tr_1, turning it on. This in turn bottoms Tr_2 so that its collector voltage goes to the negative rail, turning the f.e.t. Tr_3 off. The diode D_3 is included in the circuit so that, when the f.e.t. is in the "on" condition no gate current which could introduce errors can be drawn. If this circuit is used with d.t.l. gates, provided that no other inputs are to be driven, R_1, D_1 and D_2 can be omitted.

The circuits which have been described above comprise the electronics necessary to make a digital multimeter. However, in order to make the instrument work as a whole it is necessary to interconnect them together with appropriate switching. How this can be done is described in the next section of this article.

REFERENCE

1. D. E. O'N. Waddington and M. R. Ainley, "Low-voltage Stabilizer Using Semiconductors," *Wireless World*, Vol. 67, No. 9, 1961, pp. 479-482.

Circards — future series

As announced last month the trial period of Circards — the *Wireless World* information service on circuit design — has confirmed our hopes and the scheme is to be continued and extended.

We list below the subjects it is planned to cover in the next 10 sets of cards — although not necessarily in the order listed. The first (No. 6) will be available at the time the May issue is published. The U.K. price per set is £1 and the overseas price £1.15 (airmail postage extra).

Many readers have asked if they may order sets of future Circards to be sent as published. We have therefore introduced a subscription rate for the next ten sets (Nos 6-15) which it is hoped to issue monthly. The subscription for the U.K. will be £9 and for overseas £10.50. Orders for individual sets or subscriptions should be addressed to J. Rider, IPC Business Press, Sundry Sales, 33-40 Bowling Green Lane, London E.C.1.

Power Amplifiers: Power amplifiers, d.c., audio switching and r.f.
Constant Current Circuits: Regulating currents at high and low powers for load and bias purposes.
Opto-electronics: Generation, detection and processing of optical signals.
Basic Logic Gate Circuits: Practical gate circuits using m.o.s., t.t.l. and other logic families.
Astables: Generation of repetitive waveforms from low to high frequencies using i.c. and discrete circuits.
Micropower circuits: Operation of amplifiers, oscillators and measurement circuits at very low voltages and currents.
Wideband Amplifiers: Amplifiers of varying power levels over wide frequency bands.
Alarm circuits: Detection of fault conditions and control of alarm devices.
Pulse Modulators: Modulation of pulse waveforms for communication and instrumentation systems.
Digital Counters: Binary counters using a variety of logic families.

New readers may also like to know the subjects already covered in Circards:

1. Basic Active Filters; 2. Switching circuits: Comparators and Schmitts; 3. Waveform Generators; 4. A.C. Measurements; and 5. Audio circuits: preamplifiers, mixers, filters and tone controls. These are still available from the above address at the same individual price quoted above (they are not available at the reduced subscription rate).

More about Sonex '73

Some interesting audio equipment to look out for at the show

In addition to the list of brand names and details of the situation and times of opening of this year's Sonex audio show which were published last month, the following is a selection of further "exhibition briefs" covering some of the more interesting equipment at the show. Sonex '73 will be held in the Excelsior Hotel, West Drayton (near London Airport), from 30th March to 1st April inclusive.

Exhibition briefs

The latest combined turntable and arm from Philips will be introduced at Sonex. The two-speed deck uses a low-speed synchronous motor and belt drive with a free floating sub-chassis for turntable and arm and will be sold with Philips GP400 cartridge. Two features not previously seen on Philips decks are automatic arm return and a stylus force meter which gives a direct reading during playing.

The HTA200 tuner-amplifier is a HiSound product marketed by the Electronic Manufacturing Company and will be on show for the first time. Output from the amplifier is 50W r.m.s. Also available will be the HTA200C tuner-amplifier which incorporates a BSR810 deck.

Two new cassette recorders from BASF are the 9301 four-waveband radio cassette recorder (£75) and the 9201 (£55) both incorporating facilities for automatic switching to bias for chromium dioxide tape. This switching is a function provided by special cassettes which activate the switching device, an idea first thought of and patented by Philips. These CrO_2 cassettes will be on show with the BASF range of ferric oxide tape cassettes.

Alpha, Luxor, Pickering and Harman-Kardon are all brand names marketed by Highgate Acoustics and a selection of their equipment will be demonstrated. From Alpha, the 0007 tuner will be available as well as the CD1000 stereo cassette deck which has a claimed signal to noise ratio of >35dB. and wow and flutter <0.3%. Luxor have an additional combined deck and tuner amplifier, the 3821 together with the 6821 speakers. Pickering will display a new cartridge of the XV15 series, number 1200E. The full range of Harman-Kardon tuner-amplifiers will be displayed plus the new HK1000 cassette deck and a new tuner Citation 15.

The BCIII is a new loudspeaker from Spendor with a 12in base and 8in mid-range driver which have cones developed by Spendor. These combine with two h.f. units which are the Celestion types HF1300 and HF200. The base and mid-range drivers have vacuum formed Bextrene cones and short coil sections to increase efficiency and the power-handling capacity. Nominal impedance is 8Ω.

The Rogers demonstration of equipment will include the recently introduced Ravensbourne speaker which has a peak power handling capacity of 35W.

ADC are introducing three cartridges at Sonex the XLM, VLM and Q series. All incorporate the induced magnet principle with an electrical system of damping. Total weight of each cartridge has been reduced to just over 5g.

KEF are showing a monitor loudspeaker which uses three drive units and has an integral two-channel power amplifier incorporating an active filter dividing network. The speaker also has an electronic overload protection circuit to prevent thermal damage to the speaker drive units.

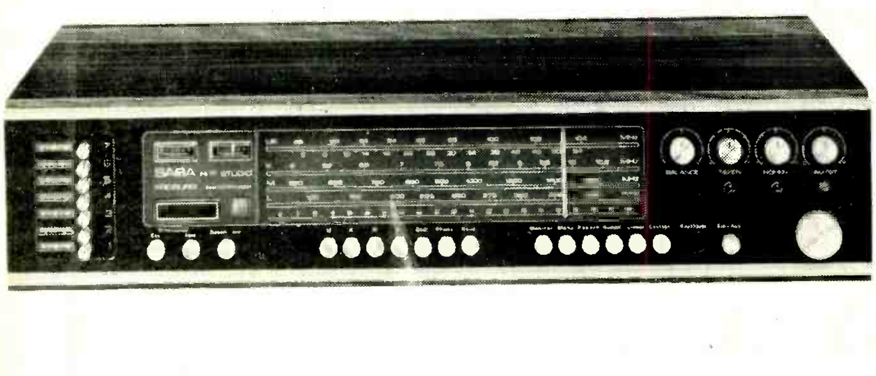
Acoustico Enterprises, distributor of the Japanese Teac equipment, will show four new items at the show — the A450 "Challenger" cassette deck (£200), the AN300 four-channel Dolby noise reduction unit (£180), the AX300 four-channel audio mixer (with six microphone and four line inputs (£200), and finally the TS130 automatic turntable (£60).

Supplementing the demonstrations and display of audio equipment, there will be a programme of lectures which will include the following:

30th March
12.00 — "Loudspeakers" by J. Wright (IMF)
15.00 — "Listening room acoustics" by K. Shearer

31st March
12.00 — "Meet the magazines" A panel of editors of journals in the audio field will be formed for discussion and questions
15.30 — "Quadraphonics", a talk and demonstration by Wensley Ruggles (Connaught Equipment) and a representative from EMI
19.00 — "Meet the magazines", panel discussing quadraphony

1st April
12.00—"Pickups and turntables" by B. J. Webb
15.30 — "Meet the magazines"



Saba Television make their first appearance at Sonex this year and will show the above Freiburg a.m./f.m. tuner, the Telecommander, which has facilities for ultrasonic remote control. Using the romote control, the listener has control over on/off switching, seven pre-set f.m. stations, volume and tone.

Optimizing Op-amps

by R. J. Isaacs, F.I.T.E., M.Inst.M.C.*

Manufacturers of op-amps often fail to specify properly input offsets' temperature coefficients and common mode rejection ratios. Fuller information is needed if optimum circuit performance is to be obtained. What can be achieved is illustrated by a design which uses a low-cost op-amp under adverse circuit conditions but gives good temperature stability over a wide range of environmental temperature.

Over the past decade or so monolithic op-amps have become a very abundant "component" in electronic equipment. During this period certain types have come down to a very low price, while more parameters are becoming recognized and defined in manufacturers' data sheets and application manuals. As is common with semiconductor devices, good performance in respect of one parameter can result in not so good a showing in another, so that selection of a device may be largely a matter of compromise by system designers.

Two parameters which are usually very vaguely specified are the temperature coefficients of input offset voltage and current. Both of these are necessary to assess the potential stability of a given device, yet some manufacturers give only typical values, some only maximum values, and others none at all! This applies particularly to the 741, a very commonly used device, which is frequently described by data sheets as "high-performance" despite its very low slew-rate and despite the almost invariably missing temperature coefficients.

One serious omission which often occurs is lack of information on the dependence of the temperature coefficients upon the magnitude of the offsets to which they refer. In general, the greater the offset the higher is its temperature coefficient. Several manufacturers do in fact state that reduction to zero of the initial offset voltage brings about a large improvement in the temperature coefficient of the initial offset. What is rarely stated, and what has been found by the author, is that if the voltage drop across the input resistors due to the input bias currents is equalized by adjustment of one of the resistors, the temperature coefficient of input offset current is greatly reduced.

Some of the extent to which temperature coefficients are influenced by the factors described could be given on the data sheets. Instead of stating vaguely that the temperature coefficients are V microvolts/deg.C and I nA/deg.C, the data sheets should give figures of the form V microvolts/deg.C/mV offset and I nA/deg.C/nA offset. These might suggest a linear relationship in each case when the relationship is not linear, but at least they would give some idea of the amount of adjustment required to improve the performance of an op-amp.

Thus it is apparent that the performance is to some extent under the control of the designer, and indeed there are occasions when the magnitude of a parameter must be controlled. For example, the common mode rejection ratio is always specified as though, come what may, it just happens. This, however, is not so. Fig. 1 shows the basic circuit of an op-amp in the inverting configuration. Because, as far as determination of gain is concerned, the input differential pair behaves like two separate amplifiers, inequality of gain on the two sides brought about by any cause gives rise to an output from the amplifier when a common-mode voltage is applied at the differential inputs. To obtain the required gain equality, and hence an optimum common-mode rejection, the gains must be equal, i.e. $R_{f1}/R_{s1} = R_{f2}/R_{s2}$.

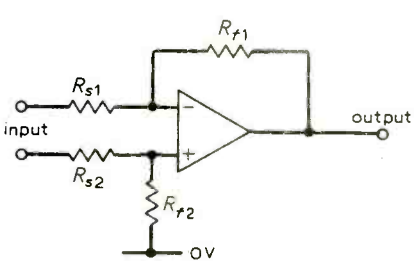


Fig. 1. Op-amp inverting configuration.

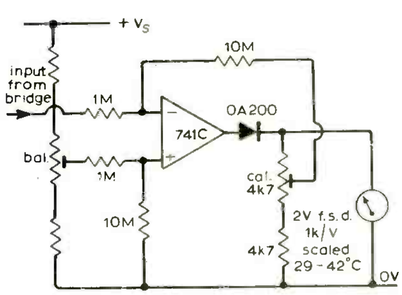


Fig. 2. Temperature scaling circuit using an op-amp.

These questions are not raised in any of the text-books the author has seen, and are of great importance when for economic reasons a low-cost amplifier has to operate with high values of input resistance. An example is shown in Fig. 2. A device we have developed incorporates a meter which indicates temperature over the range 29 to 42°C. An inverting configuration of op-amp circuit is used to enable the non-inverting input to be utilized for suppressing the meter zero. The inverting input has to be operated from one side of a balanced thermistor bridge, so the input resistors, and hence the feedback resistors, have to be high, so that no unbalance occurs in the bridge. For the meter to show temperature correctly, the "cal" control is set for a gain of approximately 17.2.

Normally, these circuit conditions may be obtained by using a low bias current operational amplifier, such as a 741L, with a unit price of £5. In this particular case the manufacturer of the instrument had for various reasons to make his component costs as low as possible, so he used a version of the 741 marketed by R. S. Components Ltd as the 741-OPA, at a price of 60p each.

On request, R. S. Components gave temperature coefficients as follows, both figures being typical:

Offset voltage t.c. 5μV/deg.C/mV offset.

Offset current t.c. 50pA/deg.C/nA offset

We also have the usually-published offsets (typical):

Voltage	1mV
Current	20nA

Hence, for a typical amplifier:

$$\text{t.c. of offset voltage} = 5 \times 1 = 5\mu\text{V/deg.C}$$

$$\text{t.c. of offset current} = 0.05 \times 20 = 1\text{nA/deg.C}$$

With 1MΩ input resistors, the latter figure causes an additional offset voltage temperature coefficient as:

$$1 \times 0.001\text{V/deg.C} = 1\text{mV/deg.C}$$

* Medical Research Council's Clinical Research Centre, Bioengineering Division.

The initial offset voltage coefficient of 5 microvolts/deg.C is negligible compared with the additional 1mV/deg.C so can be neglected.

Over the required ambient temperature range of 0 to 40°C the offset change is $1 \times 40 = 40\text{mV} = 0.04\text{V}$. This gives an output voltage change of $0.04 \times 17.2 = 0.688\text{V}$, or more than half the f.s.d. of the meter, which is clearly unacceptable. In these calculations typical figures have been used. No designer would normally use these figures in practice, but it has been shown here that even if the typical parameters were used then over the ambient temperature range specified the 741 would be very unusable. If a designer were using the maximum parameter values:

Offset voltage t.c.	12μV/deg.C/mV offset
Offset current t.c.	2.5nA/deg.C/nA offset
Offset voltage	7.5mV
Offset current	300nA

then an ambient temperature change of 40°C would produce an output voltage change of 13V, or over six times the f.s.d. of the meter! In other words, for the purpose described, a "typical" 741 would be useless and a "worst case" one meaningless, unless steps were taken to improve the temperature stability. The method of doing this is now described.

Fig. 3 shows the circuit connected for offset voltage nulling. Manufacturers recommend a low t.c. trimming potentiometer across pins 1 and 5, with its slider connected to the $-V_s$ rail. For economy reasons it was decided to use a single resistor. Pins 1 and 5 in turn were shorted to the $-V_s$ rail, and a resistance box connected between the $-V_s$ rail and the pin which gave a voltage swing in the right direction on the d.v.m. when shorted to $-V_s$. The resistance box was adjusted for zero output, and a low t.c. bridge-selected resistor connected in its place. If an output still appeared, then provided it was only a fraction of V_s:

1. It has already been shown that, even in the worst case, input offset voltage nulling in the circuit under consideration is not critical.
2. If the output voltage rests between the rails, the effect of the temperature coefficient is minimal.

Fig. 4 gives the connections for nulling the part of the offset voltage due to offset current. Pins 2 and 3 are disconnected and the resistance box dR_s connected on the side giving an output swing in the right direction. The dR_s is then carefully adjusted for as near zero output as possible. It was found that as dR_s was adjusted only a slow change of output occurred. The slower the change, the nearer to zero the output settled. Resistance box dR_s was therefore adjusted to give a very slow output change. The reason for the slow change was not investigated, but it might be safe to presume that it was due to a thermal effect on the V_{be} of each of the transistors in the differential input pair of the 741. Fig. 5 shows how the common mode rejection was optimized. In order to maintain $R_{f1}/R_{s1} = R_{f2}/R_{s2}$, a resistor is connected in series with the R_f which corresponds to the R_s which has been increased. The value of this resistor is the E24 value which brings the output closest to zero.

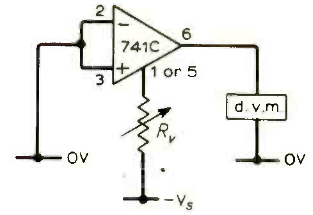


Fig. 3. Connections for nulling input offset voltage.

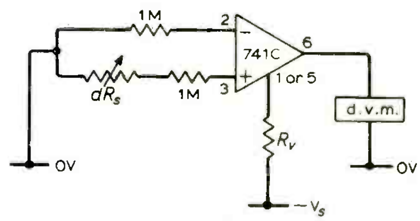


Fig. 4. Nulling additional input offset voltage due to input offset current.

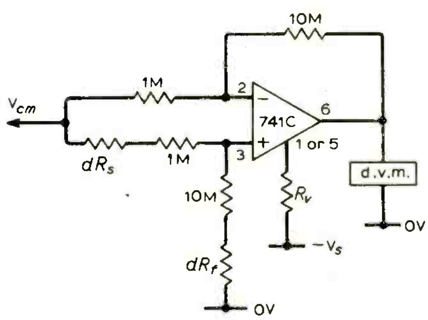


Fig. 5. Optimization of common mode rejection.

In the circuit under investigation the common mode change is very small, and is manifested by a proportional addition to the signal voltage. As this does not affect the linearity of the system, the effect can be adjusted out by means of the "cal" control. Unfortunately, unless the common-mode rejection ratio is made as high as possible, interaction takes place between the "cal" and "bal" controls, necessitating iteration of the adjustment of the two potentiometers. The procedure described brings the amount of iteration to a minimum.

A circuit which had been adjusted as described was placed in an environmental chamber and cycled, alternately 1 hour at 0°C and 1 hour at 40°C. Over this ambient temperature range the reading of the meter, over its entire range, shifted by only 50mV. This was an improvement of a factor of 13.8 over the "typical" uncorrected amplifier, and of 260 over the "worst case" one. Not bad for a low-performance "high-performance amplifier"! For a 2V f.s.d. meter calibrated 29 to 42°C, 50mV represents 0.3 deg.C. Hence, taking 20 deg.C as the median temperature, the corrected instrument circuit responds to changes in ambient temperature to the extent of ±0.15 deg. over an ambient temperature change of ±20 deg.C.

At normal ambient temperature a common-mode input of 400mV gave an output of 4mV.

Common mode rejection ratio

$$= \frac{\text{common mode input}}{\text{output}} \times \text{gain}$$

$$= \frac{400}{4} \times 17.2 = 1720, \text{ or } 65\text{dB},$$

comparing with the minimum figure given, under ideal conditions, of 70dB. As resistor values drift with time the figure obtained would deteriorate, but even if it were reduced by the unlikely amount of, say, 10dB, there would be little effect on the performance.

The manufacturer of the device incorporating the circuit investigated adapted the stabilizing procedure described to suit his own production line and reported that it was economically justified, the "total cost" of an amplifier after stabilization being well below the selling price of a high-grade amplifier.

No doubt other aspects of the performance of low-cost amplifiers could be improved by low-cost methods if required. There is, however, obviously a limit which had not been reached in the case described, where improvement would not be possible, and a more expensive device would have to be used. One example would be if a very high closed-loop gain and also a very high stability were required. All the same, it must surely be agreed that manufacturers have not released all their secrets for general use, making amplifier circuits frequently more expensive than they need be.

In writing this article the author makes acknowledgements to Mr G. Cross, also of the CRC Bioengineering Division, for his expertise on amplifier design, to Mr H. S. Wolff, Head of the Division, for facilities in conducting the investigation and to Mr J. C. P. Dalton, and also to R.S. Components Ltd for information and technical data. All of these have assisted in showing that it is sometimes possible to make a silk purse out of a sow's ear!

Correction

We regret an error in the circuit diagram (Fig.1) of the **"Solid State Teleprinter Demodulator"** published in our February issue. The junction of Tr_1 emitter, D_{10} anode, C_{65} and the "SPACE" indicator should be connected to an earth point otherwise the external "Printer magnet loop" will not operate.

Radio Propagation Disturbances 1972

*by R. A. Ham**

This article presents the author's observational records of disturbances to radio propagation for 1972. It is hoped that the information will complement the records of radio engineers who are concerned with the propagation of radio signals and help to explain to others some of the strange atmospheric conditions which were experienced during the year.

Like other years, 1972 had its share of solar, and atmospheric disturbances, and many readers may like to compare their observations with the diary of natural events were recorded by the author at his radio observatory in Sussex.

Radio blackouts on the h.f. bands, continental broadcast stations interfering with United Kingdom television pictures and f.m. radio, mobile and business radio receivers detecting broadcast stations, are all typical effects of atmospheric disturbances.

Every day, metre wave solar activity is recorded at the author's observatory, and is later correlated with the prevailing conditions on the v.h.f. bands. The aerial systems used for solar observations are illustrated in Fig. 1.

*Storrington, Sussex.

Solar

The Sun, like many other stars in the galaxy, is a nuclear furnace continuously radiating across the electromagnetic spectrum. Periodically, violent eruptions occur on the Sun and large quantities of nuclear waste are ejected into interplanetary space. Radio waves from these solar eruptions can be detected on the Earth 8.3 minutes after they occur on the Sun, but streams of complex particles which also leave the Sun during an outburst may take up to 40 hours to cross the 93 million-mile path between the Sun and the Earth.

During the past $4\frac{1}{2}$ years of daily solar observation at metre wavelengths, two regular features have emerged. First, the individual burst which may last for several minutes, and secondly, the prolonged solar storm which can last for several days. Examples of these two solar events are shown in Fig. 2.

Considering the Earth as a moving target, it is unlikely that many particles from an individual solar burst would arrive in time to coincide with the Earth's orbit. Therefore, only the high density of particles which are ejected during a prolonged solar storm are expected to strike the Earth. The solar particles which reach the Earth's orbital path, may enter and upset the natural state of the gaseous atmosphere surrounding the Earth.

Solar particles can have a twofold effect upon the Earth's atmosphere. First, they can cause an Aurora to manifest which in turn has a strange effect on terrestrial v.h.f. radio signals and secondly, the particles can disturb the Appleton (*F*) region of the ionosphere and consequently disrupt the long-distance radio signals which are transmitted on the h.f. bands.

A typical example of a "radio blackout" occurred on November 1, following a prolonged solar storm (Fig. 3.). The effect of this blackout was observed on the ten-metre band during a period when this band had been very active (communications wise) for several days. The occurrence of prolonged solar storms during 1972 is indicated by the dark regions on the chart in Fig. 3 which has been compiled from the author's daily solar observations.

A spectacular Aurora Borealis manifested on August 5 at approximately 0030 following a prolonged solar storm

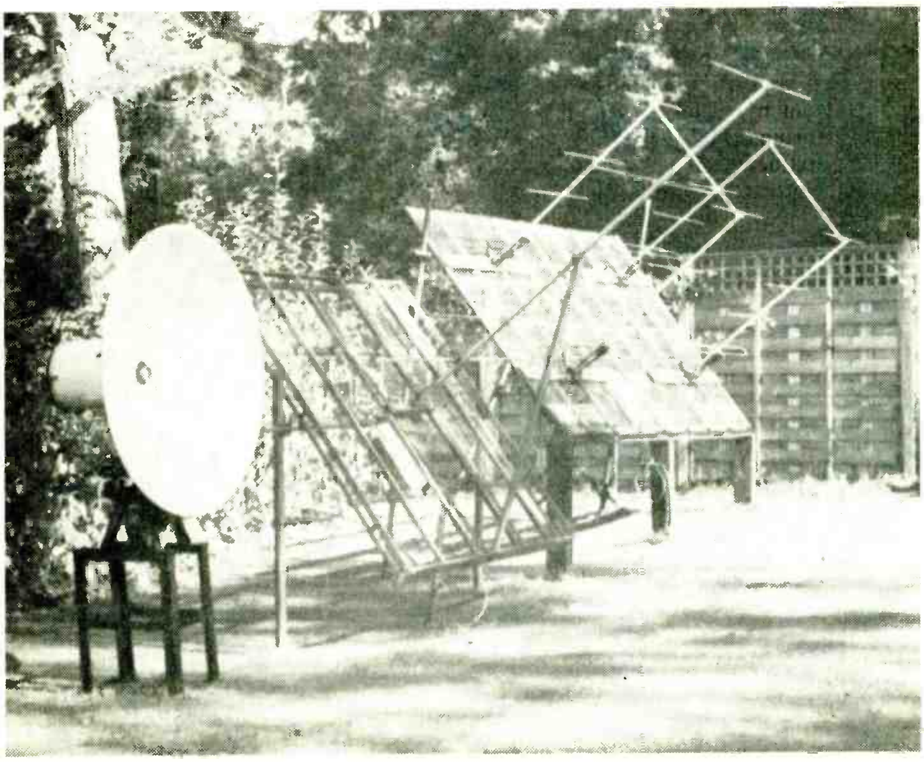


Fig. 1. The radio telescope aerials, which operate at 95 and 136MHz. The four-foot parabola is for future solar observation at microwaves.

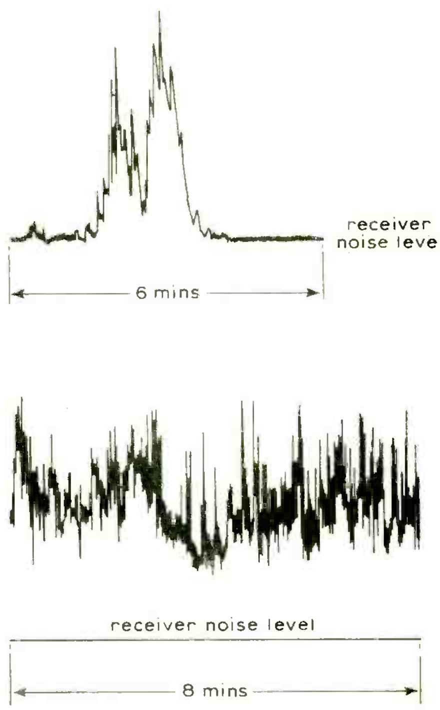


Fig. 2. (a) An individual solar burst. Observation time 6 mins on 136MHz (May 9, 1972). (b) A prolonged solar storm. Observation time 8 mins on 136MHz (September 11, 1972).

(*A* in Fig. 3). This particular auroral event gave a colourful display in the clear night sky and was visible in the south of England for about two hours. Later the same day, around 1500, another aurora manifested, but owing to the daylight this event could not be seen. However, it was detected by many radio amateurs who achieved long-distance v.h.f. contacts via auroral reflection.

Sporadic E

Frequently, during the summer months, the Heavyside (*E*) region of the ionosphere re-forms into smaller and more densely ionized areas which can deflect v.h.f. radio signals hundreds of miles beyond their intended range. Routine observations have shown that the radio frequencies which are influenced by sporadic *E* lie between 30 and 90MHz and that around 50MHz is the most vulnerable.

From Spring to Autumn, regular monitoring of 49.75MHz, watching for the sync pulses from a Russian television transmitter, provides the first warning that sporadic *E* is present. Consistent observation over several years has shown that the influence of sporadic *E* will develop around 50MHz. and gradually spread its effect above or below this frequency until it reaches its climax and then ends abruptly. On some occasions the whole frequency range (30 to 90MHz) is affected. The blocked squares on the chart in Fig. 4 indicate the days when the author observed the influence of sporadic *E* within this frequency range.

The precise cause of sporadic *E* has not yet been isolated, although many possibilities have been suggested. At present, the author holds the view that some form of solar activity is responsible for sporadic *E*. Although observations to date offer no concrete proof to link sporadic *E* with the solar activity recorded at metre wavelengths, it is hoped that future observations of the Sun at microwaves may produce some correlation.

Troposphere

Generally, tropospheric openings will extend the normal range of v.h.f. radio signals (transmitted above 100MHz) by a few hundred miles. Such events cause considerable annoyance to the viewing public, and to the mobile radio users. Early warning of a tropospheric opening can be obtained by watching the barometer for a slow decrease following a period of steady high pressure, or monitoring the signal of a distant television transmitter or radio beacon.

The daily progress of an opening can be plotted by observing the signal strength from the R.S.G.B. v.h.f. beacons which have been strategically placed throughout the United Kingdom. The author's records of tropospheric openings (Fig. 5) have been compiled from regular observations of the R.S.G.B. beacons and the monitoring of the television picture from the I.B.A. transmitter (Ch.8) which is situated in the midlands.

Fig. 3. Daily record of solar activity at 136MHz between 1230 and 1430h. Hatched squares indicate individual bursts while dark squares show prolonged solar storm. Dots indicate the days where power failure prevented observation.

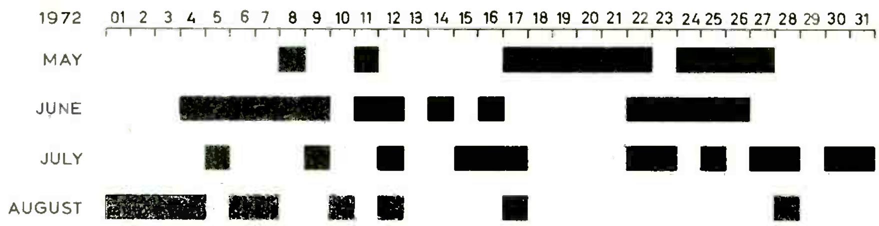


Fig. 4. Days when sporadic E *was present somewhere between 30 and 90MHz.*

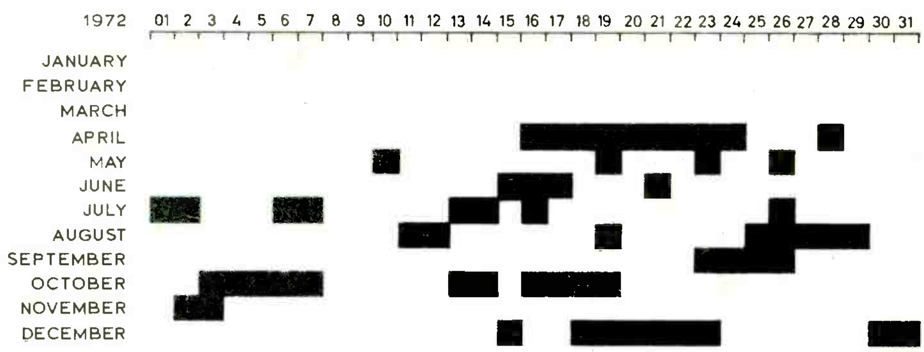


Fig. 5. Observations of tropospheric propagation during 1972 from the author's location.

Meteors

Meteor particles which collide with, and burn up in, the Earth's atmosphere, leave behind them a rapidly decaying trail of ionized gas. Observations have proved that this ionized trail will deflect a minute part of a v.h.f. radio signal over several hundred miles. The author has installed a radio system at his observatory to count the number of times that the signal from the broadcast transmitter at Gdansk, Poland, is detected in the United Kingdom via meteor trail deflection. Fortunately, the radio frequency of the Gdansk station (70.31MHz) is electrically quiet in the U.K. and therefore, it has been possible to undertake a regular daily observation for the past 16 months.

Briefly, the meteor equipment operates for 15 hours each day between 0800 and 2300 tuned to 70.31MHz. In addition to counting meteor "pings", this radio system provides the observatory with a sporadic *E* and an auroral monitor for the four-metre band.

From January 1 until December 31 1972, a total of 1,299,587 "pings" was recorded from the Gdansk transmitter during 5,137 hours of observation. It should have been possible to record for 5,367 hours, but during the year 124 hours were lost because of the power dispute, and 106 hours were given up to atmospheric disturbances, such as sporadic *E* (56 hours) and static (41 hours). Throughout the year, the hourly reading of the meteor counter was seldom missed, so it has been possible to provide a detailed account of the Earth's journey through the meteor showers.

Convention of the Audio Engineering Society

A report of proceedings and the exhibition in Rotterdam

The third annual convention of the European section of the Audio Engineering Society was held from 20th February in Rotterdam. Since this is an American based society the numbering of the convention — the 44th — was arranged to be sequential with the conventions held in America.

The study and practice of audio has for long been regarded by many as peripheral to true engineering: however, it is evident that the A.E.S. is going a long way towards demonstrating that the subject is fast moving from the realms of a "black art" to an objective and scientific discipline which is producing information to make audio a more predictable tool.

The structure of the convention

The objectives of the convention fall rather neatly into three areas. First as a point in time and place where the results of new research can be presented in the form of papers by engineers to an audience of their peers, secondly to provide some exhibition facilities for professional audio equipment and finally, but by no means least important, to act as a focal point for personal contact with those of a similar discipline but, living and working in widely separated locations. Delegates from all the European countries and America and Japan were among those present. About fifty papers were presented covering a vast range of subjects from improvements in optical soundtrack on 8mm cine film to loudspeaker test techniques and recording.

Undoubtedly the most topical papers were the seven that dealt with quadraphony, and more information on these follows later in this report, but perhaps the most exciting were masked by quite ordinary titles that seemed to promise little new information. However, perhaps one of the most powerful comments was made in a non-technical speech by the guest speaker at the A.E.S. awards presentation banquet. Dr.-Ing H. W. Steinhausen elected to talk about the trends in practical electroacoustics and suggested in the early part of his speech that although the engineering research in audio had removed much of the mystery and conjecture, its existence, as in the commercial forms of hi-fi equipment and records, owed much to the essentially artistic function of the information being carried. He went on to say, though, that he hoped the scientific and commercial aspects would not pollute the original artistry or produce equipment and software just for its own sake. To quote from his speech, "Quadraphony, a new subject much talked about in our branch [of science], is unfortunately no exception. I have not been able to personally discover nor find a teacher who will say that quadraphony is stimulated by anything other than a commercial calculation. Until today I cannot help thinking that the cart is being put before the horse; the horse has in fact four legs, but it does not seem to be clear how it is going to move them to advance into a desired or at least defined direction. . . . To awaken the dormant possibilities of quadraphony and to avoid the possibility of a costly disturbance of business one should agree on the following points:

1. What are we to understand by quadraphony? The very existence of four channels, the mutual relationship of which is not even defined yet, does not offer a sufficient criterion or the basis for a world-wide business with sound carriers [selected] at will.
2. Which are the artistic aspects to be considered the objective of the technological or commercial imagination?
3. What are the means by which we may best reach this objective technologically and economically?

The propagation — often carried out incorrectly — of systems with often dubious characteristics instead of clarifying the objectives is similar to the propagation of solutions for an unknown problem and should stop immediately because it is harmful to business."

Awards presented at the banquet were society Fellowships to Peter K. Burkowitz (chairman, European Section of the A.E.S.) "for continuous contribution to the art and quality of sound recording and recording instrumentation", Arthur C. Haddy, of Decca, "for four decades of fruitful service to the phonographic arts", and Edmund W. Mortimer, of Garrard Engineering, "for a career of contribution to the technology of automatic record players".

Papers presented

With over 45 papers being presented, it is difficult to provide a comprehensive summary of the convention and for this reason a selected few papers will be highlighted for either their interesting content or because they represented a significant contribution.

From Session C on "Listening and Perception", two papers which occasioned considerable interest were presented by co-workers Erik Rorbaek Madsen and Villy Hansen. In these they demonstrated that for the test signal used, the long held supposition (dating back to Helmholtz), that the phase (time delay) relationships of fundamental and harmonics in a signal could not be detected by the ear was wrong. They were able to show that for quite low listening levels, phase shifts as small as 5° between fundamental and second harmonic were readily detected and that the ear was clearly most sensitive to this effect in the range 500Hz to 5kHz. In a later private conversation, Erik Madsen pointed out that this coincided with the range of sensitivity to Doppler distortion as studied by Harwood of the B.B.C. It was also pointed out that the relevance of these findings to the design of loudspeakers cross-over networks was significant since cross-over frequencies are often selected in this same band. The implications extend also to the total system however, since both workers showed that a combination of elements with such a non-linear time delay, (amplifier and poor loudspeaker), was worse than if only one of the elements had poor characteristics. This showed the effect was additive.

Additional tests in reverberant rooms also showed an increased sensitivity due probably to a reinforcement of the initial impression gained from the direct sound, from the reverberant field. Finally — again in private conversation — Erik Madsen suggested that it was possible that the severe phase shifting occurring in rear image quadraphonic signals replayed in stereo could cause objectionable forms of coloration and distortion.

Occasioning some of the largest audiences of the convention were the series of papers presented by the various exponents of quadraphony systems. Arguments on methods are readily divided now into two principle camps; the purely matrix systems offered by the SQ, and QS techniques and the so-called discrete system of carrier channel discs with the interesting hybrid the matrix carrier channel disc. It was clearly evident that all systems as presented had evolved considerably in a short space of time as exemplified by both the SQ and QS proponents in the form of B.B. Bauer for CBS and J. Mosely for Sansui who each described new techniques for the enhancement of channel separation. The CBS system, demonstrated in their exhibition, consisted of a "paramatrix" logic decoder — a development from the full logic decoder which "utilizes signals in one branch of the decoder to cancel selectively the transferred signals in other branches as a function of logic decoding demands". A simple illustration of this was offered by Ben Bauer in private conversation when he pointed out that if, for example, a phantom signal was to be located in the front right loudspeaker, extraneous signals in the left front and right rear loudspeakers could be cancelled by a simple resistive addition of the out-of-phase signals. As this is an instantaneous and continuously variable process its effect would be an enhancement of separation without audible side-effects.

The QS vario-matrix adopts completely different techniques however and "scans the phase relationships between left total and right total to detect in which direction the sound is relatively superior — and how superior it is — both in level and timing. . . . It then utilizes the information so obtained to alter its own matrix coefficient from moment to moment, so as to improve the separation without changing the output level itself". A refinement of the vario-matrix is the split-band vario-matrix which splits the frequency band into two, the resultant being then processed through separate vario-matrices for separate control of the matrix coefficient in each band.

In two papers given by W. R. Isom and T. Inoue *et al,* developments in the carrier channel discrete disc were reported and concentrated mainly on the improvements in cutting speed which has now been raised successfully to half speed, making it possible for conventional lathes to be used.

With the problem of the broadcasting of quadraphonic material now imminent, it was not surprising to see two papers entered on the subject. One, which aroused a spirited exchange between the author, Lou Dorren, and Professor Geluk of Radio Nederland, dealt with discrete four-channel transmission utilizing the conventional stereo suppressed subcarrier of 38kHz plus an additional subcarrier of 76kHz. In the Dorren system the main channel carrying the monophonic receiver information consists of

$$LF + LB + RB + RF$$

and occupies the frequency band from 30Hz to 15kHz. For stereo receivers the conventional 38kHz suppressed subcarrier is modulated with

$$(LF + LB) - (RB + RF)$$

To ensure compatibility the phase of this signal is in the sine quadrant. Also in this subchannel is a second information signal

$$(LF - LB - RB + RF)$$

which is modulated on a second 38kHz subcarrier transmitted in quadrature with the first to ensure an effective utilization of the bandwidth.

Finally, a further information channel

$$(LF - LB) + (RB - RF)$$

is modulated onto a 76kHz suppressed double sideband carrier. With such an arrangement there is the problem of the radiated bandwidth of the signal to consider and in this respect Lou Dorren was able to show that it was no greater than for a conventional stereo signal. It was interesting also to note that adjacent channel interference was no worse than for the stereo situation. Signal to noise ratio is, however, about 7dB worse, which compared to the 23dB degradation from mono to stereo, was considered by Dorren to be a small percentage. One fascinating suggestion made in the concluding remarks was that with a second quadrature 76kHz carrier, five independent announcements could be made in different languages by separately modulating each information channel. Receiver decoders could contain a switching device which would be keyed by a tone to suppress the audio output from unwanted channels at the appropriate moment and thus select the appropriate language announcement. This suggestion was sharply criticized by Professor Geluk who maintained that an adequate separation could not be obtained; however, Lou Dorren appeared to be able to offer some solution to the problem and concluded that in his opinion the advantages offered of four discrete channels of information made the Dorren system superior to other systems in the field.

Convention exhibition

Concurrent with the convention was an exhibition of professional audio equipment where some novel new equipment was shown.

For Philips was a professional compact cassette recorder designed to run at a tape speed of 9.5cm/sec. This unusual development in cassette machines had three heads, enabling an optimal selection to be made of gap lengths for the various functions. A further feature of this machine was a facility for continuous variable speed selection up to 36cm/sec. Basically designed for CrO_2 tape, the replay time constant is fixed at 50μs with a flat low frequency characteristic.

In the same area, but not actually shown is the new BASF Unisette, a "king size" cassette containing 6.3mm wide CrO_2 tape. Suggested tape speed is 9.5cm/sec giving playing times up to 30 minutes. Since no machines have been built yet (Ferrograph and Studer are said to be interested) it is difficult to see how the use of this cassette will eventually develop.

EMT, well known for their reverberation plates among other studio devices, were showing a new compressor in a standard mixing desk module. This device used the novel technique of gain control by a four quadrant multiplier giving up to 40dB of control range.

With a wide display of novel product at the exhibition and a considerable volume of new information from the convention it is possible to only scratch the surface, though further product detail and information from the papers will appear in later issues where possible.

Conferences and Exhibitions

LONDON

Apr. 9-13 Earls Court
Physics Exhibition
(Inst. Physics, 47 Belgrave Sq., London SW1X 8QX)

Apr. 9-13 Earls Court
LABEX International
(U.T.P. Exhibitions, 36-37 Furnival St., London EC4A 1JH)

Apr. 10-13 IEE Savoy Place
Radio Wave Propagation above 10GHz
(Conference Dept. Institution of Electrical Engineers, Savoy Pl., London WC2R 0BL)

Apr. 25–27 Chelsea College
B.A.S. Spring Meeting
(British Acoustical Society, 1 Birdcage Walk, London SW1H 9JJ)

BOURNEMOUTH

Apr. 11–14 The Pavilion
Marketing Communications Tomorrow
(Electromation Exhibitions Ltd., Cleveland House, 344A Holdenhurst Road, Bournemouth)

Apr. 29–May 2 The Pavilion
RadTelDex '73 (Radio & Television Dealers)
(Corinthian Exhibitions, 17 Pennant Mews, London W8 5JN)

BRIGHTON

Apr. 5 & 6 University of Sussex
European Co-operation in Research and Technology
(Research and Development Society, 47 Belgrave Sq, London SW1X 8QX)

CAMBRIDGE

Apr. 2-4 The University
Computer Aided Control System Design
(I.E.E., Savoy Place, London WC2R 0BL)

COLCHESTER

Apr. 2-5 University of Essex
Software Engineering for Telecommunication Switching Systems
(I.E.E., Savoy Place, London WC2R 0BL)

HULL

Apr. 11-13 The University
Teaching of Electronic Engineering in Degree Courses
(Dr. F. W. Stephenson, Department of Electronic Engineering, The University, Hull HU6 7RX)

LANCASTER

Apr. 9-11 The University
Thin Films
(Inst. Physics, 47 Belgrave Sq, London SW1X 8QX)

LIVERPOOL

Apr. 15-18 The University
To be Continued — Education and Training
(I.E.E.T.E., 2 Savoy Hill, London WC2R 0BS)

NOTTINGHAM

Apr. 10-12 The University
Datafair 73
(British Computer Society, 29 Portland Place, London W1)

OVERSEAS

Apr. 2–7 Paris
Audiovisual and Communication Exhibition
(Société pour la Diffusion des Sciences et des Arts, 14, rue de Presles, 75740 Paris)

Apr. 2-7 Paris
Electronic Components Exhibition
(Société pour la Diffusion des Sciences et des Arts, 14 rue de Presles, Paris-15eme.)

Apr. 3-5 Dayton
Military Airborne Video Recording
(Society of Photo-optical Instrumentation Engineers, P.O. Box 288, Redondo Beach, Calif. 90277)

Apr. 9 & 10 Paris
International Conference on Alpha Numerical Display Devices and Systems
(Colloque International sur les Memoires, c/o F.N.I.E., 16 rue de Presles, 75740 Paris)

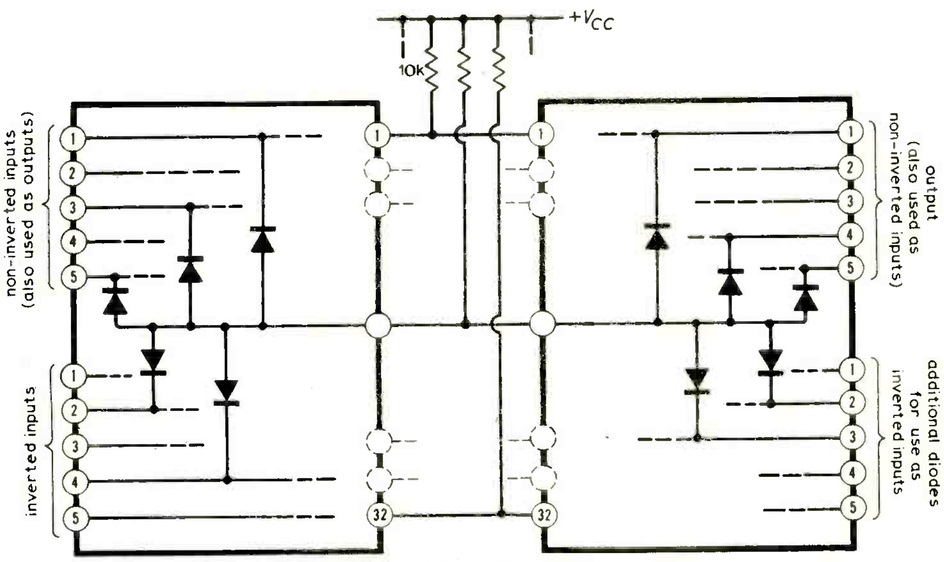
Circuit Ideas

Decoder/coder matrix

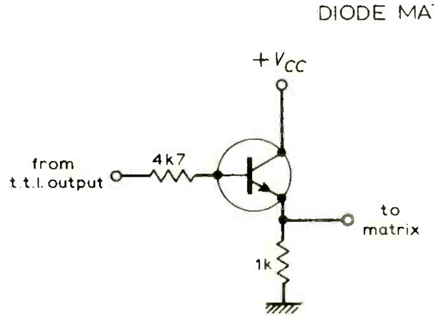
This device converts a signal in Murray (teleprinter) code to Elliott (computer) code. Each code consists of 32 5-bit binary words representing 32 alphanumeric characters. Conventionally, 32 5-input AND-gates would be used feeding into 5 32-input OR-gates. If buffers were not used, the circuit could be modified with the addition of a few extra components to become reversible, i.e. to perform the conversion in both directions.

For any combination of input signals, each of the lower ends of the 10kΩ resistors is pulled down to logical "0" except for one, which represents the selected alphanumeric character. This in turn pulls the appropriate outputs, which are connected to a high impedance circuit, up to logical "1", and so the correctly coded signal appears on the output. If the extra diodes shown are connected, the diode matrix section of the circuit is symmetrical and so with appropriate switching the circuit performs the conversion in both directions. Electromechanical switching was used for this, as the time delay was not critical, but it should be possible to arrange the switching to be done electronically. One way should be to replace the 1kΩ driver emitter resistors by transistors which would become a high impedance when the driver was not in use. Both these and the output interfaces could be permanently in circuit, and the switching performed by normal t.t.l. methods.

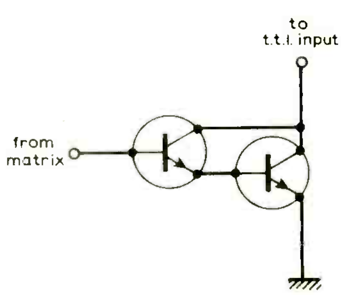
R. P. Norris,
Hatfield, Herts.



DIODE MATRIX



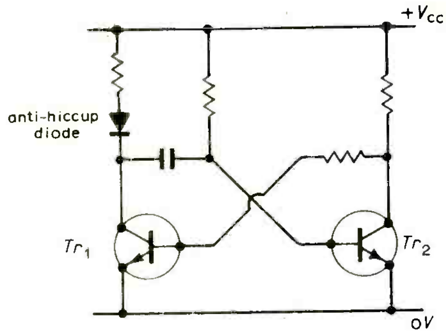
INPUT DRIVERS



OUTPUT INTERFACE

Noise-immune monostable – 1

The solution for noise-triggered monostable circuits (Circuit Ideas, Feb. 1973) was sophisticated, but requires two power supplies, and the resulting circuit looks unfamiliar to those further down the production chain. Further, one cannot guarantee that interference will not exceed a given fraction of the supply voltage. If a diode is placed in series with Tr_1 collector, for the price of a cheap component one has: a circuit which still *looks* like a monostable; no need for a bias supply; immunity from any reasonable noise spike; and no need to do any sums!

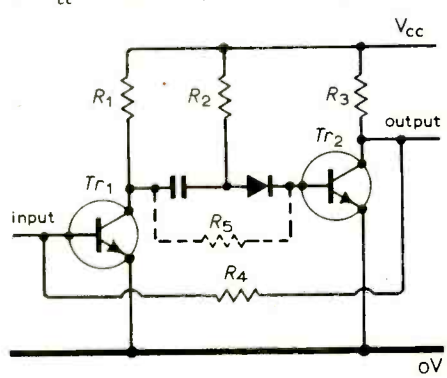


One caution; any connection directly to Tr_1 collector will bypass the protection; connections should be made upstream of the diode.

E. I. White,
Melksham,
Wilts.

Noise-immune monostable — 2

An extremely simple solution to the problem is to include R_5 which has a value $< (R_3/\beta\, min - R_1)$. Current supplied through R_1 and R_5 always holds Tr_2 in saturation while Tr_1 is cut-off, regardless of V_{cc} fluctuations, which merely reverse



bias the diode. During normal firing, Tr_1 is saturated and R_5 is simply a resistor from the base of Tr_2 to ground. Its only effect is to slightly speed-up Tr_2 by facilitating removal of base charge. The operation of the circuit is thus improved and supply-line noise immunity is increased to almost 100% of V_{cc}. As with silicon planar transistors the diode is frequently required anyway, this is achieved through the addition of one resistor only. The principle may easily be extended to astable circuits.

Peter Seligman,
Monash University,
Australia.

Letters to the Editor

The Editor does not necessarily endorse opinions expressed by his correspondents

Distortion reducer

I was particularly interested to see the article "Distortion Reducer" by D. Bollen in the February issue because it took my mind back 40 years! In *The Wireless Engineer & Experimental Wireless* for August 1933 there was (p. 413) an article by W. Baggally entitled "Distortion Cancellation in Audio Amplifiers" and a footnote to it stated that the MS was received by the Editor in October 1932.

The systems described in these two articles are substantially the same. The hardware is, of course, very different; Baggally was restricted to using filament-type valves and did not have the greater freedom available with transistors.

Anyone interested in the method of distortion reduction would do well to refer to Baggally's article in spite of its age. It contains a mathematical analysis and gives the condition for stability.

Although I have never used it, the principle has interested me so much that I have never forgotten Baggally's article. I have several times contemplated employing the principle, but I always came to the conclusion that in a new amplifier the required performance could be obtained more economically by using conventional negative feedback. Perhaps I was wrong in this, but perhaps not, for no one else seems to have used it in 40 years. Or did everyone forget it?

Be that as it may, Bollen's application of it to the reduction of distortion in an existing amplifier is a different matter. The alternative procedure would be to increase the amount of negative feedback in the amplifier to reduce the distortion and to add a pre-amplifier to make up for the resulting loss of gain. At first sight this would give the same performance with fewer extra components. It might well be, however, that this course would raise greater stability problems than those occurring with the cancellation method.

A detailed comparison of the two ways of obtaining substantially the same performance would be of great interest, especially if it treated relative stability. It would, however, be a laborious undertaking.

W. T. Cocking,
Ewell,
Surrey.

The golden rule of negative feedback is "Feedback reduces distortion in the same ratio as it reduces gain". Mr Bollen's very interesting circuits in the February issue (p. 54) look as if they are cunningly getting us around this, and giving us something for nothing, but may I suggest an alternative way of looking at their operation?

As in the standard approach to an ordinary feedback system, we focus attention on the input. The main amplifier receives three inputs. In the basic circuit of Mr Bollen's Fig. 1 these are: $-S$ *via* op-amp A; $+D_f$ *via* op-amps C and A; and $-S$ *via* op-amps B, C and A. Thus the net input of signal S has been doubled: the three op-amps function as a pre-amplifer with a gain of two. As the overall gain of the system is unchanged, the gain of the main amplifier must have been halved, and lo and behold so has the distortion.

If we then increase the gain in the distortion channel by a factor G_2 the gain of the "pre-amplifier" becomes $(1+G_2)$, the gain of the main amplifier is reduced by this factor, and so is the distortion.

The question then is whether we should get equivalent (or better) results by using a single op-amp as a pre-amplifier and increasing the ordinary negative feedback around the main amplifier. This question I leave for further discussion.

Richard G. Mellish,
Watford,
Herts.

The author replies:

Mr Mellish neglects to mention the missing fourth input term $+S$ which is derived from the output of the main amplifier. Using the same line of thinking, and dropping the term D_f, the inputs presented to the main amplifier are $-S$ from op-amp A, $-S$ from op-amps B, C and A, *and* $S+D$ from op-amps C and A. Thus we have $-S\ -S\ +S\ +\ D$ at the main amplifier input.

If, as Mr Mellish suggests, the three op-amps merely functioned as a pre-amplifier with a gain of two, and the gain of the main amplifier was halved, one would expect the signal at the main amplifier input to be twice its original value for the same level of output, but this is not the case, as one can easily determine with an oscilloscope. Even with distortion feedback loop gains of ten or more the signal present at the main amplifier input is of virtually the same amplitude as the original signal.

So where does this leave us? I think perhaps with an alternative definition of the golden rule, namely, "non-selective feedback reduces distortion in the same ratio as it reduces gain". Distortion and gain merely coexist, they are not quantities to be traded one with another, hence the distortion reducer circuit in no way attempts to give something for nothing, but instead avoids sacrificing something (gain) for nothing.

There are obviously several approaches to the problem of reducing distortion in existing amplifiers, and Mr Mellish's idea of increasing negative feedback in the main amplifier (stability permitting), while boosting gain with a low distortion pre-amp, is quite interesting. However, this might involve more than the adjustment of a single feedback resistor within the amplifier, and whether results would be equivalent or better remains to be seen.

D. Bollen.

Seeing in the dark

May I please be allowed to thank Messrs Gwilym Dann, J. R. Sanders and Stephen Waring for responding to my letter which was published in the January issue, a plea which you headed "Seeing in the dark". In my original letter I suggested that for a colour television transmission taking place or purporting to take place in semi-darkness the bandwidth of the luminance channel and the relative gain to the chrominance channel should both be reduced.

First let me deal with Mr Waring's query, "why pick on . . . . ?" etc. If this view were held generally, then we would still be using the 30-line disc and the Model-T Ford.

Mr Dann refers to "unnatural reproduction . . . television broadcasting is the portrayal of an illusion . . . ". But reproduction is not reproduction if it is unnatural and television portrays real actors and scenes, not figments of the imagination as may be conjured up by hypnosis or drugs.

All of these gentlemen disagree with processing the signal to suit human physiology. But surely this is the basis of all engineering, so let us examine some of those situations which are already accepted and are closely allied to the points under discussion.

1. Visual acuity varies with brightness, so camera manufacturers reduce the degree of horizontal aperture correction with reduction of luminance. (The *reason* for so doing is irrelevant. It is for the improvement of signal/noise ratio. But it is only the aforementioned relationship which *allows* them so to do.)
2. The Fechner Fraction increases with reduction of luminance. In bright light, luminance changes of 1% to 2% are just detectable, e.g. creases in a suit, but these go undetected in dim light. A partial compensation (as mentioned by Mr Dann) is the subtraction of a d.c. component from the signal, thus crushing out all detail in the darker tones.
3. The chrominance signals are transmitted at unnaturally low levels and given extra receiver gain because the Bailey experiment has shown that the eye is less sensitive to noise in the chrominance channel than in the luminance channel, thus enabling the overall amplitude of the complete colour signal to be kept within the limits of the luminance signal.
4. The chrominance channel is given a

narrower bandwidth than the luminance channel because we cannot detect colours at very small angles of view.
5. The N.T.S.C. system reduces two-dimensional chromaticity to one-dimensional chromaticity for intermediate angles of view (i.e. the Q-signal is omitted for modulation frequencies exceeding about 0.5 MHz).
6. In the cinema industry, many outdoor scenes purporting to show moonlight conditions appear to be shot in bright sunlight and the film processed deliberately to exclude colours and details in the shadows.

The artificial viewing conditions mentioned in my original letter and emphasized in that from Mr Sanders constitute a form of distortion, and so the use of the practices which I have suggested constitute equalizing techniques, to be compared with equalizing techniques for attenuation distortion etc. Sometimes it may be legitimate to exploit the technicalities as mentioned by the other correspondents for viewing say sports events in conditions of poor lighting, but we must be careful, particularly in such programmes as news bulletins, not to confuse or deceive. This is where the communications engineer must be distinguished from the entertainments engineer.

And finally we must also guard against conditioning the public to accept unnatural situations. We have an example of this in sound radio where the use of cheap receivers has conditioned many people to believe that the frequency range of a symphony orchestra extends from about 200 to 4000 Hz, its dynamic range being about 20 dB and its maximum volume only a few decibels above that of the announcer's voice.

Roy C. Whitehead,
The Polytechnic of North London,
London N7.

Feedback amplifiers

At the risk of overstaying my welcome on this topic, I would like to make a few comments on the interesting letter from Mr Linsley Hood in the January issue (p.11). I am in agreement with his measurements (see Fig.1) and also with his remarks on the common-mode problem in series-feedback amplifiers, which, in fairness, I did mention in my November 1972 letter (p.520) to which he refers. However, as in most engineering situations a compromise must be found between conflicting requirements and I feel that perhaps the distortion problem in low-noise series-feedback amplifiers is not as severe as Mr Linsley Hood's measurements might suggest, though I would agree that ultimately the shunt circuit could offer better linearity.

I made linearity measurements on several amplifiers including the National LM301, Fairchild μA739 and a series-feedback discrete component transistor triple (Fig.3 of my mixer design[1], also used as the example in my article on low-noise amplifiers[2]); the results are plotted in Fig.1. I made two-tone intermodulation measurements as these were more convenient with available equipment (i.e. low-distortion oscillators are not required), and furthermore the distortion products can be measured in the audio band rather than beyond the bandwidth of the amplifier as may happen with harmonic products.

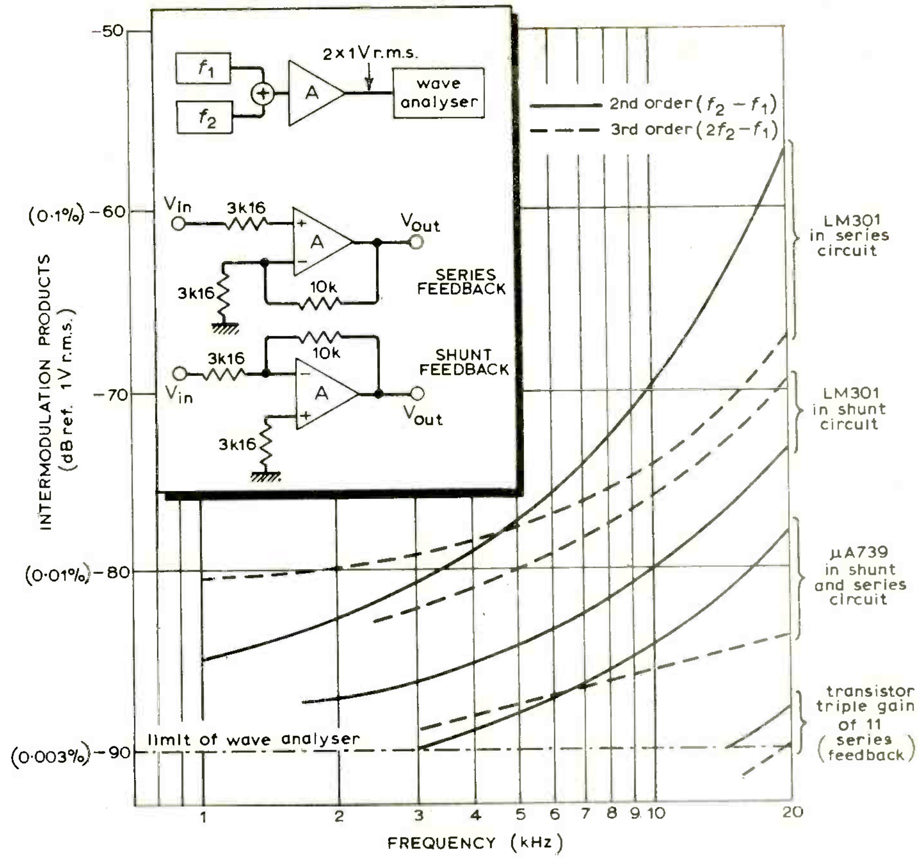


Fig. 1. Intermodulation in various amplifiers.

The LM301 (a general-purpose amplifier similar to the 741) in a test circuit like Mr Linsley Hood's, shows a markedly poorer performance in the series mode with a predominantly second order product (f_2-f_1) at high frequencies due presumably to the common-mode failure at the input. On this matter it is worth noting that the 741 specification shows the open-loop again and common-mode rejection to have fallen by 40 or 50dB at 20kHz.

In contrast, the μA739 has a c.m.r.r. of 90dB up to 20kHz and a higher gain-bandwidth product of 20MHz as well as lower distortion due to a class A output stage and a low noise figure (R_{nv} is about 600 ohms compared with 10k ohms for the 301[2]). Changing the amplifier in our test circuit to the 739 gave the expected improvement, and distortion levels for the two configurations were almost identical up to 20kHz.

Turning to the series-feedback triple, I set the feedback loop for a flat gain of 11, and under similar output levels 2 × 1$V_{r.m.s.}$ the second and third order intermodulation levels were very low and rose above −90dB only at 20kHz. These results demonstrate that, provided suitable amplifiers are chosen, a series feedback configuration, also optimized for low noise, can offer a linearity more than adequate for the most stringent audio requirements.

The analyses of RIAA equalized pickup amplifiers given in my May 1972 article[2] were for the ideal case (neglecting transistor noise, the effect of the feedback loop and biasing resistors) when it was shown that the shunt feedback configuration gives a broadband noise level of −66dB referred to 5mV at 1kHz, some 14dB worse than the series circuit, and clearly demonstrates the degradation of noise figure caused by a series input resistor very much greater than the source impedance.

For the p-n-p Liniac described in his letter, Mr Linsley Hood quotes a noise level 6dB below thermal noise (BW = 20kHz), so either the measurement bandwidth was limited or the amplifier input was open-circuit (the low-noise condition for a current amplifier). In this particular circuit, above 2kHz the feedback loop shunts the amplifier input with a 47k ohm resistor (in parallel with 1.5nF) thereby introducing a noise figure of 3dB increasing to 5dB at high frequencies due to the rising cartridge impedance (ref.2, eqn.7). Fortunately this is not too serious since the shunt circuit generates most noise below 1kHz[2].

With the shunt feedback arrangement I have often found that amplifier noise is audible above tape noise and surface noise on discs, and, with the new generation of "noise-reduced" recordings and low-output heads, I do not consider this a satisfactory situation as I believe audible background noise to be a source of listening fatigue.

However, good linearity can be achieved by current-driving large signal stages, in a series-feedback amplifier, and without degrading the noise performance as the following measurements made on the

pickup amplifier described in my mixer article[1] (Fig.3) indicate. Second order intermodulation products are −72dB (<0.03%) at 10kHz ± 130Hz for two equal output signals at 10kHz and 130Hz having a composite level of 15V pk-pk. (An intermodulation test is more realistic than t.h.d. measurements on equalizing amplifiers.) Noise, in a 20kHz bandwidth, is -78dB referred to 5mV at 1kHz, and cannot be significantly improved without using the active termination discussed in an earlier correspondence[3]. To sacrifice 14dB of signal-to-noise ratio with the shunt circuit in order to obtain a distortion level of 0.01% (probably two orders of magnitude lower than the cartridge) is, in my opinion, to eliminate one form of interference only to replace it with another.
H. P. Walker,
South Queensferry.

References

1. Walker H.P., "Stereo Mixer", *Wireless World* May 1971, p.221.
2. Walker H.P., "Low-noise Audio Amplifiers", *W.W.* May 1972, p.233.
3. Buckner/Walker, Letters, *W.W.* December 1972, P.575.

Feedback amplifiers

Mr Linsley Hood's letter in January's issue (p. 11) raises several interesting points concerning the poor distortion performance of series feedback amplifiers compared with shunt feedback amplifiers. A point of particular interest is the source of the additional distortion in the series feedback configuration, and I am of the opinion that it is attributable entirely to the common mode performance of the amplifier.

The differential amplifier shown in Fig. 1 can be characterized by the equation

$$V_o = A_d(V_1 - V_2) + A_c(V_1 + V_2)$$

where A_d is the differential gain of the amplifier and A_c is a gain factor equal to half the common mode gain since the common mode input signal is defined by $(V_1 + V_2)/2$. If the amplifier is now incorporated in a series feeback configuration, Fig. 2.

$$V_o = A_d(V_{in} - \beta V_o) + A_c(V_{in} + \beta V_o)$$

∴ closed loop gain

$$A_f = \frac{V_o}{V_{in}}$$

$$= \frac{A_d + A_c}{1 + \beta(A_d - A_c)} \qquad (1)$$

By differentiating equation 1, the relation between the fractional change in closed loop gain $\frac{dA_f}{A_f}$ and the fractional change in dif-

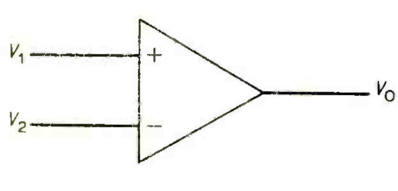


Fig. 1

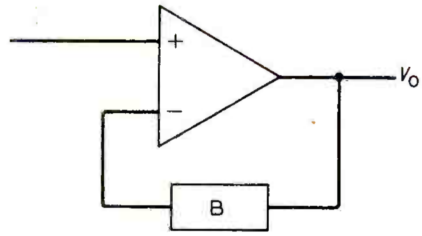


Fig. 2

ferential gain $\frac{dA_d}{A_d}$ is found to be:

$$\frac{dA_f}{A_f} = \frac{1 - 2A_c\beta}{1 + \beta(A_d + A_c)} \cdot \frac{A_d}{A_d + A_c} \cdot \frac{dA_d}{A_d}$$

$$\simeq \frac{1}{1 + A_d\beta} \frac{dA_d}{A_d} \qquad (2)$$

Similarly for a fractional change $\frac{dA_c}{A_c}$,

$$\frac{dA_f}{A_f} = \frac{1 + 2A_d\beta}{1 + \beta(A_d - A_c)} \cdot \frac{A_c}{A_d + A_c} \cdot \frac{dA_c}{A_c}$$

$$\simeq \frac{2A_c}{A_d + A_c} \frac{dA_c}{A_c} \qquad (3)$$

The approximations in equations 2 and 3 make the assumptions $A_d\beta \gg 1$, $A_d \gg A_c$ and $2A_c\beta \ll 1$.

Equation 2 gives the well known result that feedback reduces the effect of changes in differential gain by a factor $(1 + A\beta)$. Equation 3, however, shows that feedback

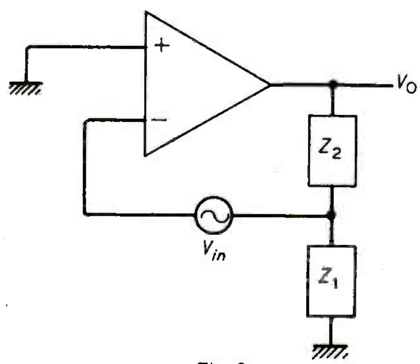


Fig. 3

can increase the effect of changes in common mode gain by a factor 2 compared to the open loop configuration. This in itself may not be important but by applying feedback the common mode signal becomes:

$$\frac{V_{in}}{2}\left[1 + \frac{A_d\beta}{1 + A_d\beta}\right] \simeq V_{in}$$

whereas the differential mode signal is reduced by the loop gain to

$$V_{in}\left[\frac{1}{1 + A_d\beta}\right]$$

Thus the ratio of the component of the output signal due to the common mode input signal, to the component of the output signal due to the differential mode input signal, is given by:

$$\frac{V_{ocm}}{V_{odm}} = \frac{A_cV_{in}\left[1 + \frac{A_d\beta}{1 + A_d\beta}\right]}{A_dV_{in}/1 + A_d\beta)} \simeq \frac{A_c}{A_d}(1 + 2A_d\beta)$$

In the closed loop configuration, the effective common mode rejection ratio is therefore reduced by a factor approximately equal to twice the loop gain and the distortion components associated with the common mode gain becomes increasingly significant.

To summarize, the cause of distortion in an amplifier with series feedback can be attributed to the fact that as well as amplifying, as in shunt feedback, the amplifier is also required to perform the subtraction of two nearly equal quantities, and any nonlinearities in this operation lead to distortion. If a linear subtraction process is performed externally to the amplifier, this source of distortion is eliminated and the feedback arrangement shown in Fig. 3 should therefore offer the low noise advantages (for low source impedance) of series feedback with the low distortion of shunt feedback. It is of course essential for this circuit that the signal source be floating.
E. F. Taylor,
Electrical Engineering Laboratories,
University of Manchester.

Sixty years ago

As a reader of the *W.W* for over fifty years I am naturally interested in the excerpts from your issues of sixty years ago, especially as they are now approaching the period of my memory.

I was particularly interested in the mention in your January 1973 issue of the anxiety felt by the Marconi Co. in 1913 regarding the competition from c.w. systems. There were a number of these developed in the first decade of this century but at that time they showed very little advantage over spark systems and it was not until the development of heterodyne receivers using triodes in about 1912 that the advantages of c.w. became apparent.

The assertion that Marconi had produced a c.w. system using a spark discharge around 1907 cannot be substantiated although the myth has been perpetuated in Baker's recent "A History of the Marconi Company". What the Marconi organization did do, about 1914, was to produce the timed spark system which used a number of disc dischargers keyed to a common shaft. These were carefully phased so that the primary discharges were additive in the common secondary, thus radiating a modulated c.w. from the aerial.

During the second decade most of the v.l.f. stations built were either of the arc type or used h.f. alternators.

The introduction of short waves in the third decade, particularly the Marconi-Franklin beam system, revolutionized radio telegraph communication and the use of v.l.f. for point-to-point services quickly came to an end.
W. L. E. Miller,
Mill Hill,
London NW7.

Industrial Electronics

2. Displacement and position

by Richard Graham

One of the rôles of industrial electronics is, as was mentioned in the introductory article last month, the rendering of aid to humans to enable them to work at much higher efficiency. The subject for discussion in this article is an illustration of just such a field of activity and is concerned with measurement of movement, position and length.

Of what? Yes, well almost anything, but in the main the devices to be described are part of machine tools and the movement or position being measured is that of the work-piece or tool. They also make possible the attainment of more and more accurate inspection, can be used as mechanical-to-electrical transducers in weighing and are finding new applications constantly in many branches of engineering.

As a class, these paragons are termed displacement transducers, a name which covers several different techniques — although each application has its own favourite method. Machine tools being perhaps the most widespread application, we can start with the type of transducer most commonly used by them — the optical variety.

Optical transducers

Two distinct types of optical displacement transducer are now in widespread operation. In the first type to be described, position is determined by counting techniques, starting from an arbitrary zero, and the equipment is categorized as "incremental". The second kind is a development of this, based on experience of the use of incremental equipment in an industrial environment, and is known as the "absolute" type of transducer.

Incremental. The first class of equipment, upon which much early work was done by Ferranti[1] and the National Physical Laboratory[2] (and later the National Engineering Laboratory), relies on the moiré effect observed when slightly crossed gratings are placed next to each other. In principle, the system is simple in the extreme; in practice, the production of gratings and the processing of the signal is fairly complex.

Assume, for a moment, that the movement of interest is that of a slide on a machine tool, and that we wish to know the amount of movement to a resolution of 2.5mm. (If this really were the required resolution, we might equally well use a piece of string, but it serves to illustrate the principle.) All that is required is a transparent sheet of glass — a grating — with opaque stripes at 2.5mm centres, a lamp, a photocell and a counter. As the slide moves with its attached grating, the photocell is alternately darkened and illuminated, the resulting pulses being displayed by the counter.

This process would work well down to a resolution where one complete cycle on the grating was small enough to compare with the size of the photocell, at which point pulses would no longer be produced and the system would be useless. At 2.5mm cycle length this situation is almost upon us, and any improvement in resolution requires a new approach. Using two gratings and the moiré effect, it is possible to recognize grating movements to a resolution of 0.0025mm or better, and by use of prismatic gratings and refined techniques to a much smaller resolution.

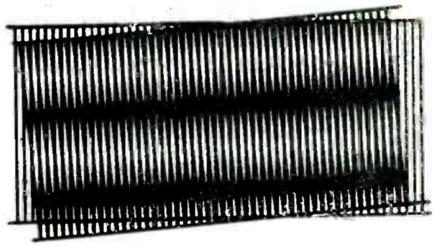


Fig. 1. Crossed gratings demonstrating the production of moiré fringes.

Fig. 1 shows the basic moire principle. As the gratings move relative to each other in a direction perpendicular to the lines, the interference pattern of fringes moves in a direction parallel to the lines, and a grating movement of one line moves the fringe pattern one fringe. The size of the fringes is adjustable by altering the angle at which the lines on the two gratings cross.

It is clear that the use of the gratings has apparently magnified the relative movement, the magnification being often 1000 times or more. An additional benefit conferred by the principle is that each "mark", instead of consisting of one dark line whose positional accuracy influences the whole system, is a "fringe" caused by the crossings of perhaps 500 pairs of lines, and the averaging effect of this reduces the need for accuracy. It must be admitted though that the producers of gratings do not allow this to get in the way of truly staggering degrees of accuracy.

Having obtained the fringes, some care must be directed towards the derivation of an electrical signal which will provide information on both the amount and direction of the relative movement. Fig. 2 shows a frequently used scheme in outline.

The use of four photocells is concerned with need to recognize direction. The gratings, or rather the grating and an index made from a small section of the larger grating, are adjusted so that one complete cycle of the interference pattern occupies the width of the four cells, so that each cell is 90° out of phase with the adjacent ones. Fig. 3 shows the waveforms from each cell as the grating moves, and subsequent signal processing. The final result is seen to be a train of pulses on either the "forward" or "reverse" outputs, and four times the number of pulses appear as would be produced by the scanning of fringes by one photocell.

It only remains to feed the pulses to a reversible counter and display to obtain a position and displacement measuring device of high accuracy, of high resolution and with digital display. For the

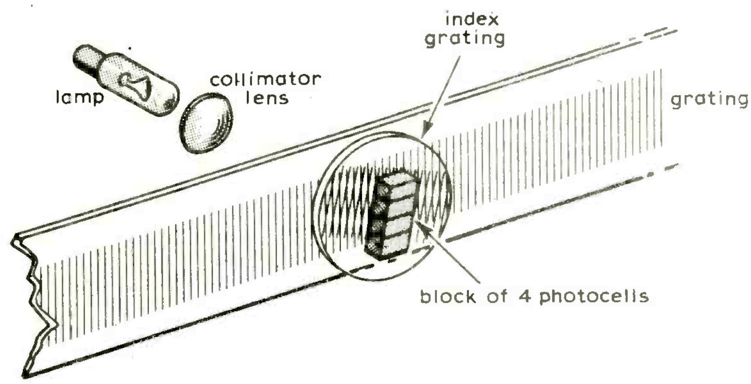


Fig. 2. A typical arrangement for the detection of fringes.

conversion of rotary motion to electrical signals, circular gratings with radial lines are made to the same order of accuracy. Increased resolution can be obtained by the use of spectroscopic gratings in which the "lines" are formed by microscopic prismatic rulings in transparent plastic, but for anything other than the most precisely controlled working conditions (the reading head gap is very important) these gratings are difficult to apply. Line densities of up to 6350 lines per inch are available.

The method of measurement just described is virtually ideal in most respects. It is unfortunate that it is somewhat vulnerable in the precise area in which the industrial environment is most inimical — it is susceptible to noise.

One of the advantages of the incremental equipment is that it can be arbitrarily set to zero at any point, because no part of the grating is different to any other part. However, this apparent advantage is obtained at a price which, in the end, proves far too expensive. The lack of uniqueness in each grating section means that if, anywhere in the system, a pulse is miscounted or a mains transient gets loose in among the counters, then all the information gathered to that instant becomes valueless. The only way to rectify such a situation is to return to the zero position and throw again.

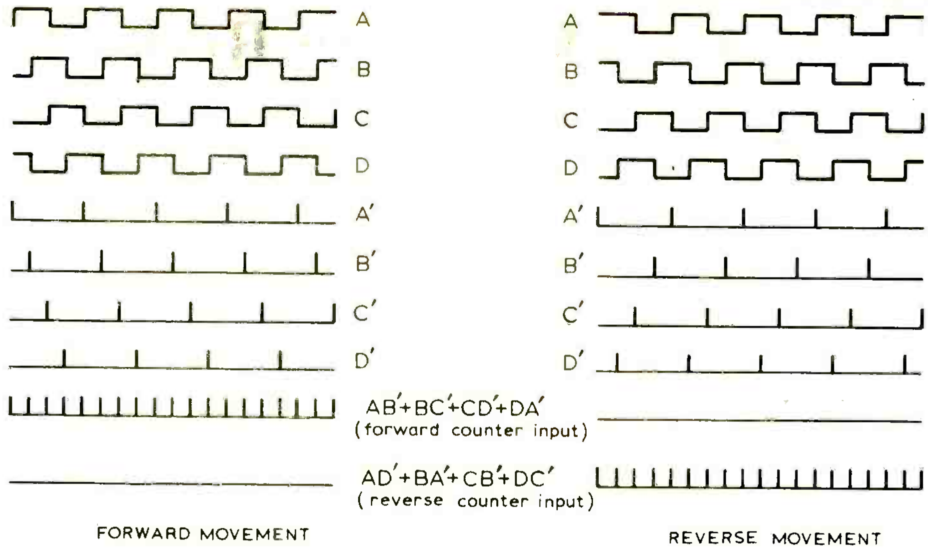


Fig. 3. The derivation of direction and count signals from four cells spaced at 90° intervals over one fringe "wavelength".

Absolute. Workers at the National Engineering Laboratory, East Kilbride, Glasgow, whose researches are chiefly directed towards machine-tool applications, evolved a hybrid analogue/digital method of using gratings in conjunction with coarse coded tracks[3]. In operation, the newer system is absolute in that, although its accuracy is entirely dependent on the finest incremental track of a multi-track grating, it does not rely on counting techniques. Interruption of the supply or transient interference do not affect results and, if a machine-tool fitted with the system is switched off, it can be re-started without the necessity of running each axis back to zero or datum.

Fig. 4 shows the relevant waveforms; the method of interpolation will be described later. A is the signal produced by the first (finest) track of a three-track grating. B is derived from A electronically, A being interpolated to provide a sub-division by 10. Also derived from A are C and D which, in antiphase, have switching points at transitions 4/5 and 9/0 of B. An "up" condition is considered to be "on". The second grating track is divided into two signals, each providing counts of 0-9, shifted in phase to each other by 180°. Operation proceeds as follows.

Assume that the reading head is in the area between 0 and 4 of the first cycle of the finest track. The interrogation waveform I_1 strobes the second-track first waveform S_1 and detects the fact that a 0 is present. The reading will therefore be from 01 to 04. At the 4/5 switch-point on the first row, waveform I_2 comes "on" and strobes S_2, which also shows 0. The readings are therefore 05-09. At this point, I_2 goes "off", I_1 comes "on" and strobes S_1, which has meanwhile changed to 1, giving readings of 10 to 14, whereupon I_1 goes "off", I_2 comes "on", strobing S_2 and finding 1 again. It will be seen that the switch points of the second track cause no error provided that they are within $\frac{1}{4}$ cycle of the first track (2.5 digits).

The process is repeated for the second and third tracks, coarser information being obtained by any suitable means, such as a coded digitizer on the lead-screw of a machine tool. The method affords many advantages over the incremental variety of grating system. Foremost, of course, is the absolute nature of the measurement and the elimination of counting and storage elements. The accuracy of the whole system is that of the first track.

The method of sub-division of each cycle of the grating pattern is basic to the system and is responsible for the uniqueness of each digit. If it can be assumed that the waveforms from the reading head are triangular instead of sinusoidal, the diagram becomes fairly easy to draw, and Fig. 5(b) is the result.

From the resistor network shown in Fig. 5(a), fed with processed reading head waveforms as indicated, each tapping point will give a signal shifted in phase by 36° from the adjacent one (Fig. 5(b)). Passed through a zero-crossing detector there emerges a ten-line shift-register code which can fairly easily be combined by means of simple logic to provide a unique one-out-of-ten code. Very fine gratings will produce sinusoidal waveforms rather than triangular ones, and the resistor network must be modified to suit.

The investigation of measurement by optical methods still continues but by the means described it is possible to measure movements up to 10 inches to a resolution of 0.0001 inches, and a rotary motion to within 3 seconds of arc.

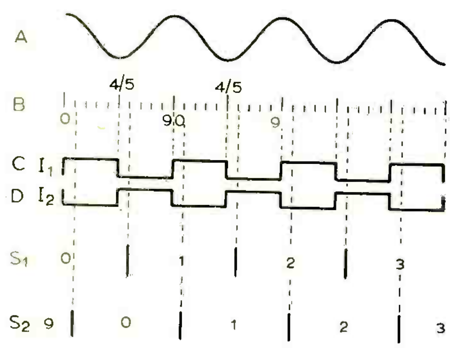


Fig. 4. N.E.L. absolute system. The first track strobes the second track to establish a reference.

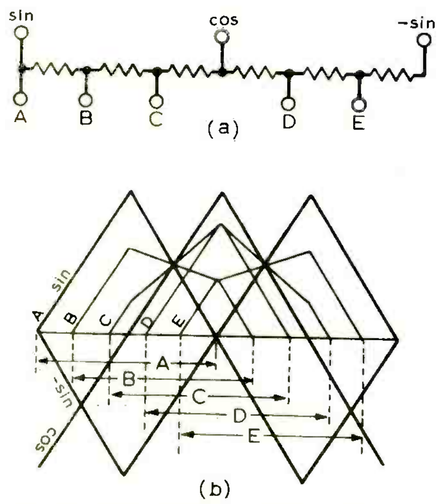


Fig. 5. (a) Resistor network to give family of phase-shifted waveforms. (b) Waveforms at tapping points of (a). Negative halves of curves are ignored. Arrows indicate zero crossings.

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World of Amateur Radio

GB2RS and Oscar 6

The need to have up-to-date orbital data for Oscar 6 is proving another inducement to listen to the weekly R.S.G.B. news bulletins "broadcast" under the call sign GB2RS from a number of different amateur stations throughout the U.K. each Sunday morning. This amateur news service has grown steadily in coverage since it was launched in September 1955 by Frank Hicks-Arnold, G6MB. It includes a number of features that professional broadcasting would find unusual. For example, it is possibly the only "broadcast service" regularly using s.s.b. as well as a.m. and where the news reader, once his broadcast is completed, immediately contacts — using his own call-sign — a number of his listening audience who may add their own comments on the news. The call sign GB2RS is transferred from one station to the next throughout the morning and the transmissions go out in the 144MHz band as well as on 3.6MHz.

For many years the first broadcast has been at 0930 hours in the London region and is usually made by Arthur Milne, G2MI, of Bromley, Kent; one of the listeners who regularly joins the "after-the-news" net is his son Geoffrey Milne, G3UMI. G2MI's s.s.b. transmission is usually followed at 1000 hours by an a.m. transmission by Len Lewis, G8ML, in the Cheltenham area.

One of the conditions imposed by the M.P.T. on these broadcasts is that all scripts have to be vetted by them in advance. Apart from the Oscar 6 predictions the bulletins often include news of DX activity, reports on propagation conditions, contest results and announcements about club meetings and special events.

Amateur television news

A Midlands branch of the British Amateur Television Club has been formed "to promote activity on the v.h.f. bands, to exchange ideas and generally to help the up-and-coming younger members". Details from the chairman, Arthur Bevington, G6AFVT/G5KS, 55 Knottsall Lane, Oldbury, Warley, Worcs. (Telephone 021-5fi2 1409).

A two-way vision contact has been made between Peter Worplesdon, VK3ZPA, Victoria, Australia, and Winston Nickols, VK7EM, in Tasmania over a distance of about 230 miles.

After trying to interest amateurs in long-distance transmission of low-definition mechanical television (reported here on page 193, April 1972), Chris Long of Victoria, Australia, is now concentrating on exchanging ¼inch tapes to 30- or 32-line standard — one of his tapes is held by I.B.A's Television Gallery. Although he also works on high-definition (up to 1500 lines) he is anxious to encourage more interest in modern low-definition systems.

An amateur TV convention is being organized in West Germany; details from Manfred May, DC6EU, Caesarstrasse 13, Bayenthal 51, D5000, Cologne.

B.A.T.C. reports that it is hoping the 70cm beacon transmissions will be moved to about 432 MHz to minimize interference to amateur TV.

Around the bands

The decline in sunspot numbers has been making itself evident in recent months by the fewer and shorter openings of the 21 and 28MHz bands and early fade-outs on 14MHz in the evenings. Nevertheless there is some evidence that 21 and 28MHz are open more often than many amateurs believe. It may well prove for example that some of the 29.5MHz stations, reported as heard through Oscar 6, may turn out to be real transmissions made on the band. The various ten-metre amateur beacons are a useful check and these now include: GB3SX Crowborough, DL01GI Salzburg, VE3TEN Ottawa and 3B8MS Mauritius all between about 28,175 and 28,200 kHz. Of these VE3TEN, over the difficult North Atlantic path, is the most elusive but has been heard in the UK.

On 3.5MHz, Norman O'Brien, G3LP, continues his regular dawn schedules with ZL4IE in New Zealand and on February 11 completed his 500th contact with misses on only about 4 days apart from holidays.

That indefatigable 1.8MHz enthusiast, Stew Perry, W1BB, reports the first contacts between Japan and the W8 district of America (JA7A0 — WA8IJI) and between Czechoslovakia and the West Coast W6 district (OK3ATP–W7DOL/W6). By the end of January, Stew Perry had already contacted 120 different DX stations in 37 countries. WA8IJI is reported to be using three Beverage receiving aerials each 1000ft long. Paul Godley, who made amateur history in 1921 by receiving many transatlantic signals using a Beverage aerial at Ardrossan, Scotland, suggests using diversity reception with either two Beverage aerials or a Beverage and a vertical. Although he gave up his American call 2ZE in 1923, he can still copy c.w. and obviously takes an interest in the revival of 1.8MHz for DX working in recent years.

In brief

At the end of 1972 there were 14,464 Class A licences; 3714 Class B; 2854 Class A/mobile; 826 Class B/mobile and 227 amateur TV licences in the U.K. Class B call signs in the G8HAA sequence are now being issued. . . . Major Jack Drudge-Coates, G2DC — one of the originators of what became the B.E.R.U. contests — has died. His life-long interest in DX operating began in the early days of international working when he operated in India. . . . The U.K. now has reciprocal licensing agreements with Austria, Belgium, Brazil, Denmark, Dominican Republic, Finland, France, Federal Republic of Germany, Israel, Luxembourg, Monaco, Netherlands, Norway, Poland, Portugal, South Africa, El Salvador, Sweden, Switzerland and the U.S.A. . . . The Radio Amateur Invalid and Bedfast Club has 421 members including 165 licensed amateurs of whom 76 are blind and 84 permanent invalids. . . . A Mini-Convention is being held at the Royal Hotel, College Green, Bristol, on Saturday, May 26 (details G. Mather, G3GKA, 8 Hills Close, Keynsham) . . . The 19th V.H.F. Convention is to be held at the Winning Post Hotel, Whitton, on Saturday, April 8 — plus probably a Sunday morning session. . . . One of the stations regularly sending slow Morse transmissions is the R.A.F. club station at Locking, Somerset, with daily sessions, Mondays to Fridays, on 1910kHz, 3590kHz and 144.050MHz (the 3590kHz transmissions are receivable over a large area). . . . Otley Radio Society is organizing a Northern Mobile Rally at Moorgrange School, West Park, Ring Road, Leeds, on May 27. . . . Also on May 27 the Maidstone Y.M.C.A. amateur radio third mobile rally at the "Y" sports centre Maidstone (details A. S. Walter, G3WXL, 4 Oak Farm Gardens, Headcorn, Ashford, Kent). . . . South Leics Mobile Rally is on May 13 at Westfield Activity Centre, Rosemary Way, Hinckley, Leics. . . . The Northern Radio Societies Association Convention is being held on May 6 at Belle Vue, Manchester. . . . GB2BWS will be a special station at the Bath and West Show, Shepton Mallet, Somerset, between May 30 and June 2.

Pat Hawker, G3VA

Letter from America

The Federal Communications Commission has ruled that all 70-detent tuners must have a maximum deviation from accuracy of ±3MHz for one half channel and numerical readout for all 70 channels. By July 1974, all 70-detent tuners must be fitted with a.f.c. and have an accuracy better than the a.f.c. range. There are no insurmountable difficulties with the 3MHz requirements but that 70-channel readout is another story! It is not easy to read all those numbers on a tiny dial and some manufacturers are experimenting with a two-dial digital system and at least one, Sony, will use a film strip on a spool. The F.C.C. probably has a greater jurisdiction over standards than the British equivalent and another regulation says that if the u.h.f. and v.h.f. channels are displayed together, every other channel must be numbered. Variable-capacitance diodes would help designers to meet some F.C.C. requirements but, at the moment, devices suitable for combined u.h.f.-v.h.f. coverage are too expensive for general use. However, firms like Motorola, Oak and Kollsman are putting their faith in these diodes and are working hard to bring down price.

Modules of one kind or another are being used extensively in current designs. For instance, the i.f. assembly in an Electrohome model (made in Canada) can be changed in the field without realignment and the i.cs and colour output transistors are all mounted on plug-in sockets. Another aid to servicing on this model is a fault indicator board which is mounted vertically on the main chassis. Five important power supply voltages are monitored and excess current causes one of these voltages to drop and the appropriate neon to light.

Figures released by the Electronic Industries Association for what they call "consumer electronics" shows a substantial rise. (I cannot get used to the idea of being a consumer, a statistic, an EDP card number!) Colour television sales for 1972 went up more than 20% to a staggering 8,843,547, just beating the black-and-white figure of 8,233,290 which was up nearly 8% from the previous year. Radio receiver sales were 55,310,910, phonographs (record players and radiograms) 7 million and tape recorders and players of all kinds — more than 19 million! Many of these products were imported from Japan, Hong-Kong, Taiwan or Korea, the proportion varying from 40% for television to something like 95% for tape recorders. . . . It was reported that a strike closed down a GE factory in Singapore because many of the female workers saw "evil spirits and ghosts". A Buddhist monk, a priest and a witch doctor were called in to exorcise the apparitions (how did they put *that* on the expense accounts?) and apparently now all is well. Pessimists would say that ghosts will soon be haunting U.S. factories but I believe imports have reached their highest point. For one thing, the standard of living is increasing in the Far East and labour costs are bound to go up. The devaluation of the dollar will have its effect too. Many Japanese companies like Sony, Pioneer and Panasonic already have production facilities in the U.S. and others will certainly follow suit. As a matter of interest, Sony claim that their U.S. plant in San Diego will be able to produce more than half of their U.S. requirements by the autumn. This plant is already assembling 6000 Trinitron colour sets a month and the output is expected to increase to some 20,000 a month by the end of the year.

Turning now to the audio scene, the quadraphonics battle still rages on with communiques from CBS, Sansui and RCA claiming converts every week. Most of the 1973 receivers have provision for four-channel adaptors and the quadraphonic receivers have switch positions for SQ, regular matrix (RM) and four-channel tape. Some, like Fisher, Sony, Toshiba and Harman-Kardon use a channel-strapping technique which allows full power to be delivered to two channels for ordinary stereo and a touch of a switch divides the output into four. In other words there are no idle channels and the customer just needs two more loudspeakers, if and when he converts. Strapping is accomplished by a phase-changing network in conjunction with a kind of bridge output arrangement, which virtually puts one output stage in series with the other.

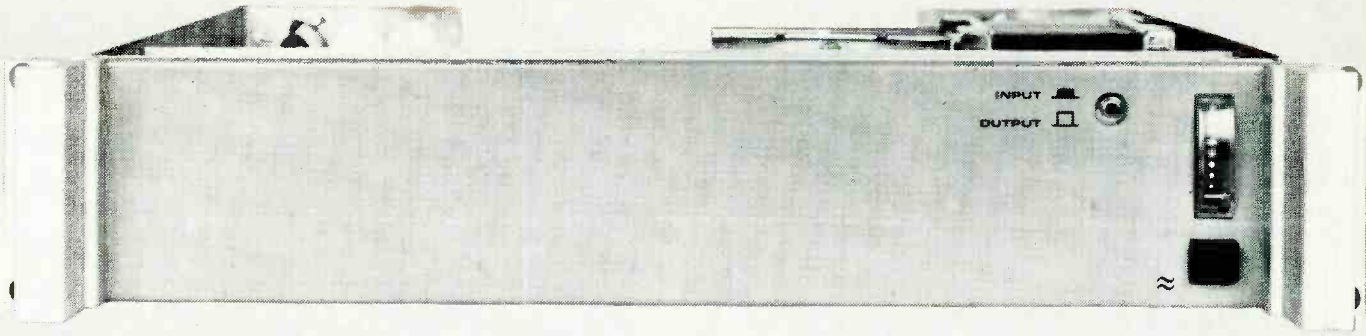
Two novel loudspeakers have appeared on the scene recently: one is the Fisher Sound Panel which uses a flat polystyrene diaphragm and is disguised as a picture. The diaphragm does not move in the conventional manner as it is fixed at the edges. So it vibrates like a drum and, naturally, sensitivity is high. To equalize amplitude response, the voice coil is coupled to the diaphragm by a plastic compliance in the form of a disc. Two dynamic drivers are employed, the bass unit being mounted off-centre for obvious reasons (anyone remember the Midgeley-Harmer?) and a treble unit mounted at one corner. The rear is partially enclosed and the system resonance is about 50 Hz. Although the overall sound quality does not compare with a conventional system in the same price category ($276 a pair) it is very pleasing and certainly far superior to similar loudspeakers which have appeared in the past. Moreover, there is a wide choice of fabrics with pictures in the contemporary style, abstract or traditional.

The other system was demonstrated recently by ESS (Electrostatic Sound Systems) and it uses a novel h.f. unit invented* by Oskar Heil. This uses a kind of convoluted ribbon with multiple interfacing cavities in a plastic material. The volume of these cavities changes in response to the movements of the ribbon (which is in a magnetic field) and it is claimed that the whole device functions as an air transformer with a gain of five. The first models demonstrated at recent shows operated from 400 Hz and so were used with a conventional bass unit. Results were quite impressive.

Banks this side of the Atlantic are rather different to the staid Barclays and Lloyds I used to know. Prospective customers are wooed with all kinds of gifts — toasters, can openers, sets of cooking utensils if only they will open an account. Recently a large Philadelphia bank announced a "Good Life" programme which I thought worth investigating. It turned out that they were offering customers television sets and appliances at cost price. Good Life or not, this kind of thing must be bad news for local dealers who are already fighting discount houses and rising costs!

G. W. Tillett

*U.S. Patent no. 3636278 is entitled "Acoustic transducer with a diaphragm forming a plurality of adjacent narrow air spaces open only at one side with the open sides of adjacent air spaces alternatingly facing in opposite directions"!



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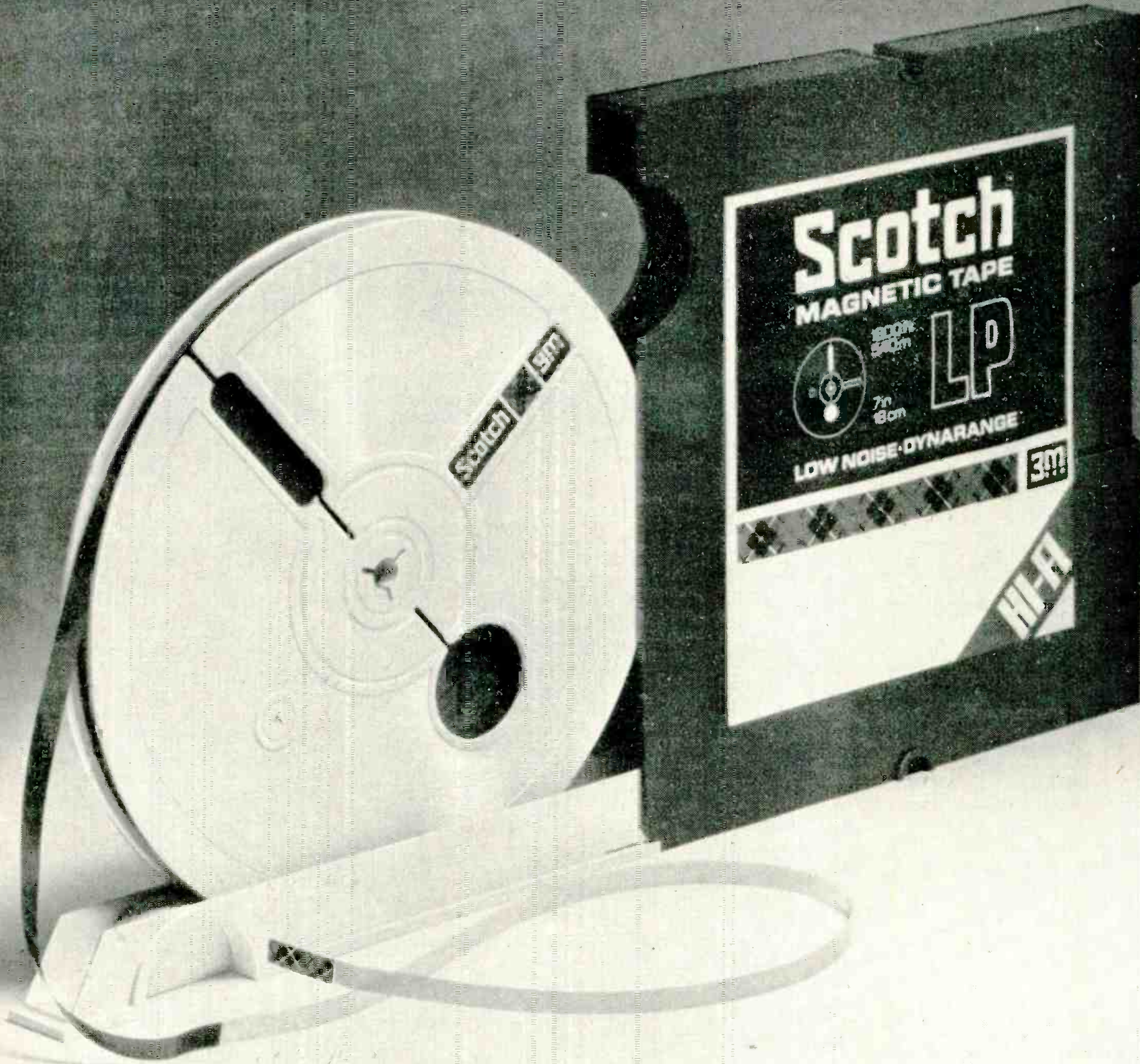

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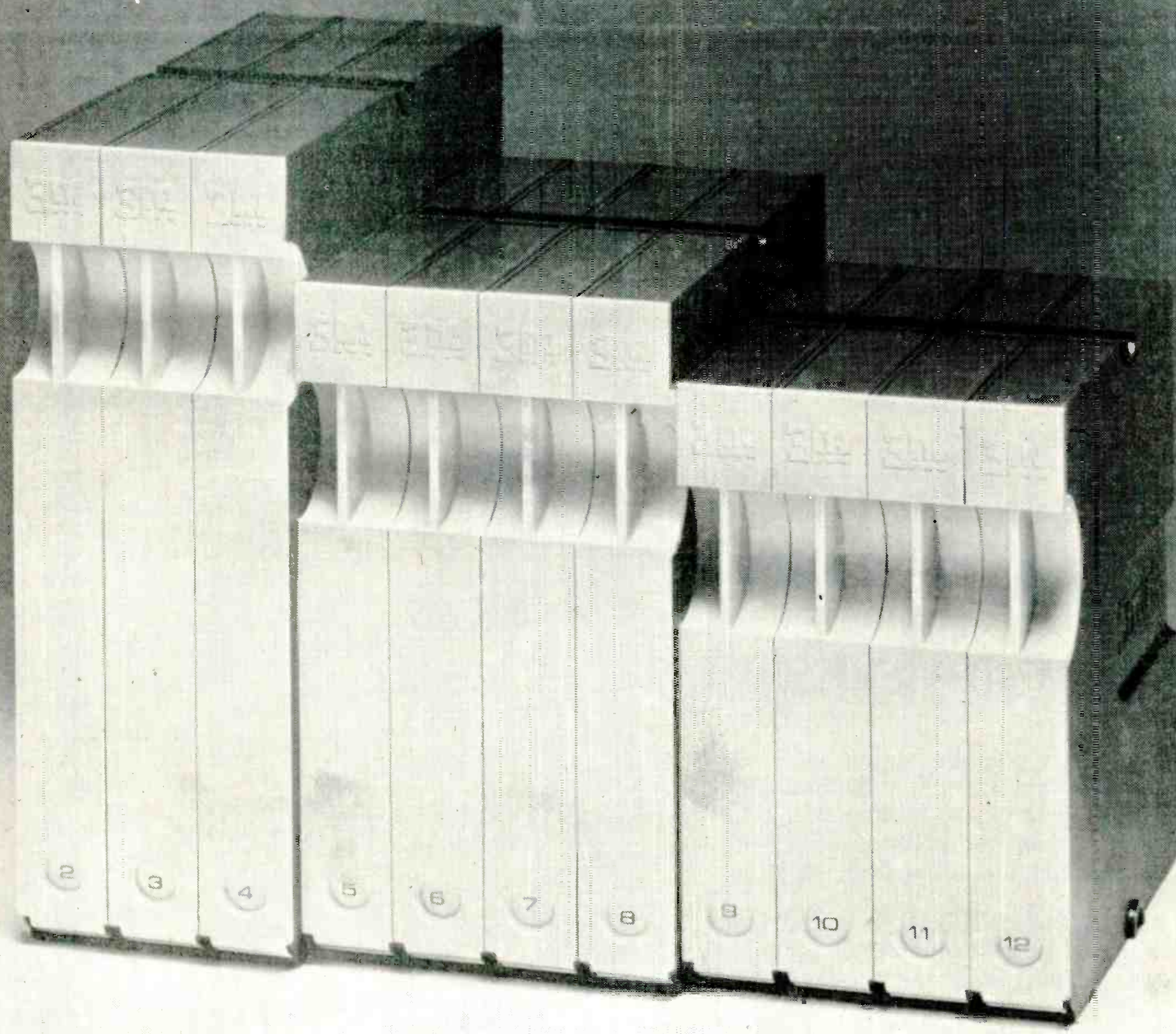

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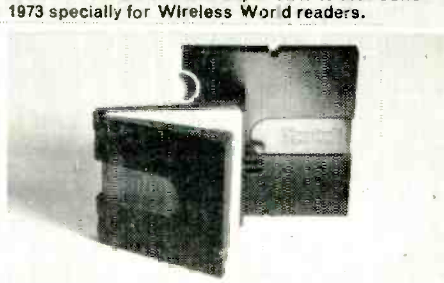

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The Compatibility of Audio Magnetic Tape

*by Basil Lane**

The relationship between magnetic tape and machine is an extremely complex one. The overall performance has been found to vary considerably with change of tape type or brand and this has prompted an attempt to produce some evidence of equivalence among popular brands. The results of a considerable number of tests are shown in a useful tabular form in this article.

Four basic parameters can be said to control the overall performance of a tape machine, three of these being peculiar to the machine, the remaining one being the collective properties of the tape. Let us commence by examining the parameters governed by the machine, the most important of which is considered to be bias.

The process of magnetic recording involves impressing upon the magnetic coating of the tape a remanent magnetization which represents in linear space an instantaneous record of the magnetizing field originating at the pole pieces of a recording head. This magnetizing field (H) is created by currents flowing in the coil of the record head and these consist of a signal current (i_S and a bias current (i_B). Unfortunately, the magnetizing process is not a linear one, since hysteresis intervenes to introduce distortions in the remanent magnetization of the tape coating. High-frequency bias is a technique which reduces the non-linearities inherent in the recording process, though it is interesting that the mechanism by which it achieves this is not well understood.

To explain some of the phenomena associated with bias, several models have been suggested[1-7], none of which, unfortunately, copes completely with all of the effects encountered. Part of the problem lies in the fact that the tape coating consists of a distribution of magnetic particle sizes each having slightly differing magnetic properties. The final properties of the coating can be said to be the average of all the individual characteristics of each particle. This distribution makes it difficult to predict particle interaction effects which tend to modify the short wavelength performance in particular.

To illustrate the effects of bias and demonstrate the effects it has upon the recorded signal, a model for the recording process developed by Bauer and Mee[7] will be described. This model, although it is not the most accurate, does provide a very graphical presentation which is very suitable for the tyro. Fig. 1 shows a longitudinal cross-section of the record head pole pieces and the magnetic coating of the tape. Dimensions will be described in terms of the co-ordinates x, y with $x=y=0$ at the centre and surface of the infinitely small gap. The current (i_B+i_S) flowing in the coil of the record head creates a magnetizing field of semicircular pattern, radius R. Since particle interaction creates a number of imponderables in an analysis of this kind, it will be neglected and the assumption made that the coating consists of a uniform dispersion of particles of the same size and shape. This implies that the bulk magnetic properties of the tape coating are those of a single particle and thus the hysteresis loop is rectangular. We can now also assume that there is one critical value of H, the magnetizing field, where remanent magnetization will occur — higher values saturating the coating, lower values having no effect. This value of magnetizing field we will call H_c. A further assumption, typical in this type of model, is that it is only the longitudinal field that is of any interest.

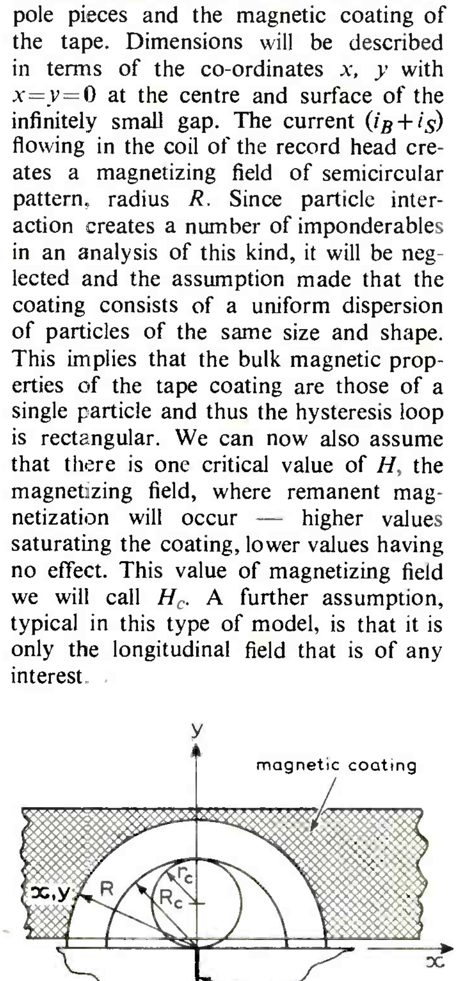

Fig. 1. Radial magnetizing field produced from the pole pieces of a record head.

We can now start to develop an expression which will give us the radius of the field pattern for the value of H_c. This radius is shown in Fig. 1 as R_c, and represents, of course, the boundary of the component of magnetization parallel to the tape motion. For convenience, this radius is shown also as being the diameter of a small circle inscribed within the semicircle and having a radius, r_c. If r_c is now obtained from the expression

$$r_c = \frac{2ni}{H_c}$$

then the radius of the circle is given, in terms of the co-ordinates x, y, by

$$r_c^2 = x^2 + (y-r_c)^2$$

where the field within the circle is larger than H_c and the field outside is smaller than the same critical value. This expression can now be developed to give us the radius of the critical field semicircle,

$$R_c(x=0) = \frac{4ni}{H_c}(i_B+i_S) \quad \ldots\ldots (1)$$

This very simple expression defines what Bauer calls the radius of the magnetizing "bubble" which is proportional to the instantaneous value of the bias and signal currents. There are one or two points which should be borne in mind, though, not the least of which is that separation between tape and head, which always exists to a small degree, dictates a finite bubble radius before the field enters the coating surface. In addition, the surface layers of the tape will inevitably be subjected to a largely perpendicular field, which means that this model is largely applicable to long wavelength recording.

Now we are in a position to examine the use of this model and as a first step, just to keep things in simple small steps, let us take the case of the recording process without bias.

Fig. 2 shows at the top, a longitudinal section of tape moving past the record head. A sinusoidal signal current is being applied to the coils which can have one of three values, first, small enough that the value of R_c is small compared to the coating thickness, second, equal to coating thickness and, finally, larger than the coating thickness. From the drawing, the depth of magnetization can be seen to be proportional to the instantaneous

*Assistant Editor, *Wireless World*.

value of R_c and thus for values of R_c up to the coating thickness, the playback head voltage follows a roughly sinusoidal form, although distortions are evident at the zero crossing due to the hysteresis effect in the record process.

Extending the principle to a.c. bias recording, if we imagine that only bias is being recorded and that the value of R_c is equal to the coating thickness, then the effect can be illustrated as in Fig. 3 (a), as a series of overlapping semicircular shells of remanent magnetization of opposing polarity. The net effect is zero magnetization. If a signal current is now applied with the bias current, the penetration depth of the a.c. bias shells is varied as the instantaneous resultant of (i_B+i_S) and thus, provided the bubble diameter resulting is no larger than the coating thickness, the remanent magnetization will be proportional to the recording field.

This model is also suitable for an examination of the effect of changes in bias level, since from Fig. 3 (b) it should be noted that areas of the tape are uniformly magnetized in the same direction of the recording field and that there is an increase in this area from the distant side of the coating with increasing signal level. It is also interesting to see that the surface layer of the tape has virtually a net zero magnetization which for long wavelengths is not of particular significance, but at short wavelength can be the cause of replay losses due to the separation of the recorded layer of coating from the head. Reduction in the value of bias will clearly assist in correcting this problem but will limit the maximum signal level achieved at long wavelengths.

There is another problem which can be studied with this model, and that is the effect of bias frequency upon signal recorded. This produces an overlap of the bias bubbles which, as bias frequency increases, causes a reduction in the overall magnetization. However, this is not really significant to the main function of this article and can be left aside.

In summary, changes in bias level will proportionately produce changes in the long wavelength magnetization and thus output voltage. This effect follows through until R_c= coating thickness (c) where the magnetization will begin to decrease. At high frequencies, short wavelengths recorded below the tape surface result in a spacing loss which is proportional to the depth of the magnetized layer and inversely proportional to wavelength. Reduction in bias will bring the magnetized layer closer to the surface and therefore increase short wavelength output.

Head gap and tape speed

The record gap length can affect the recorded signal as was explained in last month's article on tape heads.[9] Reference to Figs. 3 and 4 in that article shows that a change of gap length has little effect upon frequency response or distortion, provided that the tape is optimally biased. However, with the longer gap lengths bias is more critical for frequency response and remanent magnetization, while for short gap lengths low bias will produce rather larger amounts of distortion.

Changes in tape speed mean that the wavelength of any recorded signal also changes. Hence a 20kHz single cycle will occupy half the length of tape if the recording is made at half speed. This does mean that the recorded bias shells overlap a little more at lower tape speeds and in very critical cases may mean a change of bias to reach optimum condition. But most important of all is the effect of speed upon playback response, particularly at high frequencies, short wavelengths. Here the well known gap effect comes into play, where the recorded wavelength approaches the playback gap length and a null occurs in playback voltage. The expression

$$e \propto \sin\frac{l}{\lambda} \quad \ldots\ldots\ldots\ldots \quad (2)$$

can be used to calculate this effect; however, it should be used with caution since actual heads can depart from theory because of imprecise gap edges. A more valid approximation can be made for metal heads if the first null is taken to occur when $l=0.85\,\lambda$. In the case of ferrite playback heads the expression (2) can be taken to be quite accurate. Daniel describes the problems of playback losses in some detail.[8]

Tape properties

Magnetic tape can be divided into several groups and sub-groups dependent upon the function for which it was designed. For example, in the professional field where machines usually operate at high speeds and also have no pressure pads, the tape used often has a matt backing to improve the winding properties. In addition, since a recorded track can occupy the full width of the tape or, for stereo, half the width of the tape, the degree of tape-to-head contact is rather less important than durability under conditions of considerable splicing or other stresses. In such a case a heavy gauge plastic base is often used. This is very unsuitable for low speed or domestic machines where a 2/4 track combination is used and head-to-tape contact becomes much more important.

As was mentioned in the information on bias, coating thickness can be a very important parameter since it can to a large degree control the maximum output levels (m.o.l.) from the tape. More and more tapes are being classified as low noise or low noise, high output and generally speaking these refer to ferric oxide tapes where the magnetic particles have a considerably better dispersion and smaller range of particle sizes than was previously the case. Very little can be done these days to alter the composition of the basic oxide, most of the improvements being achieved in the two parameters mentioned above. This article is not really the place to go into detail about tape technology, but it should be emphasized that particle size in a coating formulation is extremely critical since for ferric oxide, at the small end of the scale (0.01μm) there is a tendency to

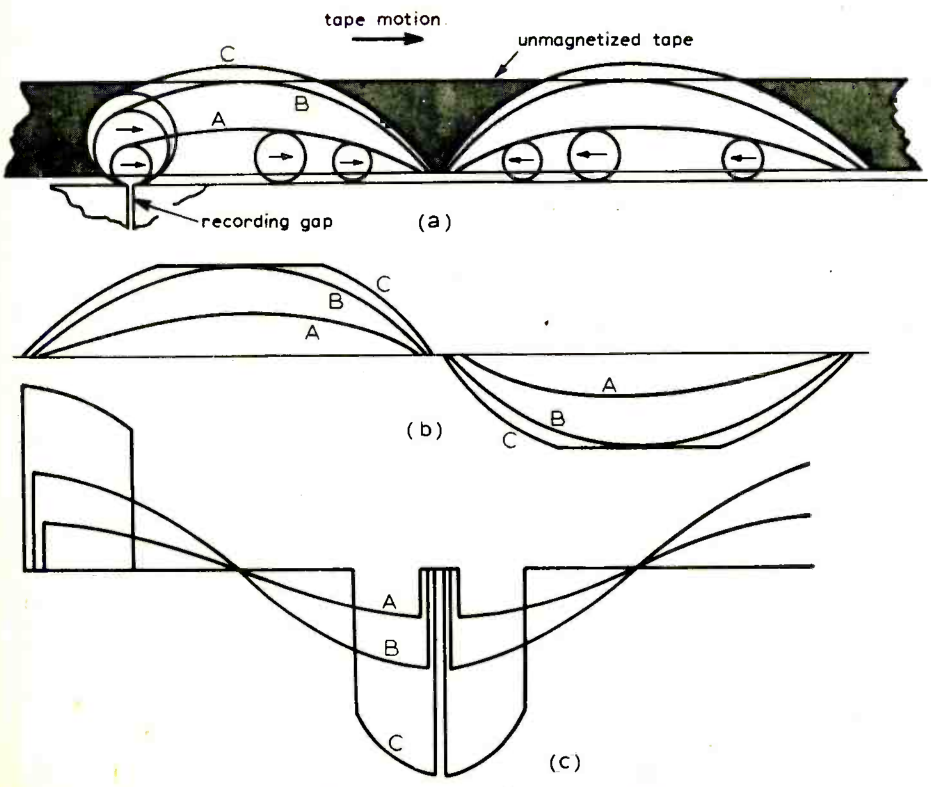

Fig. 2. Depth variable magnetization at long wavelengths and without bias.

instability due to superparamagnetic effects and at the upper end of the scale (0.2μm) multidomain effects will prevail. The tighter the tolerance in particle size and the more closely the smaller dimension can be reached, the better is the low noise performance. The additional advantage of the smaller particle size is the increased packing density possible which will increase long wavelength output.

Objectives of the investigation

For many years it has been very difficult to compare the properties of different manufacturers' tape using the data they themselves supply. The principle reason for this is the differences in test techniques adopted. In many instances it could be said that they too have entered the commercially popular "numbers game" since careful selection of parameters will produce results which show up a particular tape in a good light. Some of these problems were alleviated by the creation of the DIN standard which specifies test technique, but even so, the situation was still left a little complicated by different methods used for professional and domestic tapes and the selection of basic reference standards which were slow to move with the progress of machine and tape technology. Arguments that the DIN standard provided a basic technique for the adjustment of bias in a wide range of tape recorders do not really hold water, since it would appear that in many instances bias is used as a cure-all for defects in performance. This has been particularly noticeable in the case of cassette machines where the last hertz has been squeezed from the frequency response characteristic at the expense of distortion, long wavelength output and dropouts at high frequencies. The same to a lesser extent could be said of reel-to-reel machines and this does tend to make life very difficult for the enthusiast who is interested in overall quality rather than an extension of performance in just one direction of rather doubtful importance.

Some attempt at resolving the situation as far as tape specifications is being made by the British Standards Institution which issued in 1971 a draft specification for the testing of tape. What is just as important is that the specification also gives details of the way that the information should be presented and thus, if it is eventually adopted, we should be able to compare one manufacturer's tape with another. However, since very accurate machines are used for this function in order to measure the tape rather than tape and machine, the value of these figures to the user of a domestic machine is rather in doubt. The reason for this is that the machines themselves tend to limit the performance of the tape and thus variation in any one of the machine parameters will produce a change in the relative qualities of the B.S. tape specification.

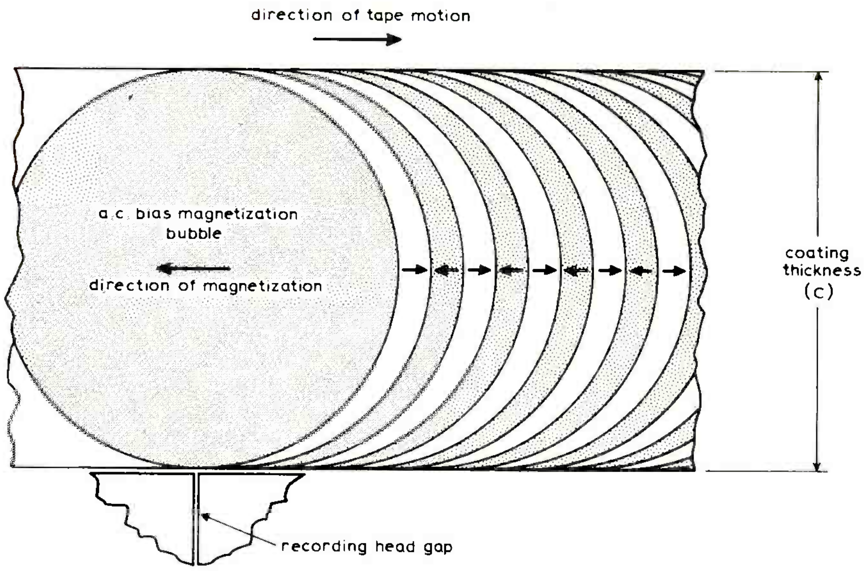

Fig. 3 (a). Recorded magnetization of bias field without signal.

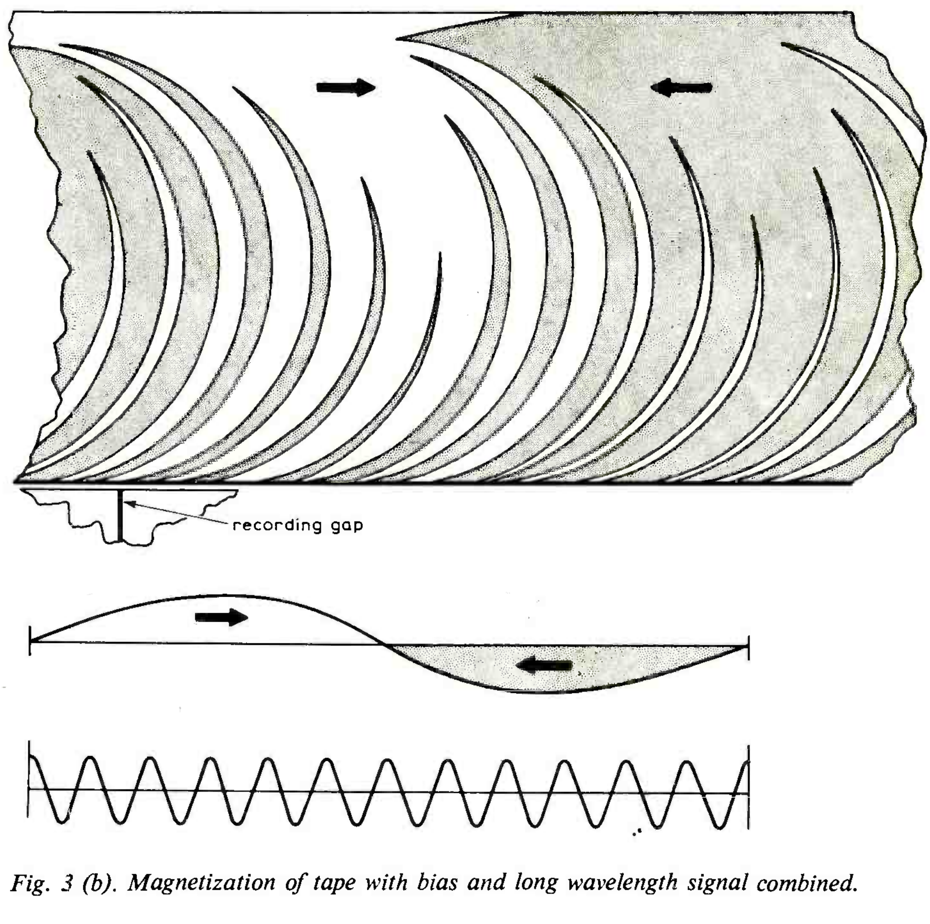

Fig. 3 (b). Magnetization of tape with bias and long wavelength signal combined.

It seems, therefore, rather foolish to try to express tape parameters in absolute terms, but rather to express them in some comparative way that allows for differences in machine characteristics. These differences may be due just to minor tolerances in setting up of individual machines on a production line, or larger performance differences due to major design differences such as record or replay head gap length or even pre-emphasis and playback equalization and tape speed. A system that copes with all these variables would seem almost impossible to create, let alone to operate, but in fact the solution may be more easily produced than at first seems possible. Such a final solution will be proposed at the end of this article, but for the moment let us concentrate upon the immediate problem in view.

In many instances new tape recorders are supplied with a sample reel of tape which represents the brand and type recommended for the particular adjustments made to the machine. Sometimes that particular tape may not be available

TABLE 1

1	0	A	X	X	X	X	A	A	A	X	A	A	A	A	A	B	A	A	A	A	A	A	A	A	A	A	A	X	A	A	A	A	B	B
2	A	0	X	A	X	X	X	X	B	B	B	A	A	A	A	A	B	A	B	B	A	X	B	A	A	A	A	X	B	A	A	A	A	A
3	B	B	+·5	X	X	X	A	B	B	A	B	A	A	A	A	A	B	B	B	A	B	A	A	A	A	A	A	A	A	X	X	A	A	A
4	A	A	X	+1	X	A	A	A	A	X	A	A	A	A	A	A	A	A	A	A	A	B	B	A	A	A	X	A	A	B	B	A	B	A
5	X	X	X	X	+1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
6	A	B	X	X	X	0	A	A	A	X	A	A	A	A	A	A	A	X	A	A	A	A	A	A	A	A	X	A	A	A	A	B	A	X
7	A	A	X	X	X	A	0	A	A	A	A	A	A	A	A	A	A	A	A	A	B	B	A	B	X	A	A	B	B	B	X	X	B	A
8	X	A	X	A	X	A	A	+1	A	B	A	A	A	A	A	A	A	A	A	A	A	B	B	A	A	X	X	A	A	B	B	B	B	X
9	A	A	X	A	X	A	A	A	+1	A	A	A	A	A	A	A	A	A	X	A	A	A	A	A	A	A	X	A	A	A	B	A	A	A
10	X	X	A	X	A	X	X	A	A	0	X	A	A	A	X	X	A	X	X	A	X	B	B	A	A	A	X	A	A	B	B	B	B	A
11	A	A	X	A	X	A	A	A	A	X	+1	A	A	A	A	A	B	A	X	A	A	A	A	A	A	A	X	A	A	A	B	A	A	A
12	A	A	B	A	X	A	A	A	A	A	A	0	A	A	A	A	A	A	A	A	B	B	B	B	A	B	X	A	B	B	B	B	B	A
13	A	A	B	A	X	A	A	A	A	A	A	A	+1	A	A	A	A	X	X	A	X	B	B	A	A	A	X	A	A	B	B	B	B	A
14	B	B	A	A	X	A	A	A	A	X	A	A	A	+·5	A	A	A	X	X	A	X	B	B	A	A	A	X	A	A	B	B	A	B	A
15	A	A	X	A	X	A	A	X	A	X	A	A	A	A	0	A	A	A	A	A	A	A	A	A	A	A	X	A	A	B	B	B	B	A
16	A	A	X	X	X	A	X	X	A	X	A	A	A	A	A	+2	A	A	A	A	B	B	B	A	A	A	X	B	A	A	A	A	A	A
17	A	A	X	A	X	A	A	A	A	X	A	A	A	A	A	A	+1	A	A	A	A	A	A	B	B	X	X	A	A	B	B	X	X	A
18	B	B	X	A	X	A	A	A	A	X	A	A	A	A	A	A	A	+1	A	A	A	B	B	A	A	X	X	A	A	A	A	B	A	A
19	B	B	X	A	X	A	A	A	A	X	A	A	A	A	A	A	A	A	+1	A	A	B	B	A	A	X	X	A	A	A	A	B	A	A
20	X	X	B	X	X	A	A	A	B	X	B	A	A	A	A	A	A	A	A	0	A	B	A	A	A	A	X	A	A	A	A	B	A	A
21	A	A	X	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	−·5	A	A	A	A	A	X	A	A	B	B	B	B	A
22	B	B	X	A	X	A	A	A	B	B	B	A	B	A	A	A	A	A	B	A	A	−1	A	B	A	B	X	A	B	B	B	B	B	A
23	B	X	X	A	B	A	B	A	B	B	B	A	B	A	A	A	A	A	B	A	A	A	0	B	B	B	B	A	B	B	B	B	B	A
24	A	A	X	A	X	B	X	B	B	X	A	X	X	X	B	B	X	X	X	B	X	X	B	+1	A	A	X	B	B	A	A	A	A	B
25	A	A	X	A	X	A	B	B	A	X	A	A	A	B	A	A	B	A	A	A	A	B	B	A	0	A	X	A	A	A	A	A	A	A
26	A	A	X	A	X	A	X	B	A	X	A	X	X	X	A	A	A	A	A	A	B	B	B	A	A	0	X	B	A	A	B	A	A	A
27	X	A	A	A	A	A	A	A	A	A	A	A	A	A	X	A	B	A	A	A	A	B	B	A	A	X	1	A	X	X	X	X	X	A
28	B	B	B	B	X	A	A	A	A	X	B	A	A	A	A	A	A	A	A	A	A	A	A	B	B	X	X	−·5	A	A	B	B	B	A
29	B	A	A	A	X	A	A	A	A	X	A	A	A	B	A	A	A	A	A	A	A	A	A	A	A	A	X	A	0	B	B	B	A	A
30	A	A	X	X	X	X	X	X	A	X	A	X	B	X	X	B	X	X	X	B	X	B	B	A	A	A	X	X	B	+2	A	A	A	B
31	A	A	X	A	X	B	X	X	B	X	A	X	X	X	B	B	B	B	B	B	B	X	X	A	A	B	X	B	B	A	0	A	A	B
32	A	A	X	A	X	X	X	X	A	X	A	X	X	X	B	B	X	X	X	B	X	X	X	A	A	A	X	X	B	A	A	+1	A	B
33	A	A	X	A	X	X	X	X	A	X	A	X	X	X	A	A	X	X	X	A	X	X	X	A	A	A	X	X	A	A	A	A	+2	A
34	A	A	A	A	A	X	A	A	A	X	A	A	A	A	A	A	A	A	A	A	A	B	B	A	A	A	X	A	A	A	B	B	B	0
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34

and so the owner seeks an alternative that produces a performance equivalent to the recommended type. If he has suitable test instruments and a knowledge of the test techniques, it is either a process of selection by trial and error testing or using the test gear to readjust the bias and, in the more sophisticated machines, pre-emphasis. Such a facility is, I feel, rare and more often than not the machine owner goes through an expensive and frustrating period of recording and listening before making the final choice.

The objective of this article is to provide a short cut in this process and give a table of equivalent tape types, enabling the user to select a new tape which will produce little change in the performance of his machine. Great emphasis should be laid on the use of the words "no change in performance", since the tables are not intended to offer alternatives which may bring about an improvement in performance — which more often than not can only be achieved by a change of tape *and* machine adjustment. Use of the tables will be described later but suffice it to say that they should provide reasonably accurate answers for tape speeds of 9.5cm/sec and 19cm/sec and most types of tape head. There will be a small variance in some instances where a very narrow-gap record/replay head is fitted.

Finally, it has proved a difficult decision to decide which parameters are of importance in determining equivalence, the final choice narrowing down to those properties which are more often noticed by the user having no instrumentation. The following comparisons were made: m.o.l. at 1kHz, this being defined as the playback signal level obtained from a tape which has produced 5% third harmonic distortion; sensitivity at −20dB below the reference flux level (32nWb/m) obtained from a correctly biased recording made on the DIN calibration tape; frequency response relative to that of the DIN tape at a range of 10 different bias settings, each separated by 1dB voltage change in a reference resistor in the head circuit, the bias setting being centred on the reference bias for the DIN tape; and the ratio of the reference level to the noise obtained after recording with bias only using a meter weighted to the I.E.C. curve.

Equivalence is considered to be obtained when a change of tape type or brand produces a change in any of the mentioned characteristics of no more than ±2dB.

Use of the Tables

Each of the tapes tested is listed in Table 2, which also gives the type of tape, e.g. single play (SP), long play (LP) etc., whether it is backed with any matt surface and the coating thickness. New types of tapes should be selected with regard to the comments made earlier in the article.

Start by looking in Table 2 for the tape you currently find satisfactory, or is recommended by the machine manufacturer — you will need the code number for use in table one.

Table one is the equivalents table where the left vertical column of numerals gives the code numbers of tapes selected from Table 2. The horizontal line of numerals gives the code numbers for equivalents selected from the table. The diagonal centre column indicates the variations in bias from that used with the DIN reference tape and is the correct relative bias for the tapes listed in the left column according to the DIN method of bias setting.

By searching along the horizontal line associated with the tape selected from

TABLE 2

Manufacturer	Tape type	Matt back	Thickness	Coating (μm)	Code No.
AGFA	PE36		LP	12	1
	PE46		DP	10	2
	PE66		TP	6	3
AMPEX	341		LP	12.7	4
	434		SP	12.7	5
BASF	PES40	√	SP	10	6
	DP26		DP	10	7
	LP35		LP	10	8
	LPR35LH	√	LP	10	9
	TP18		TP	5.5	10
	LP35LH		LP	10	11
EMI	99		LP	11	12
	88		SP	11	13
	100		DP	11	14
ZONAL	63-03		SP	15	15
	Z325P	√	SP	15	16
	Z305P		SP	15	17
PHILIPS	SP13		SP	10	18
	LP15		LP	10	19
	DP18		DP	10.5	20
SCOTCH	175		SP	12.7	21
	215		LP	10	22
	220		DP	11	23
	222		SP	12.7	24
	223		LP	12.7	25
	224		DP	12.7	26
	225		TP	6.3	27
TDK	150-7		LP	—	28
	200		DP	—	29
	1800-SD		LP	—	30
MEMOREX	600		SP	10	31
	900		LP	10	32
	1200		DP	10	33
DIN REF TAPE		√	SP	10	34

SP = Single play, DP = Double play, LP = Long play, TP = Triple play

Table 2, one sees that equivalents are marked in the vertical columns by the letter A. The letter X indicates there is no equivalence at the bias setting indicated in the diagonal column, though if the table is traced backwards, other alternatives may be offered if you are prepared to readjust the bias. For example, tracing forwards, tape 1 has the following equivalents at the bias setting for 1; tapes 2, 7, 8, 9, 11, 12 etc. However, if reverse traced from the horizontal column, tapes 4 and 6 are additional equivalents when the bias is adjusted correctly for them. The letter B indicates that if you are prepared to go to the extent of changing pre-emphasis — only to be undertaken by experts with instruments, additional alternatives could be used which may even bring an improvement in performance.

Remember, the tables are no indication of superiority, or performance of any tape; they only provide for compatible tapes which, if selected, will cause little change in overall performance. The tables will not give accurate solutions if bias settings are wildly out of adjustment and this should be borne in mind when using them.

Conclusions

Many interesting problems came to light when preparing this article which suggested an extension of this system that could be adopted by manufacturers of tape and machines alike. The original idea was first mooted in a basic form by Shirley in the Nov. 1972 edition of the *A.E.S. Journal*. Essentially it is to create a tape rating system similar to that used for photographic film. The tape could be marked with a number which describes in code form the essential data required to optimize the machine performance. The machine could be marked with a similar number (in the case of low cost products) or provided with a control covering a range of code number settings and which would optimize bias and pre-emphasis for that particular combination of tape and machine. This would leave the public free to choose brand or type in the knowledge that, if selected within the ratings suitable for the machine, optimal performance can be obtained in every case. The author is studying this idea at present.

Acknowledgments

I would like to thank Bruel and Kjaer for the loan of test equipment, and also the research, development and quality control engineers with the tape companies concerned for their valuable advice and assistance.

Appendix

The draft British Standard proposal mentioned in the text of this article is significantly different in several respects to the DIN standard currently used by European manufacturers and the NAB Standard used in America. Perhaps the most critical factor in the whole of the proposal is that which relates to the Standard Reference Tape to which all comparative measurements refer. There is a general tendency for people to think that whoever makes this tape must therefore make the best quality tapes. This is something of a fallacy, although it is true to say that the tolerances placed on the various recording properties of the tape are very difficult to meet from batch to batch.

As demonstrated in the foregoing article, it is precisely the same non-compatibility problem, arising from the very individual and secret methods used by each manufacturer, which prevents manufacturers making identical tapes which can be used as a reference. For this reason it may be some time before final agreement on the proposal can be reached.

For domestic tapes, the following parameters are suggested by the B.S. Committee as being suitable for incorporation in any published data sheet. The first item is reference bias which is defined in a new way. To quote, it is "That bias current which results in an output 10dB lower at a specified frequency (10kHz) than at 315Hz as shown on the maximum output level curves taken at those frequencies; expressed as a ratio relative to the reference bias current of the reference tape". The maximum output level at 315Hz is the 5% third harmonic distortion point, and the maximum output level at 10kHz is the point at which 20% intermodulation distortion or 1.5% of compression occurs. This technique of biasing is claimed to produce more repeatable and accurate results than the DIN method.

Also specified for the data sheet are the

Fig. 4. As yet chromium dioxide has not been produced in a reel-to-reel form; however its magnetic characteristics are different to ferric oxide and represent a considerable step away from compatibility. Many of the changes in the properties are attributable to the differences in physical structure shown here on the left in comparison with ferric oxide (right). Note the cleaner, more needle-like appearance of CrO_2 and the more regular distribution of particle size.

maximum output levels, the relative tape sensitivity at 315Hz, 1kHz, 6.3kHz and 10kHz, together with another new and interesting item called reverse tape sensitivity.

It sometimes happens that due to problems in the alignment of magnetic particles at the manufacturing stage, the tape sensitivity may be slightly different in one direction of travel to the other. This is clearly undesirable and so data on this characteristic could be valuable to the recordist. However, the only people likely to be producing tape specifications of the type envisaged in the draft proposal are manufacturers and they would be naturally keen to cure the fault. We can thus expect a uniformly high standard in this easily achieved parameter. Uniformity, that is dropouts and changes of sensitivity within the reel and from batch to batch, also have to be specified together with signal-to-noise ratio, signal-to-d.c.-noise ratio, print through at 20°C and erasability. Of particular interest are the signal-to-noise measurements and the erasability test, since test techniques have been somewhat variable and arbitrary in the past.

Signal-to-noise ratio is defined as "the ratio expressed in dB of the maximum output level at a specified frequency with reference bias to the weighted bias noise level." The weighting characteristic to be used is specified in the draft proposal and corresponds to the C.C.I.R. characteristic. The d.c. noise level referred to in the second of the noise measurements corresponds to "the noise level resulting from the application to the head of c.c., a direct-current equivalent to the r.m.s. value of the current required for the maximum output level at a specified frequency with reference bias". Finally the erasability presumably refers to the ease with which the tape is erased, no more definite indication can be given since the draft notes that this item is still under consideration.

Several other items of importance are called for, dealing with such pieces of information as the base and coating thickness and of course, the manufacturer's name and the type number of the tape.

This B.S. draft proposal is currently under consideration at the I.E.C. and it is to be hoped that it will be adopted in the near future. However, I do have grave misgivings about the tape machine manufacturers' use or rather misuse of the bias setting information. If current practice is anything to go by, they will devise bias settings which will show their machines up in the best light regardless of the consequences for overall quality performance of tape and machine. It is certainly true that a new look is needed at the methods used for specifying and presenting data on the performance of a tape machine.

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Festival du Son

As it is the first major exhibition of audio products in the European audio show calendar, the Paris Festival du Son normally offers some pointers as to what is likely to happen during the year. This year's show was rather more lively than in the past as interest among engineers is high both as to the fate of the various and so-called four-channel systems and to the progress of domestic tape package equipment (i.e. the cartridge and the cassette).

Last year O.R.T.F., the French equivalent of the B.B.C. conducted a number of not very rigorous but very interesting psycho-acoustic experiments on the results obtained from four loudspeakers at the exhibition (*W.W.* May 1971 p. 244). These were apparently inconclusive, and the effects are certainly negative in as much as few French companies displayed any interest in the subject. However, they have at least caused commercial interests there to adopt the word *Tetraphonie* in preference to Quadraphonic — spelled in goodness knows how many versions which will please a number of particular people.

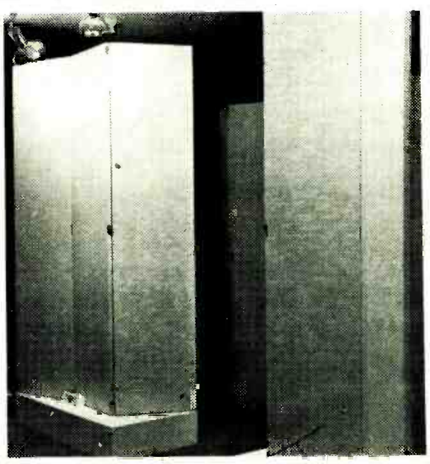
New four-channel receivers and other equipment were shown by a number of companies including Sanyo, so far not in the receiver market although they have shown matrix equipment before. National (Matsushita) provided the most comprehensive range, however, since they are determined to cater for their CD-4 system and matrix systems. Model SA 6800X is a top-of-the-line unit, certainly in terms of price, with four amplifiers, and matrix synthesizer together with a selector to vary the phase angle of the rear outputs from zero to 90° or 180°.

Like most French loudspeakers, the Japanese products used to demonstrate these no doubt excellent electronic units produced the most excruciating and unmusical noises imaginable. Needless to say, all the four-channel systems are being advocated as suitable for a wide listening area, without the slightest justification, and never any reference to the type of loudspeaker employed.

Tape cassettes are making great strides, mainly with help of Ray Dolby's invention and Japanese production technology, and Sanyo and Matsushita both stole the cassette hardware limelight with new products. Sanyo's machine employs a d.c.-servo direct-drive capstan, offers all the (by now) usual facilities such as CrO_2 equilization (not 50 μ s) as well as the gimmicks that are so easy to attach to logic-controlled mechanical functions such as "memory rewind", automatic stop which doesn't tear the tape from the reel, and touch rather than push-button control.

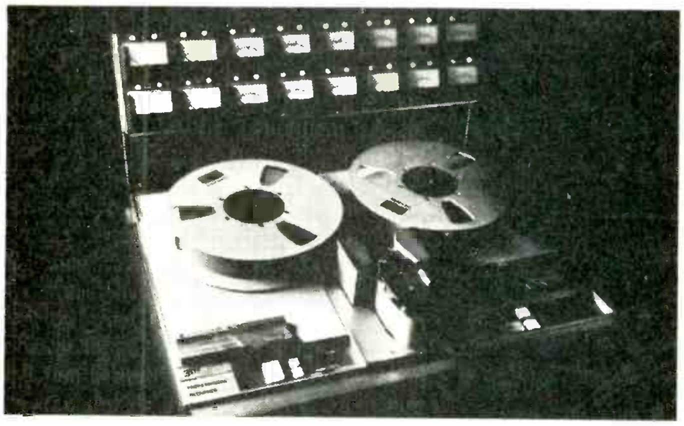
British contributions were mainly in the field of *la Tetraphonie,* with new equipment from Garrard and Tate (part of Connaught Equipment the Cambridge based o.e.m. firm which is part of the C. E. Hammond empire). Tate were demonstrating an SQ decoder and amplifier unit as well as some of the boards they manufacture.

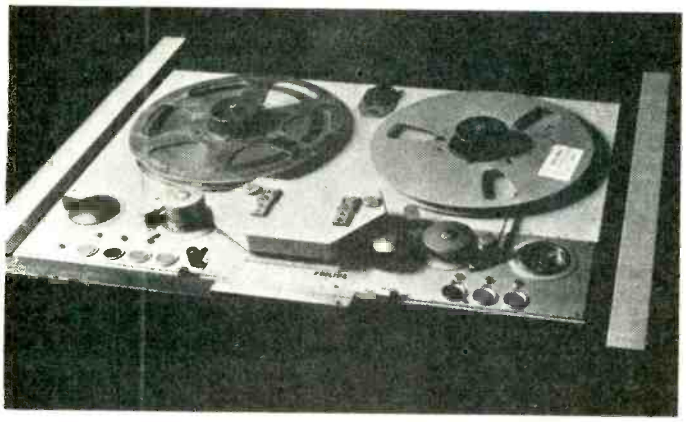
Two of their players are now available on plinths, the Zero-100 offering SQ and discrete playback facilities, selected with a push-button neatly placed by the unit's controls, while the SP25 employs an SQ decoder only. These prototypes were fitted with discrete-component decoders, but it is intended to employ the Motorola logic and matrix i.cs for the SQ circuitry (see pages 114-7, March issue). R.F.J.

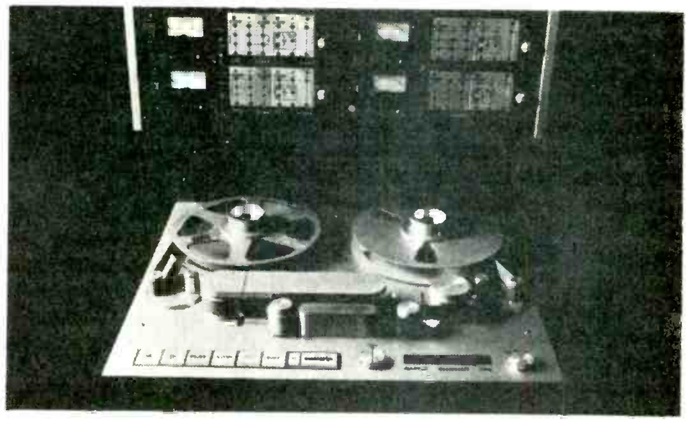


US-made Magnaplanar loudspeaker employs plastics diaphragms with printed coils — like Wharfedale's Isodynamic headset. But they're the size of a door and the price of house — £1200 a pair. Sound superb though.

They're not much use without us.







There's nothing quite so frustrating in this world as a tape recorder without tape.

So BASF make a tape for every tape recorder manufactured anywhere in the world.

Everything from $\frac{1}{8}''$ LH cassettes right through to 2″ tapes for all major studios. More than 128 different types in all.

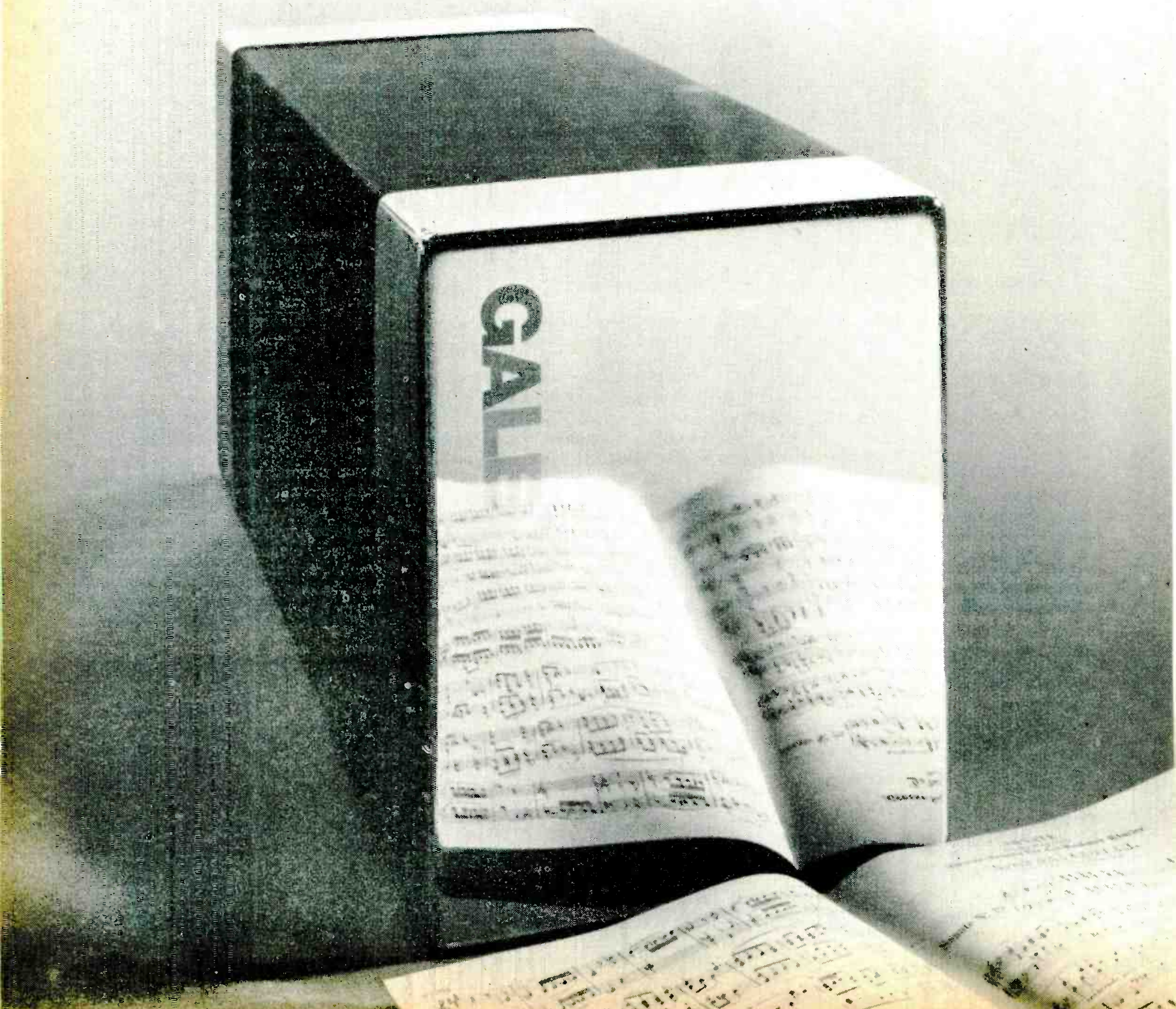
Which is not really surprising when you think that BASF were the first company in the world to make tape.

So if you've got a tape problem — we've got a tape answer — call us and see for yourself.

BASF United Kingdom Limited,
Knightsbridge House,
197 Knightsbridge,
London SW7 1SA
Telephone: 01-584 5080

BASF

WW—077 FOR FURTHER DETAILS



New Products

in sizes from $\frac{1}{8}$in diameter to $\frac{9}{16}$in diameter, and are interchangeable. The racks incorporate heatsink devices which prevent excessive temperature rise, and hold bit temperatures to approximately the same as when soldering. The design is such that two different temperatures can be maintained on the same iron merely by exchanging heatsinks. Prices range from £2.90 for a 20W iron to £6.50 for a 130W unit. Tele-Production Tools, 28B Hamlet Court Road, Westcliff-on-Sea, Essex.
WW319 for further details

Multi-channel pen recorder

Chessell Ltd announce the introduction of the model 320 continuous-line multi-channel pen recorder. The new recorder, which is designed to D.I.N. standards, will produce up to six continuous traces on a calibrated chart width of 250mm. Claimed to be physically the smallest of its kind on the U.K. market, the instrument is designed for panel mounting. Plug-in amplifier modules accepting over two hundred different ranges and types of signal and servo drive pen mechanisms together with optional features, such as ten-speed electronic chart drive, high and low alarm limits, event markers and re-transmission signal facilities are offered. Chessell Ltd. Broadwater Trading Estate, Southdownview Road, Worthing, Sussex BN14 8NL.
WW308 for further details

Termination wattmeter

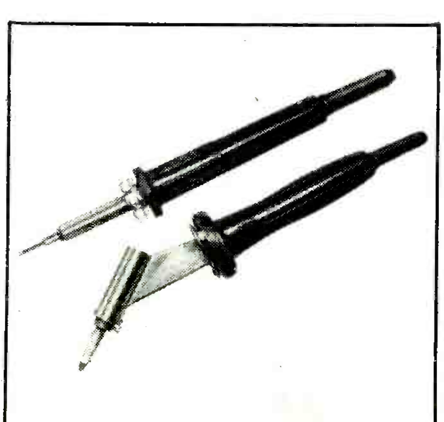
The 2601 portable, true r.m.s. reading wattmeter designed and manufactured by Green E.C.E. Ltd enables power measurements from 50mW to 300W to be made over the frequency range d.c. to 500MHz.

Switch-selected power ranges are provided covering 300mW to 300W f.s.d. Accuracy is ±5% of f.s.d. from d.c. to 200MHz and ±10% from 200MHz to 500MHz. The instrument has been designed to withstand overloads of up to 60W on the 300mW, 1W and 3W ranges and 500W on the 10W, 30W, 100W and 300W ranges. True r.m.s. power measurements are indicated on a linear scale. The detection element is a thermocouple which is insensitive to modulation peaks, short term instability and spurious signals. A switch-selected peak detector (diode) facility with a sensitivity control is included. This provides instantaneous indication of any change in input power — a facility which is useful, for example, when tuning a transmitter for peak power output. A demodulated output is provided for modulation analysis purposes.

The internal nickel-cadmium battery provides eight hours of operation and is charged automatically when the instrument is operated from a mains supply of 115-240V, 60Hz-50Hz. Accessories available include an impedance matching transformer to enable the wattmeter to be used with 75Ω equipment. The continuous rating of the load unit can be increased to 150W by the addition of a forced-air cooling blower-motor unit. Two versions are available, one for attachment to the underside of the instrument and another for attachment to the side when a standard rack mounting configuration is required. Dimensions: 20 × 9 × 25cm. Price: £295.00 ex works. Green Electronic & Communication Equipment Ltd, 5-15 Thorold Road, London N22 4YE.
WW309 for further details

Long-life soldering irons

Stiron soldering irons, now marketed by Tele-Production Tools, feature stainless steel element bobbins to minimize the oxidation of bit chamber and element cylinder, avoiding bit seizure, a common cause of iron mis-function. The irons are light and well-balanced, and feature nylon handles which remain cool to the touch even after many hours at soldering temperatures. This low heat transference is achieved by incorporating a heat buffer between handle and bit chamber, while the heating element is itself insulated by temperature-resistant mica and glass yarn. Irons are available in ratings from 20W to 130W, and feature fast heating-up times and steady free-air bit temperature. Iron plated bits with a variety of screwdriver, chisel and profile tips can be supplied



Transistor tester

Avo have introduced a transistor tester, TT169, designed specifically for simple go/no-go *in situ* testing of p-n-p and n-p-n signal or power transistors, diodes and thyristors. It is a lightweight instrument, small enough to be held in the hand and simple to use.

The tester is battery-powered and front panel indicators illuminate to identify satisfactory or faulty devices. The low operating voltage ensures that all types of device can be tested without risk of damage, even if the tester is misused. Battery replacement is easily carried out when required and a simple self-check procedure immediately indicates serviceability of the tester.

The TT169 is supplied with all the necessary leads and connectors in a plastic case, at a U.K. trade price of £15, plus v.a.t., from radio wholesalers and distributors. Avo Ltd, Avocet House, Archcliffe Road, Dover, Kent.
WW317 for further details

General purpose receiver

After 49 years of production of valve receivers, Eddystone Radio announces that the last of its valve equipments, the world-famous 830 general purpose receiver, is to be phased out of production. It will be replaced by a solid-state range of receivers, the 1830 series. Basically similar to its predecessor, it provides gapless coverage on c.w., a.m. and s.s.b. from 120 kHz to 30MHz and is suitable for mains or floating battery operation. Size and weight have been reduced and versions are available providing up to 50 crystal-controlled channels. All models can be sythesizer-driven.

All variants of the 1830 employ the same basic circuit configuration, using solid-state techniques throughout and following current modular practice. Input protection is provided by an f.e.t./m.o.s. f.e.t. front end, designed to withstand 30V r.m.s. Eddystone claim that a highly advanced circuit design is employed, using single-conversion on the low frequency ranges and double-conversion at frequencies above 1.5MHz. The first i.f. is tunable when using double-conversion and provides an incremental tuning facility with a coverage of 50kHz above and below any frequency selected on the main tuning scale. A crystal calibrator is fitted, allowing frequencies to be read to within 1kHz after standardizing the main scale at the nearest 100kHz check point.

Two independent first oscillators are provided, one for manual tuning and the other for crystal-controlled working in the band 1.5 to 30MHz. Crystals are housed in a plug-in crystal box which is fitted through an aperture in the front panel. Ten switched crystal holders are provided and interchangeable boxes are readily available if more than ten channels are needed to satisfy operational requirements. An alternative version is available, the 1830/2, equipped with five integral switch-selected crystal units, providing a total of fifty channels.

The incremental first i.f. tuning facility can be retained when the first oscillator is crystal-controlled, so relaxing the usual requirements for precise choice of crystal in this mode of operation. Alternatively, the second oscillator can also be fitted with a crystal to permit fully unattended high-stability operation. Both first oscillators can be disabled to allow use of an external synthesizer for frequency control.

Selectivity is adjustable to suit signal mode and a crystal filter is available for narrow-band c.w. reception. A separate detector is included for c.w./s.s.b. working. At s.s.b., the carrier insertion frequency is selected automatically, fine adjustment being possible by use of the b.f.o. control which operates with reduced coverage in this mode. A noise limiter is fitted, and the 100kHz i.f. output is available for connection to ancillaries such as the Eddystone solid-state panoramic display unit, 961A.

Separate a.g.c. systems are employed for the r.f. and i.f. stages, the i.f. a.g.c. being used also to operate an integral carrier-level meter, i.f. a.g.c. is brought out for inter-connection when using receivers in dual-diversity installations. Separate manual i.f. and a.f. gain controls are provided.

Audio outputs are available for loudspeaker, headset and lines, the line output being fed from an independent low-level amplifier with adjustable pre-set gain control. A small monitor speaker is fitted and all external connections, with the exception of the headset socket, are located at the rear.

The receivers can be powered directly from any 12 volt source and have internal power units for operation from all standard a.c. supplies. Eddystone Radio Ltd, Marconi House, Chelmsford CM1 1PL.

WW301 for further details

Integrated instrumentation

The BWD model 602 being marketed by Racal Instruments combines eleven separate instruments with three a.c. sources in one low cost unit. The range of outputs available provides for demonstrations or experiments such as the study of modulated waveforms, provides up to 8W to drive a lamp, loudspeaker or relay, or modulate a light source to demonstrate photoelectric effects. For convenience in setting up repetitive experiments, as in teaching applications, most of the outputs are available at a rear panel octal socket, enabling a single plug and cable to connect up complex equipment with a minimum loss of time.

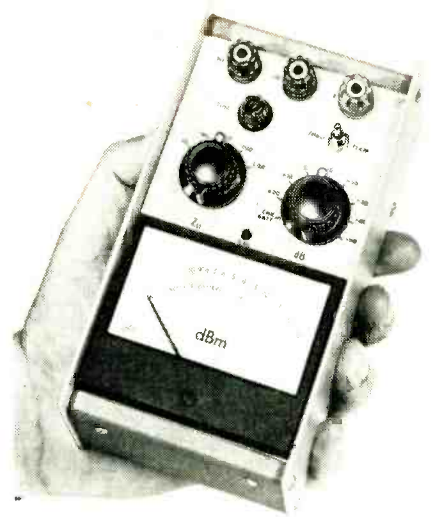
Simultaneously available facilities include 0.5Hz to 500kHz sine and square waves, a ×5 to ×100-gain amplifier with a bandwidth from 1Hz to 50kHz, +300V/35mA and minus 0-50V/1mA stabilized power supplies together with 55V, 15V and 6.3V all at 1A a.c.

Available simultaneously with the above by switch selection are 1 to 12V/2 amp or 12 to 24V/1 amp d.c. stabilized power supplies together with an 8W d.c. to 20kHz amplifier. Link connections make it possible to provide a 0.5Hz to 20kHz oscillator, an 8W square wave generator, a 500Hz to 500kHz amplitude modulated oscillator and a high-sensitivity 20kHz amplifier. The model 602 is priced at £150. Racal Instruments Ltd, Duke Street, Windsor, Berks SL4 1SB..

WW311 for further details

Hand-held decibel meter

The Hatfield hand-held decibel meter, type 1008, is a comprehensive test instrument for transmission and general level measurements. Using a taut-band meter, the 1008 provides a wide measurement range (+21 to −60dBm) and versatile input arrangements (75, 140, 600, 900 and



1200Ω bridging and terminated, balanced and unbalanced) over a frequency range of 20Hz to 150kHz. Power comes from two internal layer type batteries providing a life in excess of 50 hours if used intermittently. Hatfield Instruments Ltd, Burrington Way, Plymouth PL5 3LZ.

WW310 for further details

Solid state relay

F.R. Electronics have increased their range of solid state/hybrid relays by the addition of a plug-in relay. Fully encapsulated with a standard eight-pin octal base, the relays have a switching capability of 6A up to 240V a.c. The relay design permits easy chassis layout and also gives compatibility with electromechanical relays.

F.R. Electronics suggest that the plug-in relay should be used in place of electromechanical relays where inductive or capacitive loads are switched and life expectancy considerably in excess of electromechanical relays is required. Control is by a 5, 12 or 24V d.c. supply with a current drain of approximately 10mA. Switching Components Group, F. R. Electronics, Wimborne, Dorset BH21 2BJ.

WW302 for further details

Wirewound potentiometers

The Model 534, wirewound potentiometer (0.75in long), now available from Spectrol Reliance is claimed to meet almost every application in the 10Ω to 200kΩ resistance range. This "universal" potentiometer has been developed and designed to give maximum flexibility and versatility from a single model. It is available in three basic versions: 3 turns, 5 turns and 10 turns.

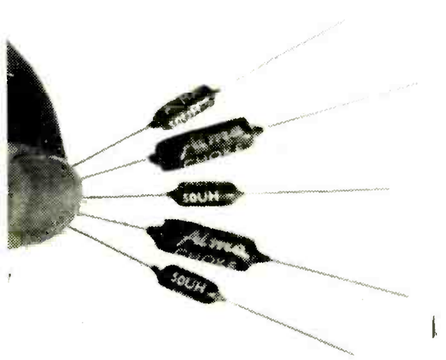
Basic standard design features include: rugged construction; no glued joints; 75oz-inch stop strength: thermoset plastic housing; stainless steel front lid and steel shaft; parallel gap welded terminations; only 5 basic assemblies; bushing or servo mount and availability of one- and two-section units.

This potentiometer also offers the component engineer a wide range of special features: many variations in mountings and shaft configurations; reduced bushing and shaft diameter combinations; dual concentric shafts; variations in shaft diameters resulting in steps and flats; rear extensions and optional front extensions, as well as non-metallic shafts and split lock bushings. Other special features include lead wire terminals, multiple ganging and non-linear functions. Spectrol Reliance Ltd, Drakes Way, Swindon, Wilts.

WW303 for further details

R.F. chokes

Alma announce a range of miniature r.f. chokes wound on non-magnetic, iron dust or ferrite core material. All windings are single layer protected by a black fluidized bed resin coating. Four types are offered covering the inductance range

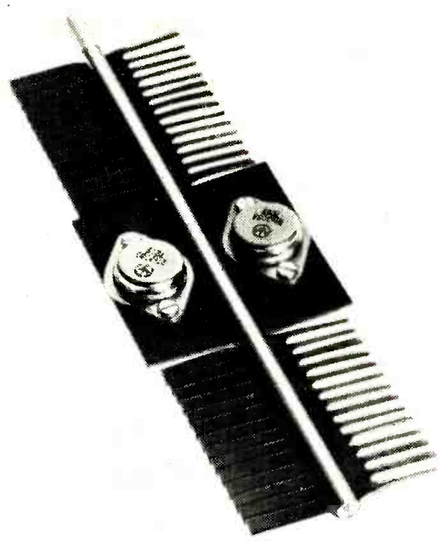


of 0.2μH to 2mH with d.c. resistance from 0.01Ω to 270Ω. User requirements can be wide and thus special chokes can be designed to meet particular customers' specifications. Alma Components Ltd, Park Road, Diss, Norfolk, IP22 3AY.

WW 315 for further details

Heatsinks

New from Redpoint Associates is a novel design of heatsink. Conventional high performance heatsinks are large and heavy. Flat plate heat pipes are one solution, but generally an expensive one. Where size and weight are of importance, the Redline series is claimed to offer an efficient, economical alternative. The heatsink comprises an assembly of twisted vane surfaces mounted on a tubular heat pipe, thereby combining the advantages of both. The result is a small, lightweight heatsink capable of high performance in any attitude. Attachments

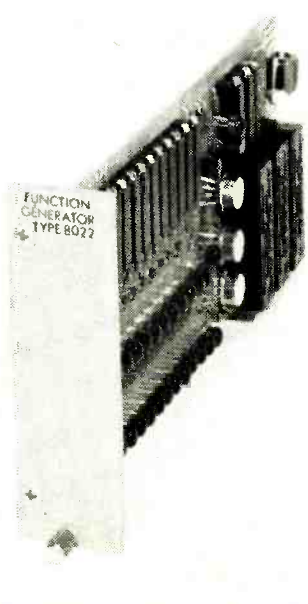


are available for a range of devices including d.i.l. i.cs. The example shown in the photograph designated the L2220 is 200 × 60mm, weighs 60g., accepts two TO-3 devices and has a thermal performance equal to that of a conventional heatsink three times its weight (e.g. the Redpoint 4M). Forced convection performance is 0.3°C/W. Price £12.00. Redpoint Associates Ltd, Cheney Manor, Swindon, Wilts.

WW 316 for further details

Arbitrary function generator

The arbitrary function generator type 8022 can be set up to develop any positive-slope arbitrary function. It may thus be used to linearize signals and to introduce non-linearities or empirical relationships into analogue computers, simulators, control and instrumentation systems. Eleven straight line segments are used to provide a close approximation to the required function, the slope of each segment being adjustable by a potentiometer. Transistor switches, programmed to operate at 1V intervals along the X axis, determine the breakpoints. Values of



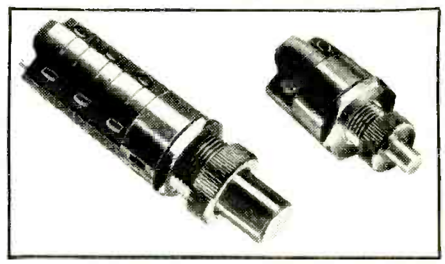
feedback resistors may be changed to modify the gap between breakpoints, permitting greater slope or more accurate following of rapid slope changes. Parallax and offset inputs are available for full four-quadrant operation.

The 8022 is fully compatible with System 8000 and with other modern analogue/hybrid computing equipment. It incorporates full system monitoring facilities, permitting the unit to be checked in the rack. Price £110. Computing Techniques Ltd, Brookers Road, Billingshurst, Sussex RH14 9RZ.

WW307 for further details

Push-button switches

Highland Electronics announce the introduction of a range of miniature illuminated, series 11, and non-illuminated, series 21, push-button switches. They are designed to meet the demand for push-button switches for electronic devices, instruments and controls which can be operated directly from mains voltage or low logic levels. All switches and annunciators have round fixing holes and can be



mounted from the rear directly on front panels or on rear sub-assemblies. They are claimed by the makers to be capable of 200,000 load switching operations. Up to 3-pole changeovers are available per switch, with gold-plated terminals and a maximum switching capability of 5A, 240V a.c. non-inductive loads.

These switches have impulse and step actions, the step action switches giving mechanical indication of state. Two designs of decorative mounting rings can be supplied and also six colours of screens or caps for each series. Highland Electronics Ltd, 33-41 Dallington Street, London EC1V 0BD.

WW 305 for further details

Switching-regulated power supplies

A series of transistor-switching regulated power supplies have been added to the Hewlett-Packard range of modular units. Nine voltage outputs most often used in system and computer applications are available in this 62600 series. Output ratings range from 4V, 160W to 28V, 300W. All units deliver full rated output to 50°C, with linear derating by only 50% at 71°C.

A 20kHz transistor switching circuit is employed in these new supplies. The design takes advantage of the foremost virtue of the switching regulator, namely efficiency. At the same time, it holds down ripple and noise to levels compatible with most low-voltage applications including computer mainframes, digital systems, and systems for industrial process automation. With operating efficiencies up to 80%, only a small percentage of power is converted to heat. Thus the units can be packaged in half-rack width cases (5 × 8 × 11½in). Thermal effects on other system components are also reduced.

All nine models are specified to 0.1% line or load regulation, 20mV r.m.s., 60mV p-p ripple and noise, and 3ms transient response following a load change from 100% to 50% and 50% to 100%. Overvoltage, overcurrent and overtemperature protection are standard features on all models.

For systems applications, the overvoltage protection circuit can be tripped by an external trigger pulse, and can initiate a pulse when the circuit is triggered from within. Also for systems applications, the supply can be programmed with a contact closure. This allows turn-off and turn-on sequencing of several power supplies. Hewlett-Packard Ltd, 224 Bath Road, Slough, Bucks, SL1 4DS.

WW304 for further details

High track-density digital heads

The magnetic tape recording division of SE Laboratories (Engineering) Ltd at Wells, Somerset, now offers high track-density digital magnetic heads for use with its own and other magnetic-tape recording systems. The standard formats are 16 tracks on 0.5in tape and 8 tracks on 0.25in tape. The track spacing is 0.030in, the write track is 0.015in wide and the read track 0.010in wide. The heads are claimed to have high dimensional track consistency and the gap scatter is better than 100μ in. They are suitable for operation in temperatures up to 70°C. "Read" and "write" heads can be supplied with inductances and gap lengths suitable for numerous types and densities of digital recording. SE Laboratories (Engineering) Ltd, Wells, Somerset BA5 1AE.

WW314 for further details

Battery powered, i.c. op-amp test oscillator

A new pocket-size, 1kHz fixed frequency test tone oscillator using i.c., operational amplifier circuitry is available from Fairchild Sound Equipment Corporation, a subsidiary of Robins Industries Corp., of Commack, L.I., N.Y.11725. The oscillator, model TG-10, is designed for professional and semi-professional use in service testing of the most sophisticated audio systems. Applications include setting system levels, testing circuit continuity, measuring distortion and serving as a cue tone generator and frequency reference.

The TG-10 is also a balanced source for mixer patch bays providing a line level or microphone level signal.

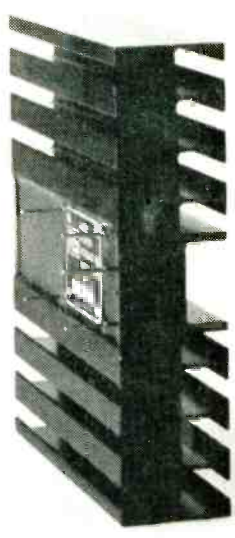
Output is 4dBm into 600Ω or 0dBm into 150Ω, continuously variable. Distortion is less than 0.1%.

Screw terminals for connecting wires and a jack for a 0.25in, three-wire ring tip and sleeve patch cord are provided. The case is aluminium and contains a 9V battery. Dimensions 3in × 4in × 1.75in. The TG-10 is priced at $69. Fairchild Sound Equipment Corporation, 75 Austin Boulevard, Commack, L.I., N.Y.11725, U.S.A.

WW312 for further details

High power voltage regulator

From RS Components an unusually designed, high power (35W) voltage regulator with integral heatsink. It operates over the voltage range of 1-30V up to 2A. There is a built-in fold-back overcurrent and short circuit protection, and little need for external components. All components for this supply are available from RS and there is also a transformer



specially designed for the device. Typical parameters at 25°C are: 0.3% load regulation (0 to 1A), 0.2% line regulation (5V change), ripple and noise 500μV max at 1A and temperature co-efficient ±0.03%/°C. The regulator is priced £7.80 and the transformer, £3.50. RS Components Ltd, P.O. Box 427, 13-17 Epworth Street, London EC2P 2HA.

WW306 for further details

Card frames

Imhof-Bedco have developed a new range of low-cost sub-racks for high density packaging of p.c.bs. These include models to accept 100 × 160mm cards in either single or double banks and models to suit all sizes of Imcard. Also, provided reasonable quantities are involved, they can be supplied with the deck plates repositioned to suit virtually any other card size. All deck plates have guides and connector mounting facilities on 82 stations of 5.08mm (0.200in) pitch, thus allowing any arrangement that is a multiple of this dimension to be used. On most models connections may be simply fitted direct to the deck plates and tapped strips are optionally available to facilitate fixing. On the Eurocard models additional mounting rails are incorporated — the type varying to the connector selected. The frames, which are supplied in easy-to-assemble kit form, are of steel construction and are finished with the side panels in textured paint, all other parts being zinc plated and clear passivated. Imhof-Bedco Ltd, Ashley Works, Ashley Road, Uxbridge, Middx UB8 2SQ.

WW338 for further details

Delay timer modules

Deltic Automation have announced the introduction of an improved range of general purpose timer modules constructed on the printed circuit board principle. These timer modules provide a time delay output and are available for operation direct from both a.c. mains and d.c. supply voltages. Design features provide a long term stable timing performance; the modules are claimed to be virtually unaffected by fluctuations of supply voltage, changes of a.c. mains frequency or variation of temperature. Output switching is provided by single pole changeover silver cadmium oxide relay contacts. Gold flashed silver contacts are also available. Five basic time ranges are offered, covering 0.1s to 330s, with five standard a.c. and d.c. timer supply voltage ranges covering 10V d.c. to 260V a.c. 50/60Hz. 100-off price £2.45 each. Deltic Automation Ltd, Tillys Lane, Staines, Middx.

WW337 for further details

Low-cost multimeters

Cosmocord have introduced two multimeters to the U.K. market, and will shortly commence manufacture in this country. The US-110, which possesses a 10μA meter movement, provides direct voltage ranges of 100mV to 250V full-scale, alternating voltage from 2.5V to 1000V full-scale, direct current up to 100mA, resistance measurement and a decibel scale (0dB = 1mW into 600Ω). A lower-cost instrument, the TH-12, is fitted with a slide switch (with an excellent detent mechanism) for function and range selection. The meter

movement is 50μA, ranges being proportionately limited with respect to the US-110. Meter protection is by means of a fuse. Both instruments are encased in ABS plastic mouldings, the TH-12 costing £6.50 and the US-110 £16. Cosmocord Ltd, Acos Works, Eleanor Cross Road, Waltham Cross, Herts.
WW 318 for further details

100MHz digital counter/timer

AMF Venner have increased the specified maximum counting rate of their Model 7737A digital counter from 80MHz to 100MHz with no increase in selling price.

Model 7737A is the most comprehensive of the "77" series. AMF Venner's range of counters utilizing purpose-designed m.o.s. l.s.i. modules for counting and dividing functions. It measures frequency up to 100MHz with input levels of 50mV or more, and below 80MHz it has an input sensitivity better than 10mV. The instrument also measures waveform period or multi-period at frequencies up to 1MHz and time interval with single-line or two-line start/stop input to 100ns resolution. Additional facilities include frequency-ratio measurement and event counting, either continuously or over a gated time interval.

The readout is a seven-digit in-line display with automatic positioning of the decimal point, and the instrument features a switchable display-storage memory.

A feature of this counter is its adjustable trigger level, enabling the user to set the input voltage at which the counter trips, so that noise and spurious transients do not affect the measurement.

Unusually, the counter presents an economic flexibility in the availability of a choice of built-in frequency references. The standard instrument is fitted with an internal 10MHz crystal reference oscillator with a maximum drift of ±5 parts per million over the temperature range — 10° to +55°C. The counter can, however, be supplied with either of two optional reference oscillators having stabilities of ±1 part per million and ±0.3 parts per million respectively. Venner, a division of AMF International Ltd, Kingston By-Pass, New Malden, Surrey.
WW 313 for further details

Solid State Devices

G. E. Electronics (London) are distributors for Crystalonics and announce the CV5000 series of High-Q Varactron voltage-variable capacitance diodes. Typical minimum Q as high as 450 at 50MHz, 30V d.c. ratings and low leakage current are features offered. Price is 34p each for 100 to 499 off.

Crystalonics have also introduced the CD125 series of monolithic 6-channel f.e.t.-switch drivers which are designed to perform the function of amplification and d.c. level shifting required between low level logic and m.o.s. or junction f.e.t. switches. G. E. Electronics (London) Ltd, Eardley House, 182/184 Campden Hill Road, Kensington, London W8 7AS.
WW320 High-Q Varactron
WW321 Switch drivers

A 4096-bit static m.o.s. read-only memory is available from Signetics in a 512×8 organization for microprogramming and code-conversion applications. The device is known as the model 2530 and has t.t.l.-compatible inputs and outputs and requires a +5V and −12V power supply.

Two high-speed logic interface devices, the 10124 quad differential line driver and the 10125 quad receiver are also available in quantity. Prices for both devices are £1.80 for 100 off in plastic encapsulation, £2.00 for 100 off in ceramic. Signetics International Corporation, Yeoman House, 63 Croydon Road, London S.E.20.
WW322 4096 bit r.o.m.
WW323 quad receiver and driver

New from Westinghouse is an addition to their range of Hyreg thick film modules. This is the AR2 single-phase a.c. regulator with a load capability up to 3.75kW from the mains supply and a surge-current rating of 175A.

A range of silicon diodes is also announced, all with a reverse recovery time of 40ns max. Types are available with reverse voltage ratings of 50-200V_{RRM} in 50 volt steps and mean forward current ratings of 10A, 6A, 2.2A and 1A. Westinghouse Brake and Signal Company Ltd, Chippenham, Wilts, SN15 1JD.
WW324 a.c. regulator
WW325 silicon diodes

Transistor AG, of Zürich, announce a range of five s.c.rs having an operating current capability of 800mA. The type numbers are BRX44 to BRX48 the variation being in the voltages which are 30V, 60V, 100V, 200V and 300V.

In the range for 1.6A r.m.s. two types in TO-39 metal casing are available. These are designated TAF520 and TAG521 and are available in voltage groups of 50V, 100V, 200V, 300V and 400V.

A plastic package rectifier in the TAB range is introduced, with a repetitive p.i.v. up to 1250V and an average forward current of 10A with T_C (case temperature) of 100°C. Also offered is a fast recovery 10A diode with a p.i.v. up to 1000V. Guaranteed recovery time at T_C=25°C is 300ns max.

Triacs from Transistor AG include current groups from 1.6A to 12A and are of "glassivated" type. This process involves producing multiple "glass"-filled grooves around the p-n junctions to give protection and stable blocking characteristics. Transistor AG, Hohlstrasse 610, 8048 Zürich Switzerland.
WW326 800mA s.c.rs
WW327 1.6A s.c.rs
WW328 TAB rectifier
WW329 fast recovery diode
WW330 glassivated triacs

Five solid state isolators are announced by Mullard. Designated types CNY22, CNY23, CNY42, CNY43 and CNY44 they can also be used as relays and switches that can operate at 100kHz.

A silicon photodiode array coupled with scanning circuits, multiplex switches and a dynamic shift register is the basis of the type 216BPY i.c. The devices are made with arrays of either 16 or 128 photodiodes and feature scanning rates between 10kHz and 5MHz. Mullard Ltd, Mullard House, Torrington Place, London WC1E 7HD.
WW333 solid state isolators
WW334 photodiode array

A wide range of red-light-emitting diodes for use in punched tape read-out equipment measurement and control systems and domestic switching applications is now offered by Siemens. These l.e.d. devices have been especially designed for use with thick and thin film circuits and units equipped with discrete or integrated semiconductor components.

A complete range of l.e.ds consisting of GaAsP material is now available including the LD24, LD25, the new LD260-269 types and four new ranges of different casings, the LD40, LD50, LD30 and LD46 diodes. All feature low current consumption, little self-heating and high vibration resistance. They can all be driven by t.t.l. logic components.

The already existing infra-red emission l.e.ds types LD24E and LD25E are now being re-introduced in an improved form as CQY17 and CQY18.

The l.e.ds types LD260-269 match the photo-transistor arrays BPX80 and BPX89. The identical layout of both permits up to ten systems per linear array. The components of the LD260 series (LD260-269) are orange-coloured and available as single diodes (LD261), double-diodes (LD262) and in up to nine-diode arrays. The LD261 is selected into groups according to the radiated power.

Green and yellow coloured diodes of the types mostly in demand will be available shortly. The production of three further types is also planned; diodes with a 2mm diameter, diodes with mushroom-shaped heads and a type with a 90° angle of radiation. Siemens Ltd, Great West House, Great West Road, Brentford, Middlesex.
WW330 GaAsP diodes
WW331 infra-red emitters
WW332 LD260 series l.e.d.

About People

Four new Fellowships have been awarded by the Royal Television Society. The new Fellows are **Walter Anderson,** O.B.E., F.I.E.E., **Ivor James,** B.Sc., F.I.E.E., F.I.E.R.E., **Charles Marshall,** B.Sc., M.I.E.E. and **Peter Rainger,** B.Sc., F.I.E.E.

Mr Anderson is head of the experimental and development department of the Independent Broadcasting Authority. He joined E.M.I. in 1940, where he worked on microwave radar and television equipment development. In 1948 he went to the B.B.C. designs department, moving in 1950 to planning and installation. He joined the newly formed I.T.A. in 1955, representing the Authority at international C.C.I.R. meetings on u.h.f. planning in the period leading to the Stockholm conference in 1961. In 1962 he became head of the I.T.A. telecommunications and experimental department and was appointed to his present post in 1967.

Mr James graduated at the University of Bristol in 1933. Joining the patent department of E.M.I. in 1937, he subsequently transferred to the research laboratories to work on military projects, high-definition television and research leading to the development of the E.M.I. 2001 colour camera. He was seconded in 1967 to the television equipment division with responsibility for development and production. Currently, he is scientific adviser on television in the E.M.I. central research laboratories.

Mr Marshall has been honorary secretary of the Royal Television Society for the last 12 years. He graduated in electrical engineering at Manchester University, and his early career was spent with Philips at Mitcham and Mullard at Salfords, engaged on television research and development. In 1954 he became Technical Editor of *British Communications & Electronics,* later joining *Systems and Communications* and then *I.E.E. News* as Editor. He returned to Mullard in 1966 as head of public relations.

Mr Rainger joined the B.B.C. as a graduate engineer in 1951, and worked on film recording and film scanners. Later, he moved to magnetic recording and the design of signal-processing equipment, much of this time being spent on electronic standards conversion. For this work, he and his team were awarded the Royal Television Society's first Geoffrey Parr Award and Mr Rainger was awarded the 1972 David Sarnoff Gold Medal by the Society of Motion Picture and Television Engineers. In 1969 he became head of the B.B.C. designs department and head of research in 1971.

Marconi Communication Systems have appointed two sales engineers to its Specialized Components Division. **Brian Henderson** qualified in electrical engineering at Dundee Technical College, and has had extensive experience in valve, microwave and microwave ferrite work. He joined Marconi's to work as a development engineer in Specialized Components' laboratories in 1967, and soon after took a course in Business Studies in which he qualified at the Mid-Essex Technical College in Chelmsford. He will be responsible for sales in the southern half of the country. **Peter Theobald** was born in Hertfordshire in 1939, was educated at Hemel Hempstead Grammar School and joined Marconi Instruments as a student apprentice in 1959. He studied at Mid-Essex Technical College for a year before going on to Hatfield Polytechnic for further study. He has had varied experience in development work, and as a sales engineer, first for Marconi Instruments and later with Marconi-Elliott Microelectronics. He went to Specialized Components Division last year, and will now take on the sales responsibility for the north.

Geoff. Galliver, M.I.E.R.E., has been engaged by Data Technology Corporation, the Californian electronic instruments manufacturing company, to set up a U.K. and European sales, marketing and service network. Mr Galliver was previously with Dana Electronics which he joined in 1967 after four years with the Solartron Group.

Professor K. Hoselitz, Ph.D., F.Inst.P., F.I.M., has been awarded the Glazebrook Medal and Prize by the Institute of Physics for his work on solid-state physics and on the technology of magnetic materials. Prof. Hoselitz is director of the Mullard research laboratories.

Donald W. Fry, M.Sc., M.I.E.E., is retiring as director of the Atomic Energy Establishment, Winfrith. From 1936 to 1940, Mr Fry was a member of the team at R.A.E. Farnborough which designed the v.h.f. equipment used by R.A.F. Fighter Command. Moving to the Telecommunications Research Establishment, Malvern, he later took part in research and development work on centimetric radar. He went to Harwell in 1946 and was appointed head of the general physics division in 1950, being awarded the Duddell Medal of the Physical Society in that year. In 1954, he became chief physicist to the U.K.A.E.A. and was appointed deputy director of the A.E.R.E. in 1958. He took up his present post in 1959. Mr Fry is succeeded as director by **Harry Cartwright,** M.B.E., M.A., A.M.I.E.E. who, after early experience with Decca Navigator and English Electric, joined the Atomic Energy Authority in 1954. He was appointed director of fast reactor systems in 1970.

E. P. Hyatt has been appointed technical director of Brandenburg Ltd. Mr Hyatt joined the company in 1954 soon after it was founded, as senior design engineer. Later he became head of research and development, and has been responsible for many of Brandenburg's designs and innovations. Among these have been a 200kV supply for the Harwell Nimrod project in 1961 and a self-regulating transformer which has recently been granted patents both in the U.K. and the U.S.A.

Peter Ashburner has joined Integrated Photomatrix Ltd as European sales executive. Previously with Teknis Ltd., his new duties are concerned with the sale and promotion of IPL's range of optoelectronic devices in mainland Europe.

Sir Robert Cockburn, K.B.E., C.B., has accepted an invitation to become chairman of the BBC's Engineering Advisory Committee, in succession to Dr. R. L. Smith-Rose, C.B.E., who is retiring. Sir Robert has had a distinguished career in Government scientific research, having been scientific adviser to the Air Ministry, controller of guided weapons and electronics, Ministry of Supply, and chief scientist, Ministry of Aviation. From 1964 to 1969 he was director of the Royal Aircraft Establishment, Farnborough, and is now a Fellow of Churchill College. He is chairman of the National Computing Centre and also of the Television Advisory Committee which recently reported on technical factors likely to affect broadcasting in the next decade.

Howard Walford has become general manager of International Rectifier's Northern European operations. In his new position, Mr Walford will be responsible for manufacturing facilities at Oxted and Newry in Northern Ireland, as well as marketing and distribution in Europe. He was initially employed in 1961 as an internal sales engineer and from this position progressed to area sales manager for S.E. England and eventually general sales manager.

Geoff. Spaul has been appointed managing director of Cosmocord after joining the company as general manager for marketing in January of 1972. Mr Spaul was formerly managing director of Sirco, the Canadian pressure and temperature switch manufacturers, for whom he founded a U.K. operation. Before this he worked in Canada as a sales engineer with Westinghouse, in the U.K. as production engineer at Ekco, export sales manager with the Taylor Instrument Company and as the divisional general manager at Evershed and Vignoles. Prior to joining Cosmocord he was acting as a consultant in marketing.

Sydney Allchurch, O.B.E., director of the British Radio Equipment Manufacturers' Association and chairman of the executive council of the Association, retired on 28th February on attaining the age of 65. During the war, Mr Allchurch served in the Ministry of Aircraft Production, dealing with the supply and installation of special radio and radar equipment for the Royal Air Force. For his work during this period he was awarded the O.B.E. In 1946 he was appointed secretary of the newly formed B.R.E.M.A., becoming director in 1960 and in 1962 chairman of the executive council. He has been director and secretary of the Radio Industry Council since January 1967, treasurer of the Radio, Television and Electronics Examination Board, and a member of the boards of the I.C.E.T.T. and B.E.A.B. He was elected a Companion of the Institution of Electronic and Radio Engineers in 1964.

Derek Crook and **Andrew Black** were appointed joint managing directors for Radiatron Components Ltd, on January 1st 1973. Mr Crook, who was formerly optoelectronics group manager with Texas Instruments, has particular responsibilities for sales and marketing, while Mr Black is responsible for general administration.

April Meetings

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

LONDON

2nd. IEE — Discussion on "Microwave holography" at 17.30 at Savoy Pl., WC2.

3rd. IEE — "Sequence control of analogue computers" by Dr. G. C. Barney and Dr. D. Miller at 17.30 at Savoy Pl., WC2.

4th. IEE — Discussion on "The place of power electronics in the undergraduate curriculum" at 17.30 at Savoy Pl., WC2.

4th. IERE — "Facsimile: A review" by M. Bowden and J. Malster at 18.00 at 9 Bedford Sq., WC1.

5th. IEE — "Experiments in the automatic monitoring of television transmissions" by G. A. McKenzie at 17.30 at Savoy Pl., WC2.

6th. IEE — Discussion on "Repeaters and terminal equipment for optical communication" at 17.30 at Savoy Pl., WC2.

10th. IERE — Colloquium on "Recent developments in systems performance measurement" at 10.00 at Botany Lecture Theatre, University College.

10th. AES — Symposium on "Multichannel recording and reproduction techniques" at 19.15 at the IEE, Savoy Pl., WC2.

11th. IEE — Colloquium on "The use of fast Fourier machines" at 10.30 at Savoy Pl., WC2.

11th. SERT — "Test equipment" by B. Ellison at 19.00 at I.B.A., 70 Brompton Rd., SW3.

12th. IEE — Discussion on "The guarding of measuring instruments: an earthy discussion" at 17.30 at Savoy Pl., WC2.

12th. RTS — Fleming Memorial Lecture on "TV: the mysteries of the organism" by Denis Forman at 19.00 at the Royal Institution, Albemarle St., W1.

16th. IEE — Colloquium on "Millimetre-wave hybrid and monolithic integrated circuits" at 14.30 at Savoy Pl., WC2.

18th. R.I.Navigation — "Offshore geophysical surveys" by T. F. Gaskell and K. V. Blaiklock at 17.00 at Royal Institution of Naval Architects, 10 Upper Belgrave St., SW1.

18th. IEE — "Tomorrow's world in radio communication" by T. R. Rowbotham at 18.30 at Savoy Pl., WC2.

25th. IEE — "Optical character recognition: promise or reality?" by J. A. Weaver at 17.30 at Savoy Pl., WC2.

25th. IERE — "Electronic aids to position fixing" by D. J. Phipps at 18.00 at 9 Bedford Sq., WC1.

26th. RTS — "Colour picture conversion without impairment? The world's first digital field rate converter" by J. Baldwin and associates at 19.00 at I.B.A., 70 Brompton Rd., SW3.

30th. IEE/I.Phys. — Colloquium on "Acoustic surface wave devices and applications" at 10.30 at Savoy Pl., WC2.

AYLESBURY

3rd. IEE — "Bio-engineering: research or service?" by Heinz S. Wolff at 19.30 at Aylesbury College, Oxford Road.

BALLYMENA

10th. IERE — "Outside broadcasting" by B. J. Slamin at 19.30 at the Technical College.

BATH

10th. IEE — "Advances in marine navigational aids" by F. M. Foley at 18.00 at the University.

BIRMINGHAM

11th. RTS — "Television service in a new university" by Malcolm Freegard at 19.00 at B.B.C. Broadcasting Centre, Pebble Mill Road.

30th. IEE — "Digitalization and automation (broadcasting)" by F. H. Steel at 18.00 at ATV Centre.

BRIGHTON

19th. IEETE — "Cryogenics and superconductivity" by Dr. Andrew R. Long at Royal Albion Hotel, (Preston Room), Old Steine.

BRISTOL

9th. IEE — "Tomorrow's world in telecommunications" by W. J. Bray at 18.00 at Queen's Bldg, the University.

19th. IEE Grads. — "Connecting a computer to a hospital laboratory" by J. Curnow at 19.30 at Bristol Radiography Centre, Horfield Rd.

CAMBRIDGE

10th. IEETE — "Technician engineers and technicians: their qualifications and status in relation to their counterparts in other EEC countries" by E. A. Bromfield and D. E. Wheatley at 19.30 at University Centre.

CARMARTHEN

11th. IEETE — "Logic systems for industrial control" by K. H. Dumbleton at 19.30 at Carmarthen Technical & Agricultural College.

CHELMSFORD

11th. IEE — "Pulsars, quasars and supernovae" by R. E. Spencer at 18.30 at King Edward VI Grammar School, Broomfield Road.

CHELTENHAM

10th. IEETE — "Radio communications" by K. W. Pearson at 19.30 at Carlton Hotel, Parabola Road.

17th. IERE — "New radio receiver development" by Prof. W. Gosling at 19.00 at G.C.H.Q., Oakley.

DARLINGTON

11th. IEE — "Electronics in crime detection" by A. T. Torlesse at 18.30 at the College of Technology.

EDINBURGH

5th. IEE — Faraday lecture on "Navigation — land, sea, air and space" by A. Stratton at 19.00 at the Usher Hall.

IPSWICH

4th. IEE — "The Open University" by J. J. Sparkes at 18.30 at Civic College, Rope Walk.

LIVERPOOL

11th. IEE — Colloquium on "Measurement and control of the environment" at 9.45 at Lecture Theatre Block, the University, Brownlow Hill.

NEWCASTLE-UPON-TYNE

10th. IEE — Faraday lecture on "Navigation — land, sea, air and space" by A. Stratton at 19.15 at the City Hall.

11th. IERE — "A country-wide data transmission network" by W. A. Ellis at 18.00 at Main Lecture Theatre, Ellison Building, The Polytechnic.

NOTTINGHAM

19th. IEE — "Controls limitations" by Prof. J. C. West at 19.00 at T1 Bldg, the University.

MIDDLESBROUGH

24th. SERT — "The CVC 5 colour receiver" by A. E. Thomas at 19.30 at Cleveland Scientific Institution, Corporation Rd.

PORTSMOUTH

10th. IEE — "Liquid crystals and their applications" by N. G. Meadows at 19.30 at the Polytechnic.

READING

5th. IERE — "Fault tolerant computing systems" by L. A. Crapnell at 19.30 at the J. J. Thomson Laboratory, The University, Whiteknights Park.

ROTHERHAM

4th. SERT — "Electronics in the electricity supply industry" by L. R. Girling at 19.15 at the College of Technology, Howard St.

STOKE-ON-TRENT

9th. IEE — "ATV Centre — technical facilities" by G. Kaye at 19.00 at N. Staffs Polytechnic.

SWANSEA

2nd. IEE — "Space communications" by J. L. Crowder at 18.00 at University College.

12th. IEE/IERE — "Some recent researches on electrical contacts" by Dr. A. Fairweather at 18.15 at University College.

TORQUAY

3rd. IEE — "High fidelity sound reproduction" by R. L. West at 14.30 at Electric Hall.

WOLVERHAMPTON

11th. IERE — "Thyristor gadgets for home entertainment" by R. G. Dancy at 19.45 at The Polytechnic.

Books Received

Digital Filters by Martin H. Ackroyd is from the Computers in Medicine Series which aims to present an account of both the clinical applications and the computer science aspects of computing in medicine. Digital filter techniques are of considerable importance in the processing of physiological data by digital computers. While digital filters have a special place in off-line signal processing on large machines, they are also being increasingly used in smaller computers for on-line applications. The contents cover introductory concepts, recursive and non-recursive filter design and applications. Also included are comprehensive references, an appendix with a set of tested Fortran IV subroutines for the design and evaluation of filters and finally a bibliography. Pp.82. Price £1.95. Butterworth & Co. Ltd., 88 Kingsway, London WC2B 6AB.

An Introduction to Metric (System International) and Applications of Metric are two text books in the Mentor series edited by A. Hossack. These books are prepared so that readers can work through the whole text or through selected sections of the course with provision for revision and making references. Testing is also continuous throughout the book. An elementary grasp of decimal arithmetic is the only pre-study requirement of the introductory book, while the applications of metric measurement has been compiled for a technical readership at "A" level mathematics standard. Pp.38 (introduction), 52 (applications). Price 35p (introduction), 45p (applications). Lutterworth Press, Luke House, Farnham Road, Guildford, Surrey.

Literature Received

For further information on any item include the WW number on the reader reply card

ACTIVE DEVICES

A catalogue of "R.F. and Microwave Devices" (sheet RFT-700J) giving basic details of power transistors rated up to 75W, small signal and switching transistors, hybrid amplifier modules and microwave transistors for application at frequencies up to 3GHz, also providing comparison and selection charts of devices, is available from R.C.A. Solid State Europe, Sunbury on Thames, Middlesex TW16 7HW WW401

Data sheets describing helium neon lasers providing 3, 5, 10 and 25mW c.w. power outputs, ruby lasers providing energy outputs of 3, 20, 50 and 100 millijoules — the smallest being battery operated, c.w. power meters with f.s.ds covering the range 1 to 1000W and a range of infra-red night viewing equipment. Plasma Electronics Ltd, 172a Bradford Road, Trading Estate, Slough, Bucks WW402

The second edition of "Collector Diffusion Isolation" shows the progress made since 1971 in terms of the greater range of applications and increased versatility in the production of specific circuit functions. Ferranti Ltd., Gem Mill, Chadderton, Oldham, Lancs OL9 8NP WW403

Two data sheets describing semiconducting microwave diodes are:

Bulletin L/0110, specifying type ML4904, X-band gallium arsenide Gunn device which provides, under suitable conditions, 10mW of c.w. power output at frequencies over the range 8.0–12.0GHz directly from a d.c. bias of between 7 and 9V WW404

Bulletin L/0111, specifying type ML4703S, double-chip silicon impatt diode yielding c.w. power output of 1.0W minimum over the frequency range 5–8GHz with operating voltage of 125V typical WW405

Microwave Associates Ltd, Dunstable, Bedfordshire LU5 4SX.

"Liquid Crystal Displays" is the title of a leaflet presenting information and drawings on the currently available four-digit seven-segment transmissive display unit providing 13mm high characters and two units, to be available in the future, of six digits and 3½ digits plus symbols. Siemens Ltd, Great West House, Great West Road, Brentford, Middlesex TW8 9DG WW406

Selecting the best semiconductor type for particular applications is the subject of the "Master Selection Guide" dealing with silicon rectifier and reference diode assemblies, a large range of discrete diodes and transistors, hybrid r.f. amplifiers, integrated and microcircuit components, microwave semiconductors, thyristors and triggering devices, transient suppressors and a number of opto-electronic devices from Motorola Semiconductors Ltd., York House, Empire Way, Wembley, Middlesex WW407

The "Topliner" components catalogue, listing over 700 of the most popular items covering resistors, potentiometers, capacitors, connectors, relays, motors, diodes and transistors, linear and digital integrated circuits, opto-electronic devices and, the latest addition, a pocket-sized calculator, was received from T.I. Supply, 165 Bath Road, Slough, Bucks WW408

A folding leaflet providing easy and quick reference to type numbers of power diodes, controlled avalanche diodes, fast switching diodes, thyristors, triacs, high-power bridge rectifiers, and high-voltage rectifiers is available from Semikron Rectifier Elements and Electronics Ltd, Brewhouse Lane, Hertford WW409

The "International Transistor Data Manual" is the first volume in a series designed to provide comprehensive ready-at-hand information about some 18,000 discrete semiconductor devices in terms of technical data and listings of alternative manufacturers with agents' names and addresses. Semicon Indexes Ltd, 29 Denmark Street, Wokingham, Berkshire RG11 2AY. Price £5.25 plus 35p postage and packing U.K. only.

PASSIVE DEVICES

A mail order electronics component catalogue containing details and prices of a wide range of discrete electronic and electrical components available from stock normally by return post. Arrow Electronics Ltd, 7 Coptfold Road, Brentwood, Essex WW410

"Spectra Strip 3C Cable" is the subject of a bulletin describing multiconductor flat insulated cable composed of between 14 and 60 multistrand or solid copper conductors insulated and then covered by a film of grey or colour coded p.v.c. Levermore and Co Ltd, 40-44 Broadway, Wimbledon, London S.W.19. ....WW411

A wide range of compact stop-band filters designed in standard waveguide sizes covering the pass-band frequency range of 5.9 to 14.2GHz and stop-band frequency range of 9.5 to 25.5GHz offering rejection ratios of between 25 and 40dB and insertion losses of between 0.15 and 0.40dB, are detailed in a specification sheet from the Professional Components Department, Ferranti Ltd, Dunsinane Avenue, Dundee DD2 3PN WW412

A leaflet illustrating the range of components which have special significance in the field of radio and television servicing, such as e.h.t. trays, dropper resistors, potentiometers, electrolytic, polyester and ceramic capacitors, transistors and diodes, was received from CB Electronic Components Ltd, 108 Stoke Newington High Street, London N16 7NY WW413

A catalogue covering the range of fixed and variable resistors manufactured by Amphenol, Electrosil and Plessey (Painton) also the wide range of capacitors made by Erie, is available from Intel Electronics Ltd, Henlow Trading Estate, Henlow, Bedfordshire WW414

EQUIPMENT

An 8-page brochure describing "Video Disc Recorders" which record and play back at up to 600 consecutive TV picture frames or 32 picture frames of simultaneous events in applications such as computer aided instruction, time-lapse and slow-motion image recording, area surveillance and command/control display is available from Data Disc Inc., 686 West Maude Avenue, Sunnyvale, California 94086 ....WW420

Equipment using the thermal stress technique which will measure the power handling capabilities and performance of power transistors under working conditions, standard parameters such as thermal resistance, h_{FE}, V_{be} and second breakdown characteristics, is detailed in a leaflet from Challenge Innovations Ltd, Northern House, Station Approach, Hitchin, Herts WW421

Technical details and new prices of pulse generators types PG-71 (5MHz, 10ns), PG-73 (20MHz, 5ns), PG-2E (10MHz, 12ns), PG-22 (50MHz, 2ns), and PG-23 (10MHz, 5ns) are available in a "pulse generator special issue newsletter" from Lyons Instruments Ltd, Hoddesdon, Herts WW422

The latest electronic kit catalogue, which includes many new items such as an integrated circuit f.m. and a.m. stereo receiver, a 60W multi-speaker system, a 5-digit 30MHz frequency counter, a 2½-digit multimeter, portable car engine analyzer and a metal locator, is available from Heath (Gloucester) Ltd, Gloucester GL2 6EE WW423

Control equipment type Ks72 × 144 which is a pneumatic regulating unit combining regulator, control device and indicating instrument having a large 140mm dial and large contrasting pointer for ease of legibility on distant or multi-indicator panels, is the subject of a brochure from Siemens Ltd, Great West House, Great West Road, Brentford, Middx. TW8 9DG WW424

A selection of low-frequency (0.001Hz to 100kHz) signal processing instruments which includes active and passive filters, variable and commutating filters, banks of filters in 1/6th, ⅓, ½ octave and constant bandwidths, spectrum shapers and signal conditioning instrumentation is shown in a folder from Kemo Ltd, 42 Chancery Lane, Beckenham, Kent, BR3 2NR WW425

APPLICATION NOTES

Three booklets dealing with various aspects of a.c. rectification, power control and signal amplification are:

"Power Electronics Technical Note No.5" providing a rectifier circuit table which gives a full list of the values necessary for the design and use of the most common single-phase and three-phase rectifier circuits. Ref. TP1310 ....WW426

"D.C. Motor Speed-Control Systems using Thyristors" showing two speed-control systems for d.c. shunt motors operating from a.c. mains supplies through half-controlled thyristor bridges. Ref. TP1348 ....WW427

The above are available from the Instrumentation and Control Electronics Division, Mullard Ltd, Mullard House, Torrington Place, London WC1E 7HD.

"Transistors for Single-sideband Linear Amplifiers" discusses the conditions necessary for practical device operation and gives some tested circuits for amplifiers with power outputs ranging from 6 to 300W p.e.p. over the band 1.6 to 30MHz. Ref. TP1337 ....WW428

Communications Electronics Division, Mullard Ltd, Mullard House, Torrington Place, London WC1E 7HD.

Application notes were received dealing with the use of type 4701 operational amplifier, which is specifically designed for the function of voltage or current-to-frequency conversion. Teledyne Philbrick, Allied Drive at Route 128, Dedham, Massachusetts 02026 ....WW429

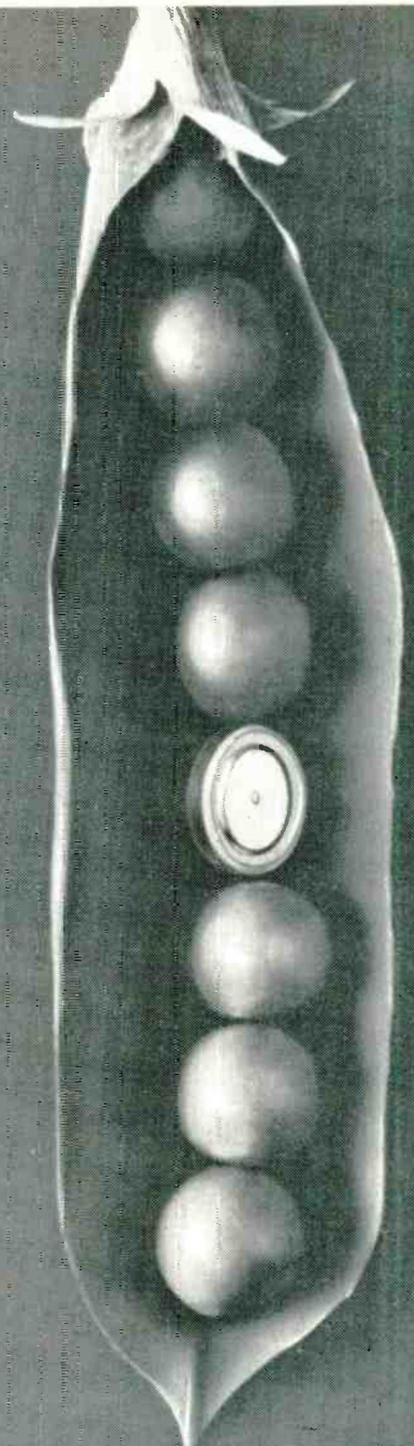
GENERAL INFORMATION

A wall chart has been received which briefly describes, in simple terms, how hybrid thick film circuits are made, a custom design and manufacturing service and includes a calendar covering the years 1972 to 1974. Coutant Electronics Ltd, 3 Trafford Road, Reading RG1 8JR WW430

A leaflet describing "Heat Pipes" shows a range of devices designed to remove heat from where it is impossible or ill-advised to dissipate it to a more convenient point is available from Redpoint Associates Ltd, Cheney Manor, Swindon, Wilts WW431

"Defining and measuring the characteristics of disc record playing equipment" is the title of BS4852 which discusses the most important parameters affecting the quality of performance of record playing equipment, the way in which the data should be presented and recommended test result recording procedures. Price £1.20 from B.S.I. Sales Branch, 101, Pentonville Road, London. N1 9ND.

The 240-page components catalogue and price list referred to in our January issue costs 55p (not 50p) plus 20p postage from Home Radio (Components) Ltd., 234-240 London Road, Mitcham, Surrey, CR4 3HD.



Sinclair Project 60

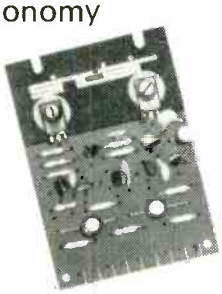
Now—the Z.50 Mk.2

with built-in automatic transient overload protection

When originally introduced, the Sinclair Z.50 proved how it was possible to design and produce a popularly priced modular power amplifier having characteristics to challenge the world's costliest amplifiers. Many thousands of Z.50's are now giving excellent service day in, day out. But we have also learned that constructors do not always use their Z.50's ideally. That is why we have introduced modifications whereby risk of damage through mis-use is greatly reduced and performance further enhanced. The Z.50 Mk.2 has improved thermal stability, more accurately regulated D.C. limiting to ensure more symetrical output voltage swing and clipping and still less distortion at lower power. Z.50 Mk.2 is compatible with all other Project 60 modules, and may be incorporated to advantage in existing systems. Eleven silicon epitaxial planar transistors are now used, two more than in the original Z.50; circuitry has been re-designed, making this versatile high performance amplifier better than ever.

with free manual
£5.48

Z.30 the power amplifier for quality and economy

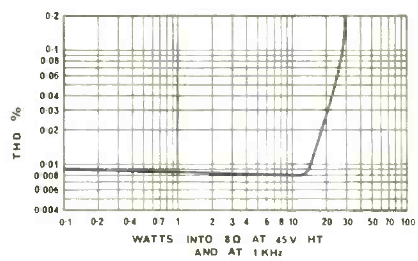


with free manual
£4.48

The Z.30 provides excellent facilities for the constructor requiring a high fidelity audio system of less power than that available from Z.50's. Using a power supply of 35 volts, Z.30 will deliver 15 watts RMS into 8 ohms, or 20 watts RMS into 3 ohms using 30 volts. Total harmonic distortion is a fantastically low 0.02% at 15 watts into 8 ohms with signal to noise ratio better than 70 dB unweighted. Input sensitivity 250mV into 100K ohms. Size 80 x 57 x 13 mm ($3\frac{1}{8}$ x $2\frac{1}{4}$ x $\frac{1}{2}$) Z.30, Z.50 and Z.50 MK.2 modules are compatible and interchangeable.

Brilliant new technical specifications

Input impedance 100 KΩ
Input (for 30w into 8Ω) 400mV
Signal to noise ratio, referred to full o/p at 30v HT 80dB or better
Distortion 0.02% up to 20W at 8Ω. See curve
Frequency response 10Hz to more than 200 KHz ±1dB
Max. supply voltage 45v (4Ω to 8Ω speakers) (50v 15Ω speakers only)
Min. supply voltage 9v
Load impedance – minimum : 4Ω at 45v HT
Load impedance – maximum : safe on open circuit



Guarantee

If, within 3 months of purchasing any product direct from Sinclair Radionics Ltd., you are dissatisfied with it, your money will be refunded at once. Many Sinclair appointed Stockists also offer this same guarantee in co-operation with Sinclair Radionics Ltd.

Each Project 60 module is tested before leaving our factory and is guaranteed to work perfectly. Should any defect arise in normal use, we will service it at once and without any charge to you, if it is returned within two years from the date of purchase. Outside this period of guarantee a small charge (typically £1.00) will be made. No charge is made for postage by surface mail. Air Mail is charged at cost.

sinclair

Typical Project 60 applications

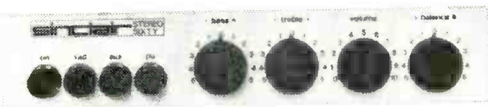
System	The Units to use	together with	Units cost
Simple battery record player	**Z.30**	Crystal P.U., 12V battery volume control, etc.	**£4.48**
Mains powered record player	**Z.30, PZ.5**	Crystal or ceramic P.U. volume control, etc.	**£9.45**
12W. RMS continuous sine wave stereo amp. for average needs	**2 x Z.30s, Stereo 60; PZ.5**	Crystal, ceramic or mag. P.U., F.M. Tuner, etc.	**£23.90**
25W. RMS continuous sine wave stereo amp. using low efficiency (high performance) speakers	**2 x Z.30s, Stereo 60; PZ.6**	High quality ceramic or magnetic P.U., F.M. Tuner, Tape Deck, etc.	**£26.90**
80W. (3 ohms) RMS continuous sine wave de luxe stereo amplifier. (60W. RMS into 8 ohms)	**2 x Z.50s, Stereo 60; PZ.8, mains transformer**	As above	**£34.88**
Indoor P.A.	**Z.50, PZ.8, mains transformer**	Mic., guitar, speakers, etc., controls	**£19.43**

F.M. Stereo Tuner **(£25)** & A.F.U. **(£5.98)** may be added as required.

WW—080 FOR FURTHER DETAILS

the world's most advanced high fidelity modules

Stereo 60 Pre-amp/control unit



Designed specifically for use on Project 60 systems, the Stereo 60 is equally suitable for use with any high quality power amplifier. Since silicon epitaxial planar transistors are used throughout, a really high signal-to-noise ratio and excellent tracking between channels is achieved. Input selection is by means of press buttons, with accurate equalisation on all input channels. The Stereo 60 is particularly easy to mount.

SPECIFICATIONS—Input sensitivities: Radio – up to 3mV. Mag. p.u. 3mV: correct to R.I.A.A. curve ±1dB :20 to 25,000 Hz. Ceramic p.u. – up to 3mV: Aux – up to 3mV. **Output:** 250mV. **Signal to noise ratio:** better than 70dB. **Channel matching:** within 1dB. **Tone controls:** TREBLE +12 to —12dB at 10KHz: BASS +12 to —12dB at 100Hz. **Front panel:** brushed aluminium with black knobs and controls. **Size:** 66 x 40 x 207mm.

Built, tested and guaranteed. **£9.98**

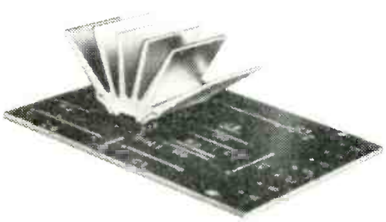
Project 60 Stereo F.M. Tuner

The phase lock loop principle was used for receiving signals from space craft because of its vastly improved signal to noise ratio. Now, Sinclair have applied the principle to an F.M. tuner with fantastically good results. Other advanced features include varicap diode tuning, printed circuit coils, an I.C. in the specially designed stero decoder and switchable squelch circuit for silent tuning between stations. In terms of a high fidelity this tuner has a lower level of distortion than any other tuner we know. Stereo broadcasts are received automatically, a panel indicator lighting up as the stereo signal is tuned in. This tuner can also be used to advantage with most other high fidelity systems.

SPECIFICATIONS—Number of transistors: 16 plus 20 in I.C. **Tuning range:** 87.5 to 108MHz. **Sensitivity:** 7μV for lock-in over full deviation. **Squelch level:** Typically 20μV. **Signal to noise ratio:** >65dB. **Audio frequency response:** 10Hz – 15KHz (±1dB). **Total harmonic distortion:** 0.15% for 30% modulation. **Stereo decoder operating level:** 2μV. **Cross talk:** 40dB. **Output voltage:** 2 x 150mV R.M.S. maximum. **Operating voltage:** 25–30VDC. **Indicators:** Stereo on ; tuning. **Size:** 93 x 40 x 207mm.

Built and tested. Post free. **£25**

Super IC.12 Integrated circuit high fidelity amplifier



Having introduced Integrated Circuits to hi-fi constructors with the IC.10, the first time an IC had ever been made available for such purposes, we have followed it with an even more efficient version, the Super IC.12, a most exciting advance over our original unit. This needs very few external resistors and capacitors to make an astonishingly good high fidelity amplifier for use with pick-up, F.M. radio or small P.A. set up, etc. The free 40 page manual supplied, details many other applications which this remarkable IC. make possible. It is the equivalent of a 22 transistor circuit contained within a 16 lead DIL package, and the finned heat sink is sufficient for all requirements. The Super IC.12 is compatible with Project 60 modules which would be used with the Z.50 and Z.30 amplifiers. Complete with free manual and printed circuit board.

SPECIFICATIONS

Output power: 6 watts RMS continuous (12 watts peak). 6–8Ω. **Frequency Response:** 5Hz to 100KHz ±1dB. **Total Harmonic Distortion:** Less than 1%. (Typical 0·1%) at all output powers and frequencies in the audio band (28V). **Load Impedance:** 3 to 15 ohms. **Input Impedance:** 250 Kohms nominal. **Power Gain:** 90dB (1,000,000,000 times) after feedback. **Supply Voltage:** 6 to 28V. **Quiescent current:** 8mA at 28V. **Size:** 22 x 45 x 28mm including pins and heat sink.

Manual available separately 15p post free.

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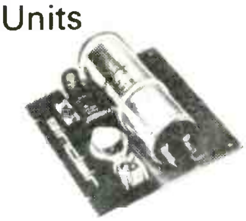
Power Supply Units The new PZ.8 Mk.3



The most reliable power supply unit ever made available to constructors. Brilliant circuitry makes failure from over load and even direct shorting of the output impossible. This is due to an ingenious re-entrant current limiting principle which, as far as we know has never before been available in any comparable unit outside the most expensive laboratory equipment. Ripple and residual noise have been reduced to the point of almost total elimination. This is, of course, the perfect unit for Project 60 assemblies, particularly where the new Z.50 MK.2 amplifiers are used. Nominal working voltage – 45.

PZ.8 Mk.3—£7.98
(Mains transformer, if required) £5.98
PZ.5 30v. unstabilised
(not suitable for Project 60 tuner) £4.98
PZ.6 35v. stabilised
(not suitable for IC. 12) £7.98

Project 605

the easy way to buy and build Project 60 without soldering

Project 605 in one pack contains: one PZ.5, two Z.30's, one Stereo 60 and one Masterlink, which has input sockets and output components grouped on a single module and all necessary leads cut to length and fitted with clips to plug straight on to the modules thus eliminating all soldering.

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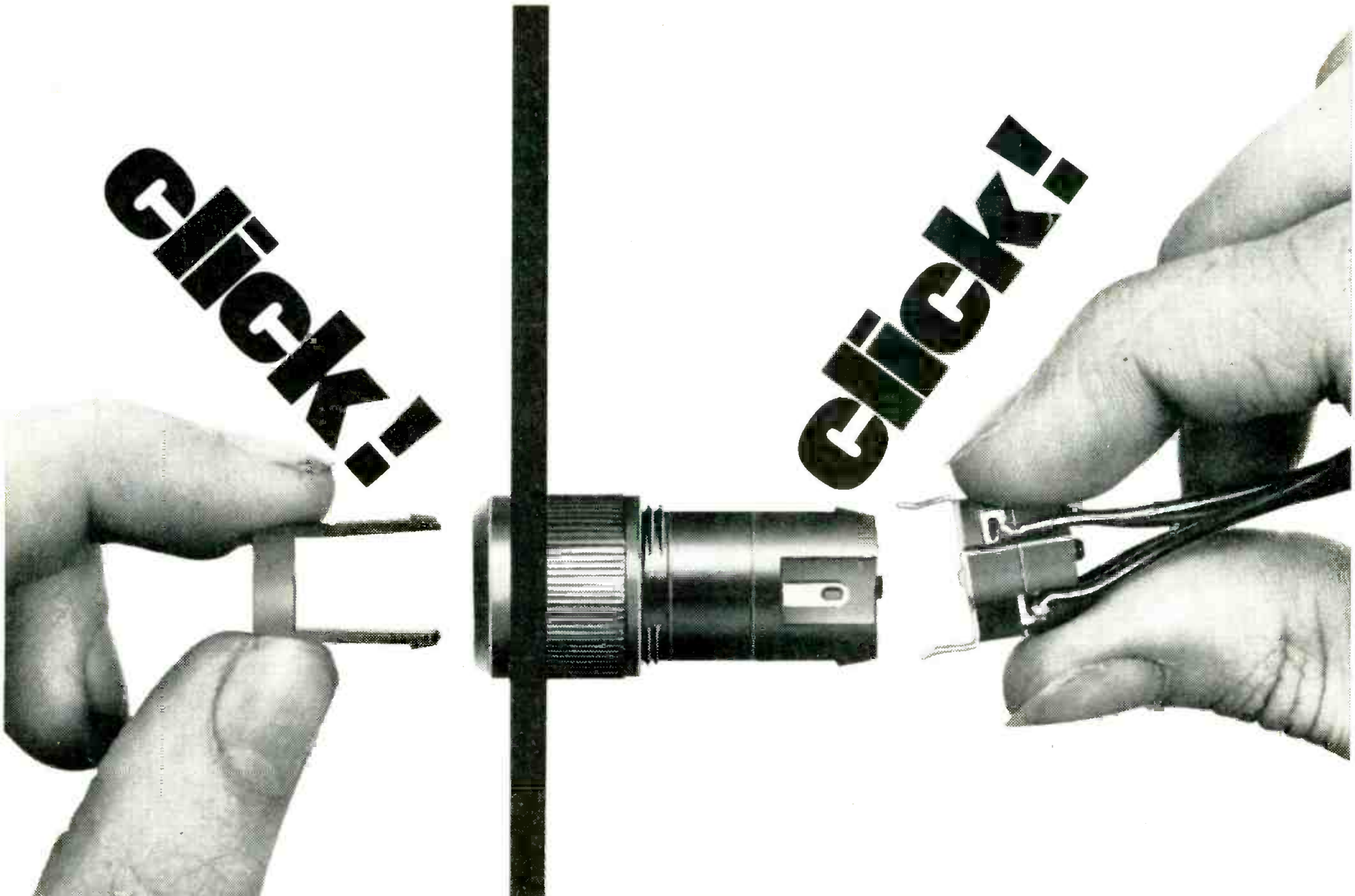

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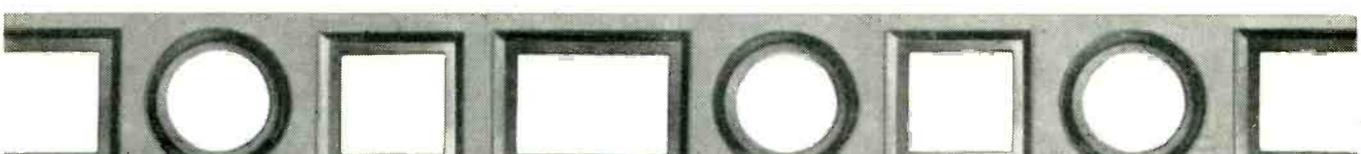

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TPA 50 - D Specification

Power Output	100 watts rms into 4 ohms 65 watts rms into 15 ohms
Freq Response	±0.1dB 20Hz to 20KHz into 15 ohms. -1dB at 150KHz
Total harmonic distortion	Less than 0.04% at all levels up to 50 watts rms into 15 ohms
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Noise	-100dB
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Price	£53

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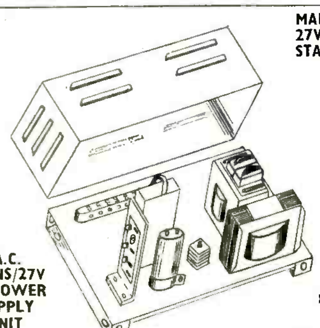

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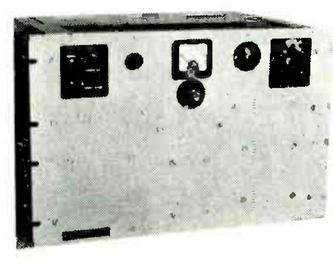

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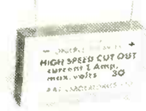

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AC180K	0·20	ASY56	0·25	BC184L	0·12	BF119	0·70
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AC187K	0·20	BC107	0·09	BC208	0·11	BF127	0·50
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AC188K	0·20	BC109	0·10	BC212L	0·11	BF153	0·45
ACY17	0·25	BC113	0·10	BC213L	0·11	BF154	0·45
ACY18	0·20	BC114	0·15	BC214L	0·14	BF155	0·70
ACY19	0·20	BC115	0·15	BC225	0·25	BF156	0·48
ACY20	0·20	BC116	0·15	BC226	0·35	BF157	0·55
ACY21	0·20	BC117	0·15	BCY30	0·24	BF158	0·55
ACY22	0·16	BC118	0·10	BCY31	0·26	BF159	0·60
ACY27	0·18	BC119	0·30	BCY32	0·30	BF160	0·40
ACY28	0·19	BC120	0·80	BCY33	0·22	BF162	0·40
ACY29	0·35	BC125	0·12	BCY34	0·25	BF163	0·40
ACY30	0·28	BC126	0·18	BCY70	0·14	BF164	0·40
ACY31	0·28	BC132	0·12	BCY71	0·18	BF165	0·40
ACY34	0·21	BC134	0·18	BCY72	0·14	BF167	0·22
ACY35	0·21	BC135	0·12	BCZ10	0·20	BF173	0·22
ACY36	0·28	BC136	0·15	BCZ11	0·25	BF176	0·35
ACY40	0·17	BC137	0·15	BCZ12	0·25	BF177	0·35
ACY41	0·18	BC139	0·40	BD121	0·60	BF178	0·30
ACY44	0·35	BC140	0·30	BD123	0·65	BF179	0·30
AD130	0·38	BC141	0·30	BD124	0·60	BF180	0·30
AD140	0·48	BC142	0·30	BD131	0·50	BF181	0·30
AD142	0·48	BC143	0·30	BD132	0·60	BF182	0·40
AD143	0·83	BC145	0·45	BD133	0·65	BF183	0·40
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BF196	0·14	OC23	0·42	2G374	0·17
BF197	0·14	OC24	0·56	2G377	0·30
BF200	0·45	OC25	0·38	2G378	0·16
BF222	0·95	OC26	0·25	2G381	0·16
BF257	0·45	OC28	0·50	2G382	0·16
BF258	0·60	OC29	0·50	2G401	0·30
BF259	0·85	OC35	0·42	2G414	0·30
BF262	0·55	OC36	0·50	2G417	0·25
BF263	0·55	OC41	0·20	2N388	0·35
BF270	0·35	OC42	0·24	2N388A	0·55
BF271	0·30	OC44	0·15	2N404	0·20
BF272	0·80	OC45	0·12	2N404A	0·28
BF273	0·35	OC70	0·10	2N524	0·42
BF274	0·35	OC71	0·10	2N527	0·49
BFW10	0·60	OC72	0·14	2N598	0·42
BFX29	0·27	OC74	0·14	2N599	0·45
BFX84	0·22	OC75	0·15	2N696	0·12
BFX85	0·30	OC76	0·15	2N697	0·13
BFX86	0·22	OC77	0·25	2N698	0·24
BFX87	0·24	OC81	0·15	2N699	0·35
BFX88	0·22	OC81D	0·15	2N706	0·08
BFY50	0·20	OC82	0·15	2N706A	0·09
BFY51	0·20	OC82D	0·15	2N708	0·12
BFY52	0·20	OC83	0·20	2N711	0·30
BFY53	0·17	OC84	0·20	2N717	0·35
BPX25	0·85	OC139	0·20	2N718	0·24
BSX19	0·15	OC140	0·20	2N718A	0·50
BSX20	0·15	OC169	0·25	2N726	0·28
BSY25	0·15	OC170	0·25	2N727	0·28
BSY26	0·15	OC171	0·25	2N743	0·20
BSY27	0·15	OC200	0·25	2N744	0·20
BSY28	0·15	OC201	0·28	2N914	0·14
BSY29	0·15	OC202	0·28	2N918	0·30
BSY38	0·18	OC203	0·25	2N929	0·21
BSY39	0·18	OC204	0·25	2N930	0·21
BSY40	0·28	OC205	0·35	2N1131	0·20
BSY41	0·28	OC309	0·40	2N1132	0·22
BSY95	0·12	P346A	0·20	2N1302	0·14
BSY95A	0·12	P397	0·42	2N1303	0·14
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C407	0·25	ORP61	0·40	2N1307	0·21
C424	0·20	ST140	0·12	2N1308	0·23
C425	0·50	ST141	0·17	2N1309	0·23
C426	0·35	TIS43	0·30	2N1613	0·20
C428	0·20	UT46	0·27	2N1711	0·20
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C442	0·30	2G302	0·19	2N1890	0·45
C444	0·35	2G303	0·19	2N1893	0·37
C450	0·22	2G304	0·24	2N2147	0·72
MAT100	0·19	2G306	0·40	2N2148	0·57
MAT101	0·20	2G308	0·35	2N2160	0·60
MAT120	0·19	2G309	0·35	2N2192	0·35
MAT121	0·20	2G339	0·20	2N2193	0·35
MPF102	0·42	2G339A	0·16	2N2194	0·35
MPF104	0·37	2G344	0·18	2N2217	0·22
MPF105	0·37	2G345	0·16	2N2218	0·20

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2N2220	0·22	2N3055	0·50	2N4060	0·12
2N2221	0·20	2N3391	0·14	2N4061	0·12
2N2222	0·20	2N3391A	0·16	2N4062	0·12
2N2368	0·17	2N3392	0·14	2N4284	0·17
2N2369	0·14	2N3393	0·14	2N4285	0·17
2N2369A	0·14	2N3394	0·14	2N4286	0·17
2N2411	0·24	2N3395	0·17	2N4287	0·17
2N2412	0·24	2N3402	0·21	2N4288	0·17
2N2646	0·47	2N3403	0·21	2N4289	0·17
2N2711	0·21	2N3404	0·28	2N4290	0·17
2N2712	0·21	2N3405	0·42	2N4291	0·17
2N2714	0·21	2N3414	0·15	2N4292	0·17
2N2904	0·17	2N3415	0·15	2N4293	0·17
2N2904A	0·21	2N3416	0·28	2N5172	0·12
2N2905	0·21	2N3417	0·28	2N5457	0·32
2N2905A	0·21	2N3525	0·75	2N5458	0·32
2N2906	0·15	2N3646	0·09	2N5459	0·40
2N2906A	0·18	2N3702	0·10	28301	0·50
2N2907	0·20	2N3703	0·10	28302A	0·42
2N2907A	0·22	2N3704	0·11	28302	0·42
2N2923	0·14	2N3705	0·10	28303	0·55
2N2924	0·14	2N3706	0·09	28304	0·70
2N2925	0·14	2N3707	0·11	28305	0·84
2N2926 (G)		2N3708	0·07	28306	0·84
	0·12	2N3709	0·09	28307	0·84
2N2926 (Y)		2N3710	0·09	28321	0·56
	0·11	2N3711	0·09	28322	0·42
2N2926 (O)		2N3819	0·28	28322A	0·42
	0·10	2N3820	0·50	28323	0·56
2N2926 (R)		2N3821	0·35	28324	0·70
	0·10	2N3823	0·28	28325	0·70
2N2926 (B)		2N3903	0·28	28326	0·70
	0·10	2N3904	0·30	28327	0·70
2N3010	0·70	2N3905	0·28	28701	0·42
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AAY30	0·09		0·42	OA79	0·07
AAZ13	0·10	BYZ10	0·35	OA81	0·07
BA100	0·10	BYZ11	0·30	OA85	0·09
BA116	0·21	BYZ12	0·30	OA90	0·06
BA126	0·22	BYZ13	0·25	OA91	0·06
BA148	0·14	BYZ16	0·40	OA95	0·07
BA154	0·12	BYZ17	0·35	OA200	0·06
BA155	0·14	BYZ18	0·35	OA202	0·07
BA156	0·13	BYZ19	0·28	SD10	0·05
BY100	0·15	CG62		SD19	0·05
BY101	0·12	(Eg) OA91		IN34	0·07
BY105	0·17		0·5	IN34A	0·07
BY114	0·12	CG651		1N914	0·06
BY126	0·14	(Eq) OA70-		1N916	0·06
BY127	0·15	OA79	0·06	IN414B	0·06
BY128	0·15	OA5	0·35	IS021	0·10
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U43	25	Sil. Trans. Plastic TO-18 A.F. BC113/114	0·50
U44	20	Sil. Trans. Plastic TO-5 BC115/NPN	0·50
U45	7	3A SCR. TO66 up to 600PIV	1·00

Code No's. mentioned above are given as a guide to the type of device in the pak. The devices themselves are normally unmarked.

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Q28	2	Silicon power rectifiers BYZ 13	0·50
Q29	4	Silicon transistors 2 × 2N696, 1 × 2N697, 1 × 2N698	0·50
Q30	7	Silicon switch transistors 2N706 NPN	0·50
Q31	6	Silicon switch transistors 2N708 NPN	0·50
Q32	3	PNP Silicon transistors 2 × 2N1131, 1 × 2N 1132	0·50
Q33	3	Silicon NPN transistors 2N1711	0·50
Q34	7	Silicon NPN transistors 2N2369, 500MHz (code P397)	0·50
Q35	3	Silicon PNP TO-5, 2 × 2N2904 & 1 × 2N2905	0·50
Q36	7	2N3646 TO-18 plastic 300 MHz NPN	0·50
Q37	3	2N3053 NPN Silicon transistors	0·50
Q38	7	NPN transistors 4 × 2N3703, 3 × 2N3702	0·50

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100	0·25	0·33	0·47	0·47	0·50	0·58	0·63	1·40
200	0·35	0·37	0·49	0·49	0·57	0·61	0·75	1·60
400	0·43	0·47	0·56	0·56	0·67	0·75	0·93	1·75
600	0·53	0·57	0·68	0·68	0·77	0·97	1·25	—
800	0·63	0·70	0·80	0·80	0·90	1·20	1·50	4·00

SIL. SECTS. TESTED

PIV	300mA	750mA	1A	1·5A	3A	10A	30A
50	0·04	0·05	0·05	0·07	0·14	0·21	0·60
100	0·04	0·06	0·05	0·13	0·16	0·23	0·75
200	0·05	0·09	0·06	0·14	0·20	0·24	1·00
400	0·06	0·13	0·07	0·20	0·27	0·37	1·25
600	0·07	0·16	0·10	0·23	0·34	0·45	1·86
800	0·10	0·17	0·11	0·25	0·37	0·55	2·00
1000	0·11	0·25	0·14	0·30	0·46	0·63	2·50
1200	—	0·33	—	0·38	0·57	0·75	—

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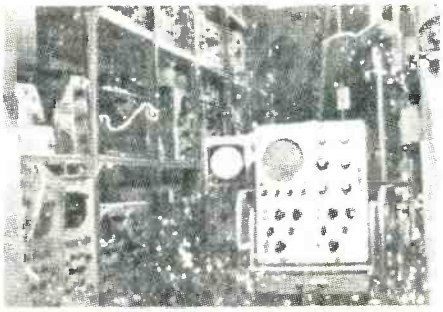

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PBA—1/A	**Bridge Supply and Indicating Unit.** Feeds ohmic transducers with a stabilized d.c. voltage. By means of a balancing network it is possible to compensate the zero balance tolerance of the transducers. The incorporated chopper amplifier amplifies the measuring signal which is indicated by a light-beam instrument, and a recorder output delivers a d.c. voltage proportioned to the measuring value. Complete with manual	£120
	WAYNE-KERR	
B.701	**VHF Admittance Bridge**	P.o.A.
M.131	**Video Noise Level Meter**	P.o.A.

★ 10% DISCOUNT ★
★ FOR CASH AND CARRY ★
★★ SALES ★★

MAINS ON-OFF ROTARY SWITCH. 2 pole, on-off. 2A. 250V. a.c. **15p** ea. + 5p p.p.
TEN TURN POTENTIOMETER. Bourns Type 3500S-1-203. Resistance 20KΩ. ± 3%. LIN ± 0·2%. **£1** ea. + 10p p.o.
500KHz QUARTZ CRYSTAL. Marconi Type. QM263B. Glass envelope. **£1** ea. + 10p p.p.
70MHz QUARTZ CRYSTAL. HC6U Type. **£1** ea. + 10p p.p.
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M.E.S. PANEL BULBS. 4·5V. 0·3A.; 5V. 0·15A.; 8V. 1·2W.; 12V. 3·6W. Any 24 for **£1** + 10p p.p.
T.O.3 POWER TRANSISTOR SOCKET. 12 for **50p** + 10p p.p.
T.O.5 TRANSIPAD. 500 for **£2·50** inc. post.
360 deg. PRECISION SERVO POTENTIOMETER. 500 ohm. 3in. dia. ¼in.-⅛in. shaft **£4** inc. post.
WIRE WOUND POTS. Colvern/Reliance 1 ohm.-100Kohm **20p** + 10p p.p.
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HIGH QUALITY TRIMMER CAPACITOR (beehive). Philips Type B04-2004 5-29pF. **25p** + 5p p.p.
2 PIN UNIVERSAL PLUG AND SOCKET (may be stacked to form multipole connector). E.M.L. Type D2, size approx. ½in. × ½in. **15p** pair; 12 pairs **£1** p.p. 6p.
VIBRATORS. Plessey Type 12.1.4.SD. 12V., XC354. 24V. **50p** + 10p p.p.

RELAYS

Clare Elliot 12V. 200 ohm; 24V. 675 ohm; 110V. 9100 ohm. 2p.c/o. Size ⅞in. × ¾in. × ⅜in. **75p** + 10p p.p.
Siemens/Varley/STC Plastic Covered. 14V. 240 ohm; 20-47V. 1250 ohm; 24V. 15000 ohm; 28V. 5800 ohm. 4p.c/o. Size 1⅛in. × 1⅛in. × ¾in. **50p** + 10p p.p.
Siemens High Speed Relay. 12V. 145 + 145 ohm; 24V. 500 + 500 ohm; 48V. 1700 + 1700 ohm. 1p.c/o. Size 2½in. × 1¼in. × ¾in. **75p** + 10p p.p.
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Plessey Sub-min. Relay. 6-12V. 250 ohm. 2p.c/o. Size 1½in. × 1in. × ⅝in. **50p** + 10p p.p.
Londex 240V. a.c. Relay 2p.c/o. H.D. contacts **60p** + 10p p.p.
Magnetic Devices 12V. 2p. make H.D. contacts. **60p** + 10p p.p.

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1 500 Carbon resistors, ¼, ½, 1, 2 watt.
2 100 Electrolytic Condensers.
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4 250 Polyester, Polycarbonate, Paper, etc. Condensers.
5 25 Potentiometers assorted.
6 250 High-stab. 1%, 2%, 5% resistors.
7 50 Assorted Tagstrips.
8 1lb. wt. Assorted Nuts, bolts, washers, spacers, etc.
9 25 Assorted swtiches, rotary, lever, micro, toggle, etc.
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ALL COMPONENTS NEW AND UNUSED
£1+25p p.p. per pack. £5 for 5 packs p/free.

MULLARD ELECTROLYTIC CAPACITORS

Axial Lead Types 437/426

2·5V		**4V**	
40μF	4p	64μF	4p
160μF	4p	125μF	4p
320μF	4p	250μF	4p
550μF	4p	400μF	4p
1000μF	5p	800μF	5p
1600μF	7p	1250μF	7p
2500μF	8p	2000μF	8p
4000μF	9p	3200μF	9p
6·4V		**16V**	
25μF	4p	250μF	8p
100μF	4p	640μF	8p
320μF	4p	**40V**	
640μF	5p	250μF	8p
1600μF	8p	400μF	9p
2500μF	9p	**64V**	
		160μF	8p

SPECIAL OFFERS

(Limited period only)

BC 107	Transistors 7p
BC 108	
BC 109	Quotations for quantities
SL 403D	**£1·30** ea.

SOLDER TAG TYPE 431

320μF	64V	17p	2000μF	16V	19p
500μF	40V	17p	3200μF	10V	19p
500μF	64V	19p	3200μF	16V	25p
800μF	25V	17p	4000μF	25V	35p
800μF	64V	24p	5000μF	10V	25p
1250μF	16V	17p	6400μF	16V	37p
1250μF	25V	19p	6400μF	25V	45p
1250μF	40V	24p	10000μF	10V	38p
1600μF	64V	35p	10000μF	16V	46p
2000μF	10V	17p	16000μF	10V	46p

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Wholesale/Retail: 369 Alum Rock Road, Birmingham B8 3DR. Tel. 021-327 2339

Special Offer ! ! !

SMALL ELECTROLYTICS

Ref. No.	Capacity	Voltage	Price	Ref. No.	Capacity	Voltage	Price
H8/1	1µf	150v	4p	H7/4A	64µf	35v	5p
H8/1A	2µf	150v	2p	H7/5	80µf	16v	4p
H8/2	2·2µf	25v	4p	H7/6	100µf	25v	5p
H8/2A	3·3µf	25v	4p	H7/6A	100µf	15v	4p
H8/3	3µf	50v	4p	H7/7	100µf	25v	4p
H8/3A	4µf	50v	4p	H7/8	125µf	16v	5p
H8/4	4·7µf	25v	4p	H7/8A	100µf	35v	6p
H8/4A	5µf	64v	4p	H7/9	100µf	63v	6p
H8/5	5µf	10v	4p	H7/9A	125µf	4v	4p
H8/5A	5µf	150v	4p	H7/10	125µf	25v	6p
H8/6A	10µf	10v	4p	H7/10A	160µf	2·5v	3p
H8/7	10µf	70v	4p	H7/11	160µf	25v	6p
H8/8	16µf	35v	4p	H7/11A	150µf	16v	5p
H8/8A	16µf	16v	4p	H7/13A	200µf	25v	8p
H8/9	20µf	6v	2p	H7/14	220µf	50v	10p
H8/9A	20µf	70v	4p	H7/14A	220µf	16v	6p
H8/10	22µf	50v	4p	H7/15	220µf	25v	5p
H8/10A	22µf	100v	4p	H7/15A	220µf	35v	10p
H8/11	25µf	12v	4p	H6/1A	250µf	4v	3p
H8/11A	24µf	275v	4p	H6/2	250µf	25v	3p
H8/12	32µf	15v	4p	H6/3A	320µf	2·5v	3p
H8/12A	30µf	10v	4p	H6/4	320µf	10v	4p
H8/13A	32µf	50v	4p	H6/4A	330µf	16v	5p
H8/14	40µf	25v	5p	H6/5	330µf	25v	10p
H8/14A	40µf	16v	4p	H6/5A	330µf	35v	15p
H8/15	47µf	50v	4p	H6/7	400µf	15v	5p
H8/15A	40µf	35v	4p	H6/8	470µf	25v	10p
H7/1	50µf	6v	3p	H6/8A	470µf	35v	20p
H7/1A	50µf	10v	4p	H6/9	500µf	15v	4p
H7/2	50µf	50v	4p	H6/9A	400µf	40v	20p
H7/2A	64µf	2·5v	2p	H6/10	750µf	12v	5p
H7/3A	64µf	25v	4p	H6/13A	1000µf	25v	16p
H7/4	64µf	15v	4p	H5/2A	2200µf	16v	15p

MULLARD ELECTROLYTIC CAPACITATORS

071 and 072 Series

Type No.	Working Voltage Vdc.	Capacitance µF	Max. Ripple Current at 50°C	Weight	Price
071 15332	16	3300	2·4 amps	1oz	15p
071 15472	16	4700	3·9 amps	1oz	17p
071 15682	16	6800	5·8 amps	$1\frac{1}{2}$oz	22p
071 15103	16	10000	7·9 amps	$2\frac{1}{2}$oz	27p
071 18222	63	2200	5·8 amps	3oz	30p
072 15752	16	7500 + 7500	10·5 amps	3oz	37p
072 15113	16	11000 + 11000	13·8 amps	$4\frac{1}{2}$oz	49p
071 16222	25	2200	2·2 amps	1oz	15p
071 16472	25	4700	5·4 amps	$1\frac{1}{2}$oz	22p
072 16502	25	5000 + 5000	9·6 amps	$3\frac{1}{2}$oz	37p
072 16752	25	7500 + 7500	12·6 amps	$4\frac{1}{2}$oz	49p
072 17342	40	3400 + 3400	9·1 amps	$3\frac{1}{2}$oz	37p
072 17502	40	5000 + 5000	12·0 amps	$4\frac{1}{2}$oz	49p
071 18681	63	680	2·1 amps	1oz	15p
072 18172	63	1650 + 1650	7·8 amps	3oz	37p

106 and 107 Series

106 15103	16	10000	7 amps	$2\frac{1}{2}$oz	65p
106 16223	25	22000	17 amps	10oz	£1·12
106 17103	40	10000	12 amps	$7\frac{1}{2}$oz	94p
106 18153	63	15000	28 amps	18oz	£1·79
107 10222	100	2200	10 amps	$5\frac{1}{2}$oz	74p

Type No.	Voltage	Capacitance	Weight	Price
102 15163	16	16000	8oz	20p
104 90003	20	39000	16oz	30p
102 16802	25	8000	7oz	25p
104 17562	40	5600	5oz	25p
104 90001	45	20000	16oz	50p
104 18332	63	3300	5oz	25p

A further 10% discount on lots of 100 of any one type.

Please calculate the weight of your order and include appropriate postage.

†Not over	Ordinary Parcels	Not over	Ordinary Parcels
$1\frac{1}{2}$lb	16p	10lb	37p
2lb	21p	14lb	47p
4lb	25p	18lb	57p
6lb	29p	22lb	67p

TRANSISTORS

Output Transistors
- BD 112 .. .. 25p
- OC 36 .. .. 50p
- BD 145 .. .. 25p

Small Signal N.P.N.
- BC 108 .. .. 10p
- BC 109 .. .. 10p
- BF 194 .. .. 10p

Transmitting Types
- BFR 64 .. .. £1
- BLY 89A £5
- BLY 93A £9

Microwave Varactor Diodes
- BXY 27/28/32/35/36/37/38/39/40/41 .. £1

Microwave Detector
- CAY 10 .. .. £5

Microwave Mixer
- CL 7331 .. .. £20

Microwave Gunn Effect Oscillator
- CL 8370 .. .. £10
- CL 8380 .. .. £10
- CL 8390 .. .. £10
- CL 8470 .. .. £40

Microwave Tunnel Diodes
- AEY 13 .. .. £5
- AEY 16 .. .. £10

R.F. Transistors
- BF 180 .. .. 20p
- BF 194 .. .. 10p
- AF 124 .. .. 20p

Field Effect Transistors
- BFW 12/13/14 .. .. 25p

Micro-miniature N.P.N.
- BFS 18R 10p
- LDA 400/403/450/452 .. .. .. 10p

Infra-red Transmitters
- CQY 11A £4
- CQY 12A £10

Light-sensitive Trans.
- OCP 70 .. .. 20p

Complementary Drivers, 2 watt (per matched pair)

INTEGRATED CIRCUITS
- TBA 500 Luminance I.C. £1
- TBA 510 Chrominance I.C. £1
- FEQ 101 64bit Memory £1
- 7400 .. .. 12p
- 7401 .. .. 12p
- 7410 .. .. 12p
- 7420 .. .. 12p
- 7440 .. .. 12p
- 7453 .. .. 12p
- 7470 .. .. 24p
- 7472 .. .. 24p
- 7473 .. .. 32p
- 7474 .. .. 32p
- 7482 .. .. 88p
- 7483 .. .. 95p
- 7490 .. .. 58p
- 7491 .. .. 78p
- 7492 .. .. 58p
- 7493 .. .. 58p
- 7495 .. .. 68p
- 5400 .. .. 10p
- 6404 .. .. 10p

NEW! NEW! NEW! NEW!

An aerosol spray providing a convenient means of producing any number of copies of a printed circuit both simply and quickly.

Method: Spray copper laminate board with light sensitive spray. Cover with transparent film upon which circuit has been drawn. Expose to light. (No need to use ultra-violet.) Spray with developer, rinse and etch in normal manner.

Light sensitive aerosol spray .. .. £1·00 plus
Developer and Etchant .. .. 50p postage

NEWER THAN NEW!!!!

Fibre Glass Board pre-treated with light-sensitive lacquer enabling you to produce prototype printed circuits within five minutes.
- 75mm × 100mm 33p
- 150mm × 100mm 66p
- 150mm × 200mm .. .. .. £1·32

Epoxy-Resin
- 75mm × 100mm 22p
- 100mm × 150mm 44p
- 150mm × 200mm 88p

Copper-clad Fibre Glass Board
- 12in × 6in 45p

Copper-clad Epoxy Resin Board
- 12in × 6in 25p

VEROBOARD

- $2\frac{1}{2}$in × 1in × 0·15in 6p
- $3\frac{3}{4}$in × $2\frac{1}{2}$in × 0·15in 16p
- $3\frac{3}{4}$in × $3\frac{3}{4}$in × 0·15in 20p
- 5in × $2\frac{1}{2}$in × 0·15in 20p
- 5in × $3\frac{3}{4}$in × 0·15in 28p
- 17in × $2\frac{1}{2}$in × 0·15in 55p
- 17in × $3\frac{3}{4}$in × 0·15in 74p
- $3\frac{3}{4}$in × $2\frac{1}{2}$in × 0·1in 21p
- $3\frac{3}{4}$in × $3\frac{3}{4}$in × 0·1in 24p
- 5in × $2\frac{1}{2}$in × 0·1in 23p
- 5in × $3\frac{3}{4}$in × 0·1in 28p

Spot Face Cutter 38p. Pin Insert Tool 48p.
Terminal Pins (0·1 or 0·15) 36 for 18p.

Special Offer Pack consisting of 5 $2\frac{1}{2}$in × 1in boards and a Spot Face Cutter—50p.
"ODDS & ENDS"—1p sq in.

MULLARD POLYESTER CAPACITORS

500,000 in STOCK!!!

·001µf	·0018µf	·0056µf	·015µf
·0012µf	·0022µf	·01µf	·033µf
·0015µf	·0027µf	·012µf	·082µf

20p dozen; 75p-100; £5-1,000; £40-10,000

·15µf ·18µf ·22µf ·39µf ·68µf

20p dozen; £1-100; £6·50-1,000; £50-10,000

ERIE MONOLITHIC CERAMIC CAPACITORS

3p each; 20p dozen; £1·75 per 100

10pf	68pf	560pf
15pf	100pf	620pf
22pf	150pf	680pf
33pf	220pf	1,000pf
39pf	330pf	
47pf	470pf	

RECTIFIERS 1N4007 1200 peak volts, 30 amps peak current, 1 amp mean current. 100 for £7·50, 1,000 £50.

£1 100 $\frac{1}{4}$-$\frac{1}{2}$ WATT RESISTORS
100 CERAMIC CAPACITORS
100 DIODES
PACK No. 1

£1 100 RESISTORS
100 CERAMIC CAPACITORS
100 POLYSTYRENE CAPACITORS
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£1 1 VERO-BOARD CUTTER
5 $2\frac{1}{2}$ in. x 1 in. x ·15 BOARDS
50 SQ. INS. "ODD PIECES" VERO
PACK No. 3

£1 100 RESISTORS
100 CERAMIC CAPACITORS
50 MULLARD POLYESTER CAPACITORS
PACK No. 4

£1 20 ASSORTED UNUSED MARKED, TESTED TRANSISTORS BC108 ETC.
PACK No. 5

£1 1 TRANSISTORISED SIGNAL TRACER KIT
1 TRANSISTORISED SIGNAL INJECTOR KIT
PACK No. 6

£1 6 COMPUTER PANELS CONTAINING MASSES OF DIODES, TRANSISTORS, INDUCTORS, RESISTORS & CAPACITORS
PACK No. 7

£1 100 RESISTORS
100 CAPACITORS (ASSORTED TYPES)
PACK No. 8

REMEMBER THE VAT-MAN COMETH! ALL PRICES INCREASE APRIL 1st!

G. F. MILWARD, Drayton Bassett, Tamworth, Staffs. Postage (minimum) per order 15p.

SERVICE TRADING CO

Postage included in prices below are inland only. For Overseas please ask for quotation. We do not issue a catalogue or list.

MATSUNAGA VARIABLE VOLTAGE TRANSFORMERS

INPUT 230 v. A.C. 50/60
OUTPUT VARIABLE 0/260 v. A.C.

Carriage Paid

BRAND NEW. All types.

50 AMP	0-260 v. at 1 amp	£7·00
	0-260 v. at 2·5 amps	£8·05
	0-260 v. at 5 amps	£11·75
	0-260 v. at 10 amps	£22·50
	0-260 v. at 15 amps	£25·00
	0-260 v. at 20 amps	£49·00
	0-260 v. at 25 amps	£58·00
	0-260 v. at 37·5 amps	£82·00
	0-260 v. at 50 amps	£98·00

1 AMP — Special discount for quantity

OPEN TYPE (Panel Mounting)

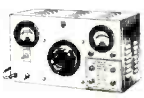
½ amp £4·75 — 1 amp £7·00 — 2½ amp £8·05

L.T. TRANSFORMERS

All primaries 220-240 volts.

Type No.	Sec. Taps	Price Incl. P.&P.
1	30, 32, 34, 36 v. at 5 amps	£5·03
2	30, 40, 50 v. at 5 amps	£7·23
3	10, 17, 18 v. at 10 amps	£5·30
4	6, 12 v. at 20 amps	£6·93
5	17, 18, 20 v. at 20 amps	£7·78
6	6, 12, 20 v. at 20 amps	£7·38
7	24 v. at 10 amps	£5·58
8	4, 6, 24, 32 v. at 12 amps	£7·65
9	6 and 12 v. at 10 amps	£4·10

36 volt 30 amp. A.C. or D.C. Variable L.T. Supply Unit

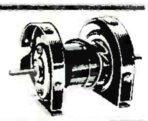


Input 220/240 v. A.C. Output Continuously variable 0-36 v. A.C./D.C. Fully isolated. Fitted in robust metal case with Voltmeter, Ammeter, Panel Indicator and chrome handles. Input and Output fully fused. Ideally suited for Lab. or Industrial use. £70 incl. p. & c.

MOTOROLA MAC11/6 PLASTIC TRIAC 400 PIV 10 AMP

Now available EX STOCK supplied complete with full data and applications sheet. Price **£1·12** incl. P. & P. Suitable Diac 30p (RCA40583).

DOUBLE ENDED MOTOR UNIT



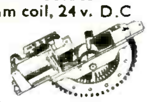
Powerful, continuously rated, 2 speed. Either **6 or 12 volt D.C.** operation. Price £2·00 incl. P. & P.

POWER RHEOSTATS

(NEW) Ceramic construction, winding embedded in Vitreous Enamel, heavy duty brush assembly designed for continuous duty. **AVAILABLE FROM STOCK IN THE FOLLOWING 11 VALUES:**
100 WATT 1 ohm 10a., 5 ohm 4.7a., 10 ohm 3a., 25 ohm 2a., 50 ohm 1.4a., 100 ohm 1a., 250 ohm ·7a., 500 ohm ·45a., 1k ohm 280mA., 1·5k ohm 230mA., 2·5k ohm ·2a., 5k ohm 140mA., Diameter 3¼in. Shaft length ¾in. dia. $\frac{15}{64}$in., **£1·73**, incl. P. & P.
50 WATT 1·12/10/25/50/100/250/500/1K/1·5K/2·5K/5K ohm. All at **£1·23**, incl. P. & P.
25 WATT 10/25/50/100/250/500/1K/1·5K/2·5K/3·5K ohm. All at **98p**, incl. P. & P.

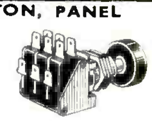
Black Silver Skirted knob calibrated in Nos. 1-9. 1½ in. dia brass bush. Ideal for above Rheostats, **18p** ea.

UNISELECTOR SWITCHES—NEW



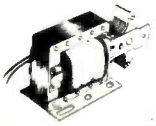
4 BANK 25 WAY FULL WIPER 25 ohm coil, 24 v. D.C operation **£6·13** inc. P. & P.
6 BANK 25 WAY FULL WIPER 25 ohm coil, 24 v. D.C. **£6·75**, inc. P. & P.
8 BANK 25 WAY FULL WIPER 24 v. D.C. operation. **£7·88**, inc. P. & P.

'HONEYWELL' PUSH BUTTON, PANEL MOUNTING MICRO SWITCH ASSEMBLY



Each bank comprises of a change-over rated at 10 amps 240 volt A.C. Black knob 1 in. dia. Fixing hole ⅝ in. Prices: 1-bank **30p**, 2-bank **40p**, 3-bank **55p**. (Illustrated) inc. P. & P. Special quotes for quantities.

230 VOLT AC SOLENOID



EXTREMELY POWERFUL SOLENOID with approximately 14lb. pull, 1 inch travel. Fitted with mounting feet. Size 4 inches long, 2⅜ inches wide and 3 inches high. Price **£2·00** including post & pkg.

230-250 VOLT A.C. SOLENOID
(Similar in appearance to above illustration.) Approx. 1½lb. pull. Size of feet 1⅜ × 1$\frac{3}{16}$. Price **85p** incl. P. & P. Manufactured by Westool Ltd.

18-24 VOLT D.C. SOLENOID
Size: O.A.L. 3⅝ in. × 1½ in. × 1 in. Maximum push ⅝ at approx. 1 lb. PRICE: **75p** incl. P. & P.

STROBE! STROBE! STROBE!

FOUR EASY TO BUILD KITS USING XENON WHITE LIGHT FLASH TUBES, SOLID STATE TIMING + TRIGGERING CIRCUITS, PROVISION FOR EXTERNAL TRIGGERING. 230-250v. A.C. OPERATION.

EXPERIMENTERS "ECONOMY" KIT
Adjustable 1 to 30 Flash per sec. All electronic components including Veroboard S.C.R. Unijunction Xenon Tube + Instructions **£6·55** incl. P. & P.

NEW INDUSTRIAL KIT
Ideally suitable for schools, laboratories etc. Roller tin printed circuit. New trigger coil, plastic thyristor. Adjustable 1-80 f.p.s., approx. ¼ output of Hy-Lyght. Price **£11·00**. incl. P. & P.

HY-LIGHT STROBE
Designed for use in large rooms, halls and the photographic field and utilizes a silica tube, printed circuit and a special trigger coil, Speed adjustable 1-20 f.p.s. Light output greater than many (so called 4 Joule) strobes. Price **£12·50**. incl. P. & P.

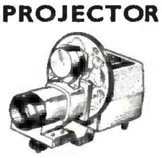
'SUPER' HY-LIGHT KIT
Approx. 4 times the light output of our well proven Hy-Lyght strobe.
Incorporating, Heavy duty power supply.
Variable speed from 1-13 flash per sec.
Reactor control circuit producing an intense white light.

Never before a Strobe Kit with so HIGH an output at so LOW a price. ONLY £20·75, incl. P. & P.
ATTRACTIVE, ROBUST, FULLY VENTILATED METAL CASE specially designed for the Super Hy-Lyght Kit including reflector, **£7·45** incl. P. & P.
FOR HY-LYGHT STROBE incl. reflector, **£4·45** incl. P. & P.
7-INCH POLISHED REFLECTOR. Ideally suited for above Strobe Kits. Price **66p** incl. P. & P.

RAINBOW STROBE FOUR LIGHT CONTROL MODULE

Will operate four of our Hy-Lyght or Super Hy-Lyght Strobes in either 1, 2, 3, 4 sequence; 2 + ; or all together. Thoroughly tested and reliable. Complete with full connection instructions. Price: **£18·75** incl. P. & P. Send S.A.E. for details.

COLOUR WHEEL PROJECTOR



Complete with oil filled colour wheel. 100 watt lamp. 200/240V AC. Features extremely efficient optical system. **£18·85**, incl. P. & P.

6 INCH COLOURWHEEL
As used for Disco lighting effects, etc. Price **£5·75** inc. p. & p.

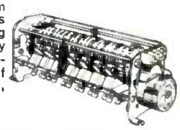
BIG BLACK LIGHT

400 Watt. Mercury vapour ultra violet lamp. Outer bulb designed to absorb visible light and transmit u.v. rays. Extremely compact and powerful source of u.v. Inumerable industrial applications also ideal for stage, display, discos etc. P.F. ballast is essential with these bulbs. Price of matched ballast & bulb **£16·50**. incl. P.&P. Spare bulb **£7·30**, incl. P.&P.

BLACK LIGHT FLUORESCENT U.V. TUBES
4ft. 40 watt. Price **£5·80** incl. P. & P. (For use in standard bi-pin fluorescent fittings). MINI 9 inch 6 watt black light U.V. tube. **£1·45** incl. P. & P.

IMPORTANT
FROM APRIL 1st. V.A.T.
(at the standard rate)
MUST BE ADDED TO ALL PRICES

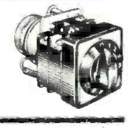
HONEYWELL PROGRAMME TIMERS



240V. A.C. 5 r.p.m. motor. Each cam operating a c/o micro switch. Cams are individually variable, allowing inumerable combinations. Ideally suited for machinery control, automation etc. Also in the field of entertainment, for chaser lights, animated displays, etc.
15 cam model **£6·00** incl. P. & P.
10 cam model **£5·00** incl. P. & P.
2 cam model with 15 r.p.m. motor **£2·00** incl. P. & P.

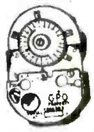
SIMPLE 12 CAM PROGRAMMER with 4 adjustable cams and 8 that may be profiled to individual requirements. Available with 15 or 13 r.p.m. motor **£3·75** incl. P. & P.

24 HOUR TIMER



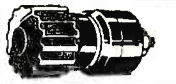
Can be adjusted to give a switching delay of between ½ hr. to 24 hrs. Driven by 200/250v. A.C. synchronous motor. 15 amp. c/o contacts. Mfg. Crater Controls Ltd. Supplied with scale calibrated 0-10 (2 hours per division) Brand new. **£2·00** incl. P. & P.

VENNER ELECTRIC TIME SWITCH



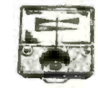
200/250 volt. Ex-GPO. Tested, perfect condition. Two ON, two OFF, every 24 hrs. at any manually pre-set time. Price: 15 amp, **£3·45**. 20 amp, **£3·95**. Incl. P. & P. Also available with Solar Dial ON at dusk, OFF at dawn. Prices as above.

INSULATED TERMINALS



Available in black, red, white, yellow, blue and green. New **10p** each. Incl. P. & P. Minimum order 6.

METER BARGAIN



BALANCE/LEVEL METERS
100-0-100 Micro Amp. Size 1½in. × 1½in. × ⅞in. Price only **75p** including P. & P.

AMMETERS NEW! 2½in. FLUSH ROUND

available as D.C. Amps 1, 5, 10, 15, 20 or A.C. Amps 1, 5, 10, 15, 20. Both types **£1·75** incl. P. & P. 0-300V. A.C. **£1·90** incl. P. & P.

RELAYS

SIEMENS PLESSEY, etc. MINIATURE RELAYS

1	2	3	4	1	2	3	4
				700	12-24	2 c/o	63p*
52	4-6	6M	63p	700	15-35	2c/oHD	73p*
52	4-6	4 c/o	78p*	700	6-12	1c/oHD	50p*
150	6-12	4 c/o	78p*	700	16-24	6 M	63p*
185	8-12	6 M	63p*	700	20-30	6 c/o	75p
280	9-12	2 c/o	73p*	1250	24-36	4 c/o	63p*
410	10-18	4 c/o	73p*	2500	36-45	6 M	63p*
600	9-18	2 c/o	63p	2400	30-48	4 c/o	50p
700	16-24	4M2B	63p*	9000	40-70	2 c/o	50p*
700	16-24	4 c/o	78p*	15k	85-110	6 M	50p*

(1) Coil ohms; (2) Working d.c. volts; (3) Contacts; (4) Price HD=Heavy Duty. All Post Paid. (*including Base)

12 VOLT D.C. RELAY
Type 1: Three sets c/o contacts 5 amp. **78p** incl. P. & P. (Similar to illustration below).
Type 2: One set c/o contacts **60p** incl. P. & P.
Type 3: 4-8 volt 3 c/o HD, 67 ohm coil. **78p**. Incl. P. & P.

SPECIAL OFFER.
700 ohm. 4 c/o Ex. new equipment. **£50·00** per 100 incl. bases (minimum 100).

'DIAMOND H' 230 VOLT A.C. RELAYS (Unused)

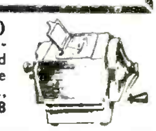
Three sets c/o contacts rated at 5 amps. Price **60p**. incl. P. & P. (100 lots **£40·00** incl. P. & P.)

230 VOLT A.C. RELAYS M.f.g. 'Keyswitch'
One set c/o contacts rated at 7·5 amps. Boxed. Price **45p**. Incl. P. & P. (100 lots **£32·00** incl. P. & P.)

MINIATURE RELAYS
9-12 volt D.C. operation. 2 c/o 500 M.A. contacts. Size only 1 in.×⅞×½ in. Price **58p** incl. P. & P.
30-36 v. D.C. operation. 2 c/o 500 M.A. contacts. 3,200 ohm coil. Size only 1×$\frac{11}{16}$×$\frac{11}{16}$ in. **43p** incl. P. & P.

MINIATURE LATCHING RELAY
Mfg. by Clare-Elliott Ltd. (Type F) 2 c/o permanent latching in either direction. Coil 1150 ohm. 15-30 v. D.C. New 73p, incl. P. & P.

INSULATION TESTERS (NEW)



Test to I.E.E. Spec. Rugged metal construction, suitable for bench or field work, constant speed clutch. Size L 8 in., W. 4 in., H. 6 in. weight 6 lb., **500 VOLTS**, 500 megohms **£28** carriage paid
1,000 VOLTS, 1,000 megohms **£34** carriage paid

240 A.C. SOLENOID OPERATED FLUID VALVE

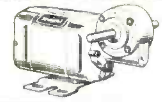
Will handle liquids or gases. Forged brass body, stainless steel core and spring ½ in. b.s.p. inlet/outlet. Precision made. British mfg. PRICE: **£1·95** incl. P. & P. Special quotation for quantity. NEW in original packing.

230V/240V COMPACT SYNCHRONOUS GEARED MOTORS

Manufactured by either Sangamo, Haydon or Smith. Built-in gearbox.
5 RPM A/cw — 3 RPH A/cw — 20 RPH cw
2 RPH cw — 6 RPH cw — 12 RPH cw — All at 75p
cw=Clockwise. A/cw=Anti-clockwise

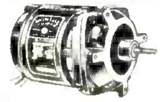
REVERSIBLE SPLIT PHASE MOTOR
250 r.p.m. 100-115/210-240V AC. 2 in. × 1 in. Ideal for rim-drive models, display etc. Extremely powerful for size **75p**. incl. P. & P. (including small capacitor.)

PARVALUX TYPE: SDI.S/89400/OM



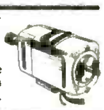
230/250v. A.C. 50 r.p.m. 22 lb/ins. Continuously rated, Incl. base **£7·30** incl. P. & P. new and unused.

BODINE TYPE N.C.I. GEARED MOTOR



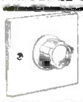
(Type J) 71 r.p.m. torque 10 lb. in. **Reversible** 1/70th h.p. cycle ·38 amp. **(Type 2) 28 r.p.m.** torque 20 lb. in **Reversible** 1/80th h.p. 50 cycle ·28 amp.
The above two precision made U.S.A. motors are offered in 'as new' condition. Input voltage of motor 115v A.C. Supplied complete with transformer for **230/240v A.C. Input.**
Price, either type **£3·85** plus 52p P. & P. or less transformer **£2·52** incl. P. & P.
These motors are ideal for rotating aerials, drawing curtains, display stands, vending machines, etc, etc.

PARVALUX TYPE SD2. 200/250 VOLT A.C. D.C. HIGH SPEED MOTOR



Speed 9,000 r.p.m. approx. or 3,200 r.p.m if used with built-in governor, or variable speed over a wide range if used in conjunction with our Dimmer Switch, illustrated below. PRICE: **£2·00** incl. P. & P.

600 WATT DIMMER SWITCH



Easily fitted. Fully guaranteed by makers Will control up to 600 watts of all lights except fluorescent at mains voltage. Complete with simple instructions. £3 including P.&P

ALL MAIL ORDERS, ALSO CALLERS AT:
57 BRIDGMAN ROAD, CHISWICK, LONDON, W4 5BB. Phone: 01-995 1560
Closed Saturdays.

SERVICE TRADING CO.
SHOWROOMS NOW OPEN
AMPLE PARKING

PERSONAL CALLERS ONLY
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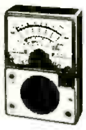
Tel.: 01-437 0576

MULTIMETERS *for EVERY purpose!*

TS60 POCKET MULTIMETER High-precision at low-cost. Ranges: D.C. 15V., 150V., 1,000V. (10,000 opv). A.C. 15V, 150V., 100V. (1,000 opv). D.C. Current 150mA. Resistance 100k/ohms. **£1·85**. Post 15p.

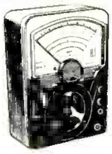
MODEL 1092 Testmeter. 5,000 O.P.V. 0/3/15/150/300/1200 V. D.C. 0/6/30/300/600 V. A.C. 0/300μA/300 MA 0/10K/1 meg Ω Decibels —10 to +16 db **£2·75** each. Post 15p.

HIOKI MODEL 720X 20,000 O.P.V. Overload protection 5/25/100/500/1000 VDC. 10/50/250/1000 VAC. 50μA/250 mA. 20K/2 meg ohm. —5 to +62db. **£4·97**. Post 15p.

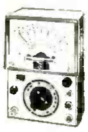


HIOKI MODEL 730X 30,000 O.P.V. Overload protection. 6/30/60/300/600/1200 VDC. 12/60/120/600/1200 VAC. 60 μA/30 mA/300 mA. 2K/200K/2 megohm. —10 to +63 db. **£6·50**. Post 15p.

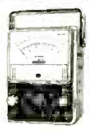
MODEL TE-200 20,000 O.P.V. Mirror scale, overload protection. 0/5/25/125/1,000V. D.C. 0/10/50/250/1,000V. A.C. 0/50 μA/250 mA. 0/60K/6 megΩ. —20 to +62 db. **£3·95**. Post 15p.



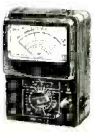
MODEL 500 30,000 O.P.V. with overload protection, mirror scale. 0/.5/2.5/10/25/100/250/500/1,000 v. D.C. 0/2.5/10/25/100/250/500/1,000 v. A.C. 0/50μA/5/50/500 mA. 12 amp. D.C. 0/60/K/6 meg/60 meg Ω. **£8·87**. Post paid.



HIOKI MODEL 750X 50,000 o.p.v. 43 ranges 0-0.3 to 1,200v. D.C. 0-3 to 1,200 v. A.C. 0-30μA/300mA. 0-3K/30 meg. ohms. —10 to +17 db. **£8·97**. Post 20p.

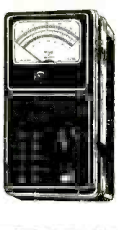


HT100B4 MULTIMETER Features A.C. current ranges. 100,000 o.p.v. Mirror Scale, Overload protection. 0/·5/2·5/10/50/250/500/1000 V DC. 0/2·5/10/50/250/1000 V AC. 0/10/250MμA/2·5/25/250 MA/10 Amp DC. 10 Amp AC. 0/20K/200K/2MEG/20MEG. — 20 + 62 db **£12·50**. Post 25p.

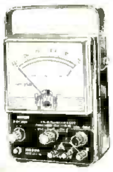


370 WTR MULTI METER Features A.C. current ranges. 20,000 o.p.v. 0/·5/2·5/10/50/250/500/1000 V DC. 0/2·5/10/50/250/500/1000 V AC 0/50μA/1/10/100MA/1/10 Amp DC. 0/100MA/1/10 Amp AC. 0/5K/50K/500K/5MEG/50MEG. — 20 + 62 db. **£15**. Post 25p.

RUSSIAN 22 RANGE MULTIMETER



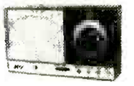
Model U437 10,000 o.p.v. A first class versatile instrument manufactured in U.S.S.R. to the highest standards. Ranges: 2·5/10/50/250/500/1000v D.C. 2·5/10/50/250/500/1000v A.C. D.C. Current 100 wA/1/10/100 mA/1A. Resistance 300 ohms/3/30/300K/3M Ω Complete with batteries, test leads, instructions and sturdy steel carrying case. Our Price **£5·97**. Post 25p.



KAMODEN HM.350 TRANSISTOR TESTOR High quality instrument to test Reverse Leak current and DC current Amplification factor of NPN, PNP, transistors, diodes, SCR's etc. 4in. × 4¾in. clear scale meter. Operates from internal batteries. Complete with instructions leads and carrying handle. **£12·50** Post 30p.

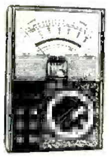
ROUND SCALE TYPE PENCIL TESTER MODEL TS.68

Completely portable, simple to use pocket sized tester. Ranges: 0/3/30/300v A.C. and D.C. at 2,000 o.p.v. Resistance 0-20K ohms. Only **£1·97**. Post 13p.



LT601 MULTIMETER New style 20,000 o.p.v. pocket multimeter. 5 / 25 / 50 / 250 / 2500V. D.C. 10/50/100/500/1000V. A.C. 50μA/250mA. 6K/6 meg ohms. —20 to +22db. **£3·75**. Post 20p.

MODEL TH-12 20,000 o.p.v. Overload protection. Slide switch selector. 0/·25/2·5/10/50/250/1000V. D.C. 0/10/50/250/1000V. A.C. 0/50μA/25/250mA D.C. 0/3K/30K/300K/3 meg. —20 to +50db. **£4·97**. Post 15p.



MODEL TE-300 30,000 O.P.V. Mirror scale, overload protection 0/.6/3/15/60/300/1,200 V.D.C. 0/6/30/120/600/1,200 V.A.C. 0/30μA/6mA/6 OmA/300mA/600mA. 0/8K/80K/800K/8 meg. -20 to + 63 db. **£5·97**. Post 15p.

MODEL PL436. 20kΩ/Volt D.C. 8kΩ/Volt A.C Mirror scale. ·6/3/12/30/120/600V D.C. 3/30/120/600V A.C. 50/600μA/60/600 mA. 10/100K/1 Meg/10 meg Ω. —20 to +46db. **£6·97**. Post 12p.

TMK MODEL TW-50K 46 ranges, mirror scale, 50K/Vol. D.C. 5K /Volt A.C. D.C.: Volts ·125, ·25, 1 25, 2·5, 5, 10, 25, 50, 125, 250, 500, 1,000V. A.C. Volts: 1·5, 3, 5, 10, 25, 50, 125, 250, 500, 1,000V. D.C. Current: 25, 50μA, 2·5, 5, 25, 50, 250, 500mA, 5, 10 amp. Resistance: 10K, 100K, 1 MEG, 10 MEGΩ. Decibels: —20 to +81·5 db. **£8·50**. Post 17p.

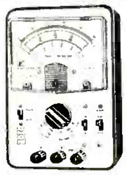
MODEL K228A Taut band suspension. Overload protection. Polarity reversing switch. 30,000 o.p.v. 50/0/·5/2·5/15/250/500/1000/2500V D.C. 0/15/50/150/500/1000V. A.C. 0/50μA/5/50/150/500mA/5A D.C. 0/3K/300K/3 meg. **£8·95**. Post 20p.

HIOKI MODEL 700X 100,000 O.P.V. Overload protection. Mirror scale. ·3/·6/1·2/1·5/3/6/12/30/60/120/300/600/1200 VDC. 1·5/3/6/12/30/60/150/300/600/1200 VAC. 15/30vA/3/6/30/60/150/300 mA. 6/12 AMP DC. 2K/200 K/2 Meg/20 megohm. —20 to +63db. **£13·50**. Post 20p.

MODEL C-7080 EN Giant 6in. mirror scale. 20,000 o.p.v. 0/·25/1/2·5/10/50/250/1000/5000V. D.C. 0 / 2·5 / 10 / 50 / 250 / 1000 / 5000V. A.C. 0/50μA/1/10/100/500mA/10 amp. D.C. 0/2K/200K/20 meg. —20 to +50 db. **£13·95**. Post 35p.

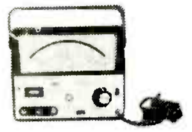
U4312 MULTIMETER Extremely sturdy instrument for general electrical use. 667 o.p.v. 0/·3/1·5/7·5/30/60/150/300/600/900 VDC and 75mV. 0/·3/1·5/7·5/30/60/150/300/600/900 VAC. 0/300μA/1·5/6/15/60/150/600MA/1·5/6 AMP. D.C. 0/1·5/6/15/60/150/600MA/1·5/6 AMP. A.C.0/200 Ω/3K/30KΩ. Accuracy DC 1%. AC 1·5%. Knife edge pointer, mirror scale. Complete with sturdy metal carrying case, leads and instructions. **£9·50**. Post 25p.

Selected TEST EQUIPMENT



FTC-401 TRANSISTOR TESTER Full capabilities for measuring A, B and ICO. NPN or PNP. Equally adaptable for checking diodes. Supplied complete with instructions, battery and leads. **£7·50**. Post 20p.

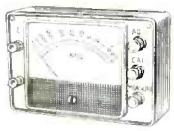
Model S-100TR MULTIMETER/TRANSISTOR TESTER 100,000 o.p.v. MIRROR SCALE/OVERLOAD PROTECTION 0/·12—·6/3/12/30/120/600 V DC. 0/6/30/120/600 V. AC. 0/12/600uA/12/300MA/12 Amp. DC. 0/10K/1 MEG/100 MEG. — 20 to + 50 db. 0·01 —·2 mfd. Transistor tester measures Alpha, beta and Ico. Complete with batteries, instructions and leads. **£13·50**. Post 25p.



MODEL 449A IN CIRCUIT TRANSISTOR TESTER Checks true A.C. beta in/out. Checks Icbo. Checks diodes in/out. Checks SCR etc. Beta H1 10-500. LO2-50. Icbo 0–5000μA. 220/240V. A.C. operation. £17·50. Post 25p.

RF-300 AF/RF SIGNAL GENERATOR

All transistorised, compact, fully portable. AF sine wave 18Hz. to 220KHz. AF square wave 18Hz. to 100KHz. Output sine/square 10v. P.P. RF 100KHz. to 200 MHz. Output 1v. maximum. Operation 220/240v. A.C. Complete with instructions and leads. **£29·95**. Post 50p.



KAMODEN HMG-500 INSULATION RESISTANCE TESTER Range 0-1000 Megohms, 500 Volt. Battery operated. Wide range clear meter 4¾in. × 4in. Complete with de luxe carrying case, batteries, instructions. **£19·95**. Post 30p.

MODEL L-55 FET V.O.M. Input impedance 10 meg. ohms. 0/3/1·2/6/30/120/600V. D.C. 0/3/12/60/120/600V. A.C. 0/120μA/120mA. D.C. 0/1K/100K/10 meg/100 meg ohms. £15·97. Post 25p.

CI-5 PULSE OSCILLOSCOPE For display of pulsed and periodic waveforms in electronic circuits. VERT. AMP. Bandwidth 10MHz. Sensitivity at 100KHz VRMS/mm. .1–25; HOR. AMP. Bandwidth 500KHz. Sensitivity at 100KHz. V RMS/mm. .3–25; Preset triggered sweep 1–3,000μsec.; free running 20–200,000Hz in nine ranges. Calibrator pips. 220 × 360 × 430mm. 115-230V. A.C. operation. £39·00. Carr. paid.

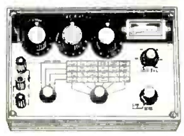
TO-3 PORTABLE OSCILLOSCOPE. 3" TUBE

Y amp. Sensitivity. .1v p-p/CM. Bandwidth 1.5 cps —1.5 MHZ. Input imp. 2 meg Ω. 25 PF. X amp sensitivity. ·9v p-p/CM. bandwidth 1.5 cps—800 KHZ. Input imp. 2 meg Ω 20 PF. Time base. 5 ranges 10 cps—300 KHZ. Synchronization. Internal/external. Illuminated scale. 140 × 215 × 330 mm. Weigt 15½lbs. 220/240 V. A.C. Supplied brand new with handbook **£40·00**. Carr. 50p.

RUSSIAN CI-16 DOUBLE BEAM OSCILLOSCOPE 5 mc/s Pass Band. Separate Y1 and Y2 amplifiers. Rectangular 5in. × 4in. C.R.T. Calibrated triggered sweep from ·2 μ/sec. to 100 milli-sec. per cm. Free running time base 50 c/s–1 mc/s. Built-in time base calibrator and amplitude calibrator. Supplied complete with all accessories and instruction manual. £87 Carr. paid.

TE-16A Transistorised Signal Generator. 5 ranges 400kHz—30mHz. An inexpensive instrument for the handyman. Operates on 9v battery. Wide easy to read scale. 800kHz modulation. 5¼ × 5¼ × 3¾in. Complete with instructions and leads. **£7·97**. Post 25p.

TRANSISTORISED L.C.R. A.C MEASURING BRIDGE.

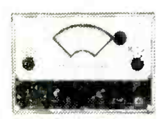


A new portable bridge offering excellent range and accuracy at low cost. Ranges: R. 1Ω—11.1 MEG Ω 6 Ranges ± 1%. L. 1μH—111 HENRIES. 6 Ranges — 2%. C. 10PF ± 1110MFD. 6 Ranges ± 2%. TURNS RATIO 1:1/1000—1:11100 6 Ranges ± 1%. Bridge voltage at 1,000 CPS. Operated from 9 volts. 100μA. Meter indication. Attractive 2 tone metal case. Size 7¾" × 5" × 2" **£20**. Post 25p.

MODEL TE.15 GRID DIP METER Transistorised. Operates as Grid Dip, Oscillator, Absorption Wave Meter and Oscillating Detector Frequency range 440Kc/s–280Mc/s in 6 coils. 500μA Meter. 9V. battery operation. Size 180 × 80 × 40mm. **£12·50**. Post 20p.

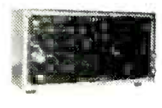
BELCO AF-5A SOLID STATE SINE SQUARE WAVE C.R. OSCILLATOR

Sine 18-200,000 Hz; Square 18-50,000 Hz



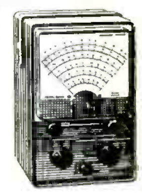
Output max. + 10 dB (10 K ohms). Operation internal batteries. Attractive 2-tone case 7½in. × 5in. × 2in. Price **£17.50** Carr. 17p.

MODEL MG-100 SINE SQUARE WAVE AUDIO GENERATOR Range: 19-220,000 Hz Sine Wave 19-100,000 Hz Square Wave. Output Sine or Square wave 10v. P. to P. Size 180 × 90 × 90mm. Operation 220/240v A. C. **£17 50**. Post 37p.



MODEL AT201 DECADE ATTENUATOR Frequency range: 0–200KHz. Attenuator: 0-111db., 0·1db. step. Impedance 600 ohms. Max. input power 30dbm. Size 180 × 90 × 55mm. **£12·50**. Post 37p.

TE-65 VALVE VOLTMETER



High quality instrument with 28 ranges. D.C. volts 1.5-1,500 v. A.C. volts 1.5-1,500 v. Resistance up to 1,000 megohms. 220/240v. A.C. operation Complete with probe and instructions. **£17·50**. Post 30p. Additions. Probes available: R.F. **£2·12** H.V **£2·50**.

MODEL U4311 SUB-STANDARD MULTI-RANGE VOLT AMMETER Sensitivity 330 ohms/Volt A.C. and D.C. Accuracy ·5% D.C. 1% A.C. Scale length 165mm. 0/300/750μA/1·5/3/7·5/15/30/75/150/300/750mA/1·5/3/7·5 AMP. D.C. 0/3/7·5/15/30/75/150/300/750mA/1·5/3/7·5 AMP. A.C. 0/75/150/300/750mV/1·5/3/7·5/15/30/75/150/300/750V. D.C. 0/750mV 1·5/3/7·5/15/30/75/150/300/650V. A.C. Automatic cut out. Supplied complete with test leads, manual and test certificates. **£49**. Post 50p.

G. W. SMITH & Co. (Radio) Ltd.

Also see opposite page and next two pages

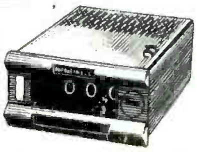
KAMODEN HM.720B F.E.T. V.O.M.

Input impedance 10 meg. ohms.
Ranges:
0/·25/1/2·5/10/50/250/1000V, D.C.
0/2·5/10/50/250/1000V. A.C.
0/25μA/2·5/25/250 MA D.C.
−20 to +62dB
0/5K/50K/500K/5 meg/500 meg ohms.
£14·95. Post 30p.

KAMODEN 72.200 MULTITESTER

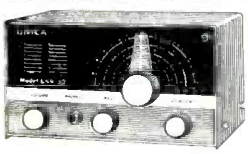
High sensitivity tester. 200,000 o.p.v. Overload protection. Mirror scale. Ranges:
0/·06/·3/3/30/120/600/1200V. D.C.
0/3/12/60/300/11,200V A.C.
0/6μA/1·2mA/120mA/600mA/12A. D.C.
0/12A. A.C.
−20 to +63dB.
0/2K/200K/2 meg/200 meg ohms.
£16·95. Post 30p.

HONEYWELL DIGITAL VOLTMETER VT.100



Can be panel or bench mounted. Basic meter measures 1 volt DC, but can be used to measure a wide range of AC and DC volt, current and ohms with optional plug in cards. Specification: Accuracy: ± 0·2, ± 1 digit. Resolution: 1 mV. Number of digits: 3 plus fourth overrange digit. Overrange: 100% (up to 1·999). Input impedance: 1000 Meg ohm. Measuring cycle: 1 per second. Adjustment: Automatic zeroing, full scale adjustment against an internal reference voltage. Overload: to 100v. D.C. Input: Fully floating (3 poles). Input power: 110-230v. A.C. 50/60 cycles. Overall size: 5⅛in. × 2 13/16in. × 8 3/16in. AVAILABLE BRAND NEW AND FULLY GUARANTEED.

£35.50 Carr. 50p.



UNR 30 RECEIVER

4 Bands covering 550kc/s - 30mc/s. B.F.O. Built in Speaker 220/240v AC. Brand new with instructions. **£15·75.** Carr. 37p.

UR-1A SOLID STATE COMMUNICATION RECEIVER

4 Bands covering 550kc/s–30mc/s. FET, S Meter. Variable BFO for SSB, Built-in Speaker, Bandspread, Sensitivity Control. 220/240v. A.C. or 12v. D.C. 12⅛″×4½″×7″. Brand new with instructions. **£25.** Carr. 37p.

SKYWOOD CX203 COMMUNICATION RECEIVER

Solid state. Coverage on 5 bands, 200-420 KHz and ·55 to 30 MHz. Illuminated slide rule dial. Bandspread. Aerial tuning. BFO. AVC. ANL. 'S' meter. AM/CW/SS B. Integrated speaker and phone socket. Operation 220/240v AC or 12v DC. Size 325×266×150 mm. Complete with instructions and circuit. **£32·50.** Carr. 50p.

LAFAYETTE HA-600 SOLID STATE RECEIVER

General coverage 150-400 kc/s, 550kc/s-30 mc/s. FET front end, 2 mech. filters, product detector, variable B.F.O., noise limiter, S Meter Bandspread. RF Gain. 15″×9¼″×8¼″. 18 lb. 220/240v A.C. or 12V D.C. Brand new with instructions. **£50.** Carr. 50p.

TRIO 9R59DS COMMUNICATION RECEIVER

4 band covering 550 Kc/s. to 30 Mc/s. continuous and electrical bandspread on 10, 15, 20, 40 and 80 metres. 8 valve plus 7 diode circuit. 4/8 ohm output and phone jack. SSB-CW. ANL. Variable BFO. S meter. Sep. bandspread dial. IF frequency 445 Kc/s. audio output 1.5w. Variable RF and FA gain controls 115/250v A.C. Size: 7in. × 13in. × 10in. with instruction manual. **£49·50.** Carr. paid.

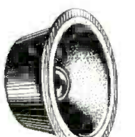
SINCLAIR IC-12

List price £2·98
OUR PRICE
£1·80
Post 10p.

SINCLAIR PROJECT 60 PACKAGE DEALS

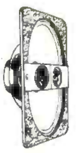
2×Z30/Stereo 60/PZ5 **£15·95.** P. & P. 37p.
2×Z30/Stereo 60/PZ6 **£18·00.** P. & P. 37p.
2×Z50/Stereo 60/PZ8 **£20·25.** P. & P. 37p.
Transformer for PZ8 **£2·97** extra.
Active Filter Unit **£4·45** extra.
Pair of Q16 Speakers **£13·00** extra.
Sinclair Project 605 **£20·97.** P. & P. 37p.
All other Sinclair Products in stock.
2000 Stereo Amplifier **£21·95.** Carr. 50p.
3000 Stereo Amplifier **£28·50.** Carr. 50p.
2000/3000 Stereo Tuner **£29·95.** Carr. 50p.

WHARFEDALE MID-RANGE HI-FI UNITS



As used in world famous system. 5in. dia. Impedance 4/8 ohms. High flux ceramic magnet. 20 watts rms. Brand new **£1·50.** Carr. 37p.

EMI LOUDSPEAKERS



Model 350. 13″ x 8″ with single tweeter/crossover. 20-20,000 Hz. 15 watt RMS. Available 8 or 15 ohms.
£7·25 each. Post 37p.
Model 450. 13″ x 8″ with twin tweeters/crossover. 55-13,000 Hz. 8 watt RMS. Available 8 or 15 ohms.
£3·62 each. Post 25p.

SPECIAL OFFER! STEREO SPEAKERS

Matched pair of stereo bookshelf speakers. Deluxe teak veneered finish. Size 14⅛in. × 9in. × 7½in. 8 ohms 8 watt RMS. 16 watt peak. Complete with DIN lead. **£12·95** pr. Carr. 50p.

1021 STEREO LISTENING STATION

For balancing and gain selection of loudspeakers with additional facility for stereo headphone switching. 2 gain controls, speaker on-off slide switch, stereo headphone sockets. 6″ x 4″ x 2½″. **£2·25.** Post 15p.

MP7 MIXER PREAMPLIFIER

5 microphone inputs each with individual gain controls enabling complete mixing facilities. Battery operated. 9¼″ x 5″ x 3″. Inputs Mics: 3 x 3mV 50K; 2 x 3mV 600 ohm. Phono meg. 4 mV 50K. Phono ceramic 100mV 1 meg. Output 250mV 100K. **£8·97.** Post 20p.

NEW GARRARD MODULES

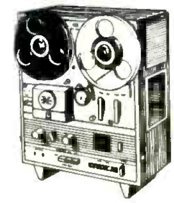
Popular range of Garrard decks with Shure cartridge fitted in de luxe plinth with hinged lid.

SP25 III Module/M75-6	£23·50
AP76 Module/M75-6	£33·80
AP96 Module/M75-6	£38·75
Zero 100S Module/M93E	£52·60

Carr. 50p extra any item.

AKAI BARGAINS

SUPER MONEY-SAVING OFFERS—ALL BRAND NEW AND FULLY GUARANTEED



CASSETTE (P. & P. 50p)	
CS35D Deck	£59·50
CS35 Recorder	£67·00
CS35/CSS8 Speakers	£82·95
GXC40D Deck	£67·95
GXC40 Recorder	£82·95
GXC40T Deck/Receiver	£123·95
GXC45 Deck	£89·95
GXC46D Dolby Deck	£103·50
GXC46 Recorder	£115·95
GXC60D Deck	£111·95
GXC65D Dolby Deck	£110·25
CARTRIDGE (P. & P. 50p)	
CR81 Deck with amps.	£80·95
CR81D Deck	£65·95
CR81T Recorder/Receiver	£118·90
CR80SS 4 channel Recorder	£145·00
CR80DSS 4 channel Recorder	£121·95
TAPE (P. & P. 75p)	
4000DS Deck	£73·95
4000DS Dust Cover	£4·75
1721L Recorder	£73·95

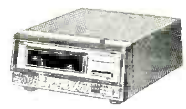
X5000 Recorder	£99·95
X201D Deck	£132·95
GX220D Deck	£148·50
GX221D Deck	£169·95
GX280D Deck	£249·40
GX370 Deck	£259·95
TAPE/CASSETTE (P. & P. 75p)	
GX1900D Deck	£177·95
TAPE/CARTRIDGE (P. & P. 75p)	
X1810D Deck	£169·95
TAPE/CASSETTE/CARTRIDGE (P. & P. 75p)	
X2000SD Recorder	£223·30
MICROPHONES (P. & P. 50p)	
ADM.11 Dynamic (pair)	£7·50

DOLBY SYSTEM NOISE REDUCTION UNIT

Improves the performance of cassette and semi-professional recorders. Reduces tape hiss by 3dB at 600 Hz, 6 dB at 1200 Hz and 10 dB for all frequencies above 300 Hz. Controls for input levels and noise reduction on record and replay. 2 meters for Dolby level. Off tape monitoring. Frequency response: 20 Hz to 15kHz ± 1 dB 19 kHz — 35 dB. Size 15⅞″×9″×3¼″. A.C. 200/250 V.

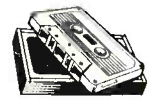
OUR PRICE **£32·50** Carr. 50p.

B.S.R. TD8S 8-TRACK STEREO TAPE PLAYER DECK



Integrated preamps (output 125 mV) to feed into any stereo amplifier. Automatic and manual programme selector. 4 pole synchronous motor. 210/240 V. A.C. OUR PRICE **£16·25** Carr. 50p.
BSR TD83V **£19·95.** Post 50p.

TAPE CASSETTES

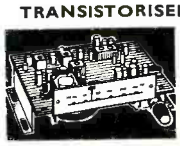


Top quality Hi-Fi Low Noise in Library cases.

	5	10	25
C60	£1·29	£2·53	£5·99
C90	£1·85	£3·62	£8·59
C120	£2·29	£4·48	£10·63
	P & P 15p	Post Free	Post Free

Tape Head Cleaner 30p each

TRANSISTORISED FM TUNER



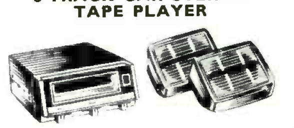
6 TRANSISTOR HIGH QUALITY TUNER SIZE ONLY 6in. × 4in. × 2½in. 3 I.F. stages. Double tuned discriminator. Ample output to feed most amplifiers. Operates on 9 volt battery. Coverage 88-108 Mc/s. Ready built ready for use. Fantastic value for money, **£6·37.** Post 12p.
STEREO MULTIPLEX ADAPTORS, **£4·97.**

AUDIO TRONIC ACR. 3500 MW/LW CAR RADIO

Fully transistorised, dual waveband. Size 6⅛in. × 4⅞in. × 2in. 12v. D.C. Neg. or Pos. earth. Complete with fixing kit, speaker and leads.

ONLY £7·50 Post 20p.

SUPER BARGAIN! AUDIO TRONIC ACP. 8 8-TRACK CAR STEREO TAPE PLAYER



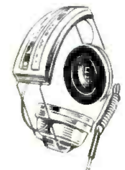
Complete with speakers. Attractive black and silver finish, 12 volt neg. earth. Slider controls for Volume, tone and balance. Channel selector button with red pilot lamp. Complete with mounting brackets and instructions.

ONLY £15·95 Post 50p.

TE 1018 DE-LUXE MONO HIGH IMPEDANCE HEADSET

Sensitive, soft earpads, adjustable headband. Magnetic, impedance 2,600 ohms.
£1·97. Post 15p.

KOSS SP.3XC STEREO HEADPHONES



Response 10–15,000 Hz. Impedance 4–6 ohms. Brand new, boxed and fully guaranteed. (List £9·50). OUR PRICE **£6·50.** Post 25p.

TE-1035 STEREO HEADPHONES

Low cost high performance stereo headphones. Foam rubber ear cups. Adjustable headband. 8 ohm impedance. 25-18,000 Hz. With lead and stereo jack plug. ONLY **£1·97.** Post 12p.

HOSIDEN DH-08S DE-LUXE STEREO HEADPHONES

Features unique mechanical 2 way units and fitted adjustable level controls. 8 ohm impedance 20-20,000 cps. Complete with spring lead and stereo jack plug. **£7·97.** Post 12p.

HOSIDEN DH-02S STEREO HEADPHONES

Wonderful value and excellent performance combined. Adjustable head band. 8 ohm impedance. 20-12,000 cps. Complete with lead and stereo jack plug. ONLY **£2·37** Post 12p.

SPECIAL OFFER! ROTEL RH700 STEREO HEADPHONES

20-20,000Hz. 8-16 ohm (List £9.95). OUR PRICE **£6·75.** Post 25p.

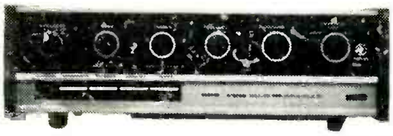
HA-10 STEREO HEADPHONE AMPLIFIER

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. Inputs 5MU/100MU. Output 50MW. **£5·97.** Post 15p.

G. W. SMITH & Co. (Radio) Ltd.
Also see previous pages and opposite page.

FANTASTIC OFFER!

NIKKO TRM 50 STEREO AMPLIFIER



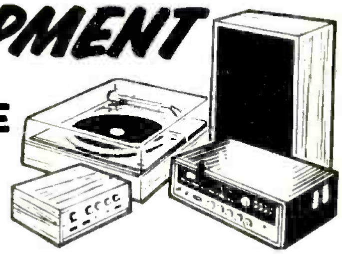
17 + 17 watts rms stereo amplifier with inputs for Magnetic and Crystal phono, Tuner, Tape, Aux. and Tape Monitor. Outputs for two pairs of stereo speakers and Tape. Stereo headphone socket. Full range of controls including loudness control, scratch filter etc. Size 13in. × 9½in. × 3¾in. Unrepeatable offer—limited stocks!

List price £59·50
OUR PRICE **£39·95**
Carriage 50p.

HI-FI EQUIPMENT

SAVE UP TO 33⅓% OR MORE

SEND S.A.E. FOR FULL DISCOUNT PRICE LISTS AND PACKAGE OFFERS

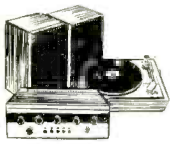


NIKKO TRM 50 SYSTEM

Nikko TRM50 17 + 17 watt stereo amplifier, BSR MP60, plinth and cover, Goldring G800 cartridge, pair of Linton 2 speakers and all leads.

OUR PRICE **£94·95** Carr. & Ins. £1·50

LEAK DELTA 30 SYSTEM



Leak Delta 30 stereo amplifier, Goldring GL75, plinth, cover and G800 cartridge. Pair of Leak 150 speakers and all leads.

OUR PRICE **£123·50** Carr. & Ins. £1·50

AMSTRAD 8000 II SYSTEM

Amstrad 8000 II 7 + 7 watt amplifier. BSR MP60, plinth and cover, Goldring G800 cartridge, pair of Apollo speakers and all leads.

OUR PRICE **£48·25** Carr. £1·00

Amplifier only, £16·95. Carr. 50p.

AUDIOTRONIC LA.1700 SYSTEM

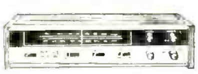
17 + 17 watt stereo amplifier. Garrard AP76 with Goldring G800 cartridge, teak veneered plinth with cover and a pair of Wharfedale Linton 2 speakers in matching teak.

OUR PRICE **£92·95** Carr. & Ins. £1·50

Matching LT1700 AM/FM Stereo Tuner £41·50 if purchased with above system.

SUPER MONEY SAVING OFFER!

TELETON R.4300L



3 waveband stereo tuner amp. 2 × 5W Medium/Long/Stereo FM. Full range of controls. Input for tape or ceramic cartridge.

List over £50·00 OUR PRICE **£27·50** Post 50p

VAT INFORMATION

All mail orders received on or after April 1st will be subject to Value Added Tax. This must be added to the total value of goods ordered (including postage/carriage) and enclosed with order.

WHARFEDALE LINTON SYSTEM

Wharfedale Linton Amplifier. Linton Turntable, pair of Linton 2 speakers and all leads.

OUR PRICE **£106·00** Carr. & Ins. £1·25

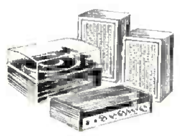
LINTON RECEIVER SYSTEM £155·00. Carr. & Ins. £1.50

MONOTONE 6750 SYSTEM

Monotone AM/FM 4 + 4 watt stereo tuner amplifier, Garrard 2025 T/C, plinth and cover, stereo cartridge, pair of matching speakers and all leads.

OUR PRICE **£35·50** Carr. £1·00

TELETON SAQ206B SYSTEM

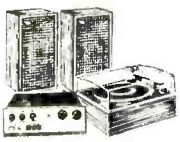


Teleton SAQ206B 8 + 8 watt amplifier. BSR MP60, plinth and cover, Goldring G800 cartridge, pair of Apollo speakers and all leads.

OUR PRICE **£54·40** Carr. £1·50

Amplifier only, £22·95. Post 50p.

TRIO KA 2000A SYSTEM



Trio KA 2000A 16 + 16 watt amplifier. BSR MP60, plinth and cover. Goldring G800 cartridge, pair of Denton 2 speakers and all leads.

OUR PRICE **£79·95** Carr. £1·25

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10 + 10 watts rms. Five push buttons with separate scales for pre-tuning to desired FM station. Housed in a handsome walnut finished cabinet with BSR P128/MP60 record deck with Goldring G800H stereo magnetic cartridge. Offered complete with cover and a pair of matching Medway speakers, size 18" × 11" × 8".

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2 speeds 33⅓ and 45 r.p.m. Lighweight tubular counter-balanced arm. Belt driven low speed synchronous motor. Viscous damped pick up lift/lower device. Complete with teak plinth and hinged cover. GA308 PU with GP400 stereo magnetic cartridge (List £47·65). OUR PRICE £29·95. Post 75p. LIMITED NUMBER ONLY!

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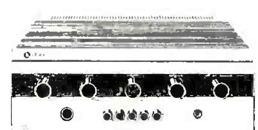

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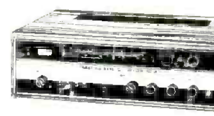

MODEL AA6300 AM/FM STEREO TUNER AMPLIFIER

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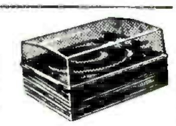

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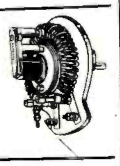

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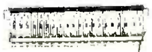

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HART ELECTRONICS

In keeping with our policy of offering kits of parts for advanced audio projects to a standard which will please the constructor who is professionally engagedin the electronic industry and who is therefore used to the advanced standards of quality and designs used therein, we have pleasure in giving brief details of our latest projects.

The Bailey Pre-Amp., was published in 1966 and we have been supplying kits of parts for it since then. We have therefore an unparalleled length of experience on which to draw when adapting this unit to take advantage of new components which have become available to make our kit the best that has ever been offered. The new kit is easier to assemble, as there is little wiring, the controls, switches and input sockets are all mounted on the clearly marked fibreglass P.C.B.'s. The new kit is more versatile because it is split into two stereo units. The tone control unit with volume, Bass, Treble, Balance and Filter can be used on its own for 250mV flat inputs and will give an output up to 2V to drive most power amps. The front end unit has the input switch selecting Mag; PU, Cer; PU, Mic, Radio and Tape head inputs. Output 250mV.

The new kit performs better because the Tone control incorporates the Quilter Bootstrap circuit to give lower distortion at all control settings. The front end has the Burrows mod, for ceramic pickups and higher rumble cut-off with facilities to adjust the Tone balance and level to suit different makes of transducer. Switches have click suppression circuitry for ultimate refinement of operation.

Full details are in our lists.

Our kits for the Stuart tape recorder have been built by Mr. Stuart and received his enthusiastic approval. This unit is an easy way to convert that ageing recorder with a good deck up to modern top flight standards. We stock heads for 2 or 4 track stereo and also for cassettes.

Reprints of the first and second articles are 15p each, post free.

For free list, please send foolscap (9 x 4") s.a.e.

ALL U.K. ORDERS ARE POST FREE. *OVERSEAS AT COST.*

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Personal callers are always welcome, but please note we are closed all day Saturday

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Wilkinsons

RELAYS P.O. TYPE 3000 AND 600
BUILT TO YOUR SPECIFICATION
Contacts up to 8 changeover

★ DUST COVERS
★ QUICK DELIVERY
★ KEEN PRICES
★ QUOTATIONS BY RETURN HOME & OVERSEAS

SWITCHES Double Pole On/Off 3 amp 250 volt, one hole fixing, **£1.50** per ten. Post paid.
IMHOF BLOWER UNITS in a standard 19in. rack mounting assembly with Glass Fibre Air Filter and directional Duct. Capacitor Fan Motor 1/50th h.p. 200/250 volts or 100/125 volts 2,800 r.p.m. **£17·50.** Carr. **&1·50.**
BURGESS DOUBLE BREAK two circuit Microswitches 25 amp 250 volt AC, **£2** per box of ten, **£15** per 100. Post paid.
BRIDGE MEGGERS, SERIES I, 1,000 volts, range 0/100 M ohms-infinity, with resistance Box 0/9999 ohms. Brand new, **£65·00** each. Carriage **75p.**
FREQUENCY METERS. 45/55 c.p.s. 230 v. A.C. 6in. dia. flush round **£10.** Post **70p.**
SELSYN MOTORS 230 volts AC BTH type S1406 **£10** each. **Past 70p.**
GEARED MOTORS. 1 r.p.m. or 3 r.p.m. 4 watts very powerful, reversible 24 v. A.C.. **£2·75,** post 20p, can be operated from 230 v. with our **£1·20** Transformer. Post **30p.**
MINIATURE DIGITAL INDICATOR. size of digits ⅝ in., illuminated by 28 volt lamps, reading 0 to 9 with decimal points, quick disconnect at rear of unit for easy lamp replacement. This miniaturized digital display operates on a rear-projection principle when one of the twelve lamps at the rear of the unit is lighted, the lamp projects the corresponding digit on the condensing lens through a projection lens on to the viewing screen at the front of the unit. **£3** each. Post paid. Illustrated details available.

L. WILKINSON (CROYDON) LTD., LONGLEY HOUSE, LONGLEY RD., CROYDON, CR0 3LH. Phone 01-684 0236 Grams: WILCO CROYDON

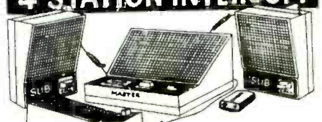
WW—103 FOR FURTHER DETAILS

Transistor TELEPHONE AMPLIFIER

Our price ONLY
£2·99

Increase efficiency of Office, Shop and Workshop with this **DELUXE TELEPHONE AMPLIFIER** which enables you to take down long telephone messages or converse without holding the handset. Just moisten the suction pad and stick it to one side of the telephone. A useful office aid. On/Off switch. Volume control. Operates on one 9v battery. Size 3in. × 4in. Ready to operate. Add 14p extra for battery. P & P 22p.

4-STATION INTERCOM



£7·25

This NEW, versatile **De Luxe 4-Station Transistorised Intercom (1 Master and 3 Subs)** for desk or wall mounting can solve your communication problems instantly. Effective range 300ft. Call/talk/listen from **Master to Subs** and **Subs to Master.** With Selector switch. Ideally suitable for office, shop, home or surgery. Adaptable for Mains. Complete with three 66ft. connecting wires and accessories. On/Off switch volume control. P. & P. 40p.

WEST LONDON DIRECT SUPPLIES
169 KENSINGTON HIGH STREET, LONDON W8 6SN

THE GABRAPHONE "ALOUETTE" DISC-ROTOR UNIT

The entirely new "Alouette" disc rotor unit now added to the Gabraphone range has been designed using anti-acoustic feedback principles to ensure complete freedom from microphony effects, even at the lowest frequencies. Motor rumble is eliminated by the mechanical drive system employed, while electronic motor control results in exceptional wow performance.

Motor speed is controlled by a two-position switch, and a fine adjustment.

Modular construction is employed both for the mechanical assemblies and the electronic units, and the "Alouette" is produced in an elegantly styled perspex cabinet finished in black and white, with a hinged, semi-transparent lid.

The "Alouette" mechanism is also to be incorporated into the Gabraphone 2001-6 reproducer systems, where it will be ideally suited to the unique method of multi-channel signal processing employed.

ENQUIRIES

UNITED KINGDOM AND
COMMON MARKET COUNTRIES
MODERN ENG & TECHNOLOGY
4, STATION ROAD WEST
CANTERBURY, KENT

CANADA, U.S.A. AND JAPAN
GABR INCORPORATED
MONTREAL
CANADA

MINIATURE WAFER SWITCHES

2 pole, 2 way—4 pole, 2 way—2 pole, 3 way—4 pole, 3 way—2 pole, 4 way—3 pole, 4 way—2 pole, 6 way, 1 pole, 12 way. All at **20p** each.

TOGGLE SWITCHES

Metal, all standard types with metal dolly 240v. 3 amp: SP, ST **15p** SP, DT, **20p** DP, ST **20p** DP, DT. **25p** less 10% for ten of same type.

ROCKER SWITCH

13 amp self-fixing into an oblong hole. Size approximately 1in. × ⅜in., **8p** each, 10 for **72p**.

SLIDE SWITCHES

Slide Switch. 2 pole change over panel mounting by two 6 BA screws. Size approx. 1" × ⅜" rated 250v lamp. **7p** each, 10 for **63p**.

Ditto as above but for printed circuit **6p** each. 10 for **54p**.

Sub Miniature Slide Switch. DPDT 19mm (¾" approx.) between fixing centres. **12p** each or 10 for **£1·08**.

DOUBLE LEAF CONTACT

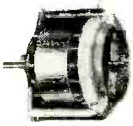
Very slight pressure closes both contacts. **7p** each. 10 for **63p**

Plastic push-rod suitable for operating. **5p** each, **45p** for 10

LIGHT CELL

Almost zero resistant in sunlight increases to 10 K. Ohms in dark or dull light, epoxy resin sealed. Size approx. 1 in. dia. by ¼ in. thick. Rated at 500 MW. wire ended. **55p**. Suit most circuits.

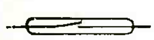
PAPST MOTORS



Est. 1/20th h.p. Made for 110-120 volt working, but two of these work ideally together off our standard 240 volt mains. A really beautiful motor, extremely quiet running and reversible. **£1·50** each. Postage one 23p, two 33p. 230 V. model **£3**

LUMINOUS CORD SWITCHES

Double pole with neon let into side so luminous in dark. Ideal for dark room light or for use with waterproof element—new plastic case. **25p** 10 for **£2·25** 3 heat model **38p** 10 for **£3·42**.



REED SWITCHES

Glass encased, switches operated by external magnet—gold welded contacts. We can now offer 3 types:

Miniature. 1" long × approximately ⅛" diameter. Will make and break up to ½A up to 300V. Price **13p** each, **£1·20** doz.

Standard. 2" long × $\frac{3}{16}$" diameter. This will break currents of up to 1A, voltage up to 250V. Price **10p** each, **90p** per dozen.

Flat. Flat type. 2" long, just over $\frac{1}{16}$" thick, flattened out, so that it can be fitted into a smaller space or a larger quantity may be packed into a square solenoid. Rating 1A 200V Price **30p** each, **£3** per dozen.

Small ceramic magnets to operate these reed switches **9p** each, **90p** dozen.

Dry Reed Relays. Solenoids on moulded bobbins within magnetic shields—printed circuit or panel mounting.

Ref.	*Coil Resistance*	*Reed Switches*	*Price*
71005	2 K	1 normally open	**25p**
81916	5 K	1 normally open. 1 normally closed	**75p**
05003	4 K	1 normally open	**25p**
62040	1500 & 500 ohms	1 normally open	**35p**

DRILL CONTROLLER

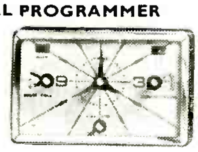
New 1kW model.

Electronically changes speed from approximately 10 revs. to maximum. Full power at all speeds by finger-tip control. Kit includes all parts, case, everything and full instructions **£1·50**, plus 13p post and insurance. Made up model also available **£2·25** plus 13p p. & p.

BAKELITE INSTRUMENT CASE

Size approx. 6¾" × 3¾" × 2" deep with brass inserts in four corners and bakelite panel. This is a very strong case suitable to house instruments and special rigs, etc. Price **45p** each. Paxlids **10p** extra.

15A ELECTRICAL PROGRAMMER



Learn in your sleep: Have radio playing and kettle boiling as you awake—switch on lights to ward off intruders—have warm house to come home to. All these and many other things you can do if you invest in an electrical programmer. Clock by famous maker with 15 amp. on/off switch. Switch on time can be set anywhere to stay on up to 6 hours. Independent 60 minute memory jogger. A beautiful unit. Price **£1·95** + 20p p. & p. or with glass front chrome bezel **75p** extra.

WATERPROOF HEATING ELEMENT
26 yards length 70W. Self-regulating temperature control. **50p** post free.

HIGH ACCURACY THERMOSTAT

Uses differential comparator I.C. with thermistor as probe. Designer claims temperature control to within 1/7th of a degree. Complete kit with power pack **£5·50**.

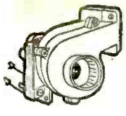
TREASURE TRACER

Complete Kit (except wooden battens) to make the metal detector as the circuit in Practical Wireless August issue. **£2·95** plus 20p post and insurance.

NUMICATOR TUBES

For digital instruments, counters, timers clocks, etc. Hi-vac XN.13. Price **£1·50** each 10 for **£13·50**.

CENTRIFUGAL BLOWER



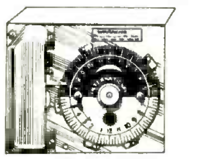
Miniature mains driven blower centrifugal type blower unit by Woods, powerful but specially built for quiet running—driven by cushioned induction motor with specially built low noise bearings. Overall size of blower is approx. 4½" × 4½" × 4". When mounted by its flange air is blown into the equipment but to suck air out mount it from the centre using a clamp, ideal for cooling electrical equipment, or fitting into a cooker hood, film drying cabinet or for removing flux smoke when soldering etc., etc. A real bargain at **£1·85**.

MULLARD I.F. MODULE

This is a fully screened intermediate frequency module for amplification and detection of f.m. signals at 10·7MHz and a.m. signals at 470kHz. The first stage is used as an i.f. amplifier for f.m. and a self-oscillating mixer for a.m. operation, in conjunction with an external oscillator coil. **85p** each. 10 for **£7·85**. 100 for **£62.50**. With connection dig.

MULLARD UNILEX

This D.I.Y. Stereo Amplifier is still available complete at **£7** for the four Mullard Modules. or Modules can be bought separately as follows:—
4 watt amplifier module (2 required) Mullard Ref. No. E.P.9000—**£1·45** each.
Pre amp module Mullard Ref. No. E.P.9001—**£1·80** each.
Power module—Mullard Ref. No. E.P.9002—**£2·30** each.
In addition and made to Mullard Specification we offer:—
Standard Control Unit with escutcheon + Knobs **£3·00**.



ELECTRIC TIME SWITCH

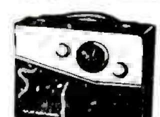
Made by Smiths these are A.C. mains operated. NOT CLOCKWORK. Ideal for mounting on rack or shelf or can be built into box with 13A socket. 2 completely adjustable time periods per 24 hours, 5 amp changeover contacts will switch circuit on or off during these periods. **£2·50** post and ins., 23p. Additional time contacts **50p** pair.

COMPUTER TAPE

2,400ft. of the Best Magnetic Tape money can buy. Some users claim good results with Video and sound. 1in., ¾in. or ½in. wide, **£1.00** plus 30p. post. Spare spools and cassettes **50p**.

½" Scotch tape. Brand new. Suits most video recorders. **£3·00** for 2,400ft.

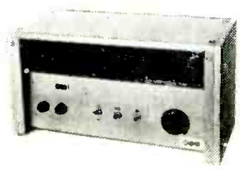
THIS MONTH'S SNIP



GOOD COMPANION I.C. MODEL

We can now offer this fine receiver but in I.C. version using Ferranti ZN414 and Mullard AF Module 1172. Cabinet size approx. 11in. wide × 8in. high × 3in. deep. Complete with excellent 2 tone cabinet with assembly instructions **£5·75**.

ERGOTROL UNITS



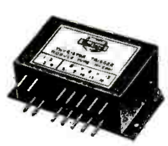
These units made by the Mullard Group are for operating and controlling d.c. Motors and equipment from A.C. mains.

Thyristors are used and these supply a variable d.c. resulting in motor speed control and operating efficiency far superior to most other methods.

The units are contained in wall mounting cabinets with front control panel on which are fuses—push buttons for on/off and the variable thriystor firing control.

4 models are available—all are brand new in makers cases:
Model 2410 for up to 5 amps **£17·50**
Model 2411 for up to 10 amps **£27·50**

MULLARD THYRISTOR TRIGGER MODULE



This produces pulses for phase control triggering. it has two isolated out-puts, so one thyristor or two thyristors (in separate arms of bridge) may be controlled by one module. The timing circuit is synchronised to the mains frequency and control is by an external variable resistor or from a voltage or current source. Provision is made for feedback where automatic control is required. Price **£4·50** each or 10 for **£40·00**.

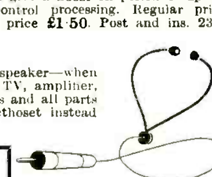
THERMOSTAT WITH THERMOMETER

Made by Honeywell for normal air temperatures 40°-80°F. (5-25°C.). This is a precision instrument with a differential which can be adjusted to better than 1·5°F. A mercury switch breaks on temp. rise—the switch is operated by coiled bi-metal element and an adjustable heater is incorporated for heat anticipation. Elegantly styled and encased in an ivory plastic case with clear plastic windows, thermometer above and switch setting scale below. Size approx. 3·8" × 3·2" × 1·4" deep. Can be mounted on conduit box or directly on wall. Price **£1·25** each or 10 for **£11·25**.

HORSTMANN "TIME & SET" SWITCH

(A 30 Amp Switch.) Just the thing if you want to come home to a warm house without it costing you a fortune. You can delay the switch on time of your electric fires, etc., up to 14 hours from setting time or you can use the switch to give a boost on period of up to 3 hours. Equally suitable to control processing. Regular price probably around £5. Special snip price **£1·50**. Post and ins. 23p.

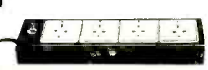
RADIO STETHOSCOPE



Easiest way to fault find—traces signal from aerial to speaker—when signal stops you've found the fault. Use it on Radio, TV, amplifier, anything—complete kit comprises two special transistors and all parts including probe tube and crystal earpiece, **£2**—twin stethoset instead of earpiece **75p** extra—post and ins. 20p.

● VAT PLEASE ADD 10% ON ALL ITEMS ORDERED AFTER APRIL 1st

DISTRIBUTION PANELS



Just what you need for work bench or lab. 4 × 13 amp sockets in metal box to take standard 13 amp fused plugs and on/off switch with neon warning light. Supplied complete with 7 feet of heavy cable. Wired up ready to work. **£2·25** less plug; plus 25p P. & P.

MULLARD AUDIO AMPLIFIERS

All in module form, each ready built complete with heat sinks and connection tags, data supplied.
Model 1153 500mW power output **65p**.
Model 1172 750mW power output **85p**.
Model EP9000 4 watt power output **£1·45**.
EP9001 twin channel or stereo pre amp. **£1·80**.
10% discount if 10 or more ordered.

CAR PANEL SWITCH. Our Ref. No. SO1. Arco made. Has long flat ended toggle black and chrome finish. Rated 2A. at 250v. and is double pole on/off. Listed at 45p. Our price **22p** each.

CAR PANEL AUTO. SWITCH. Ref. No. SO3. Again a flat ended toggle. Made by Arrow. A 3 position double pole change over switch centre off for auto aerials, reversing motors etc. **30p** each.

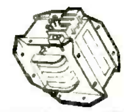
3 PIN PLUG AND SOCKET. Our Ref. No. PSO1. Flat pins, American style rated at 10A. 250v. Socket panel mounting. Plug is white and intended for flex. Useful where non standard power outlet is required. Also suitable for speaker leads. etc., etc. Price **25p** per pair.

3 PIN REVERSE PLUG AND SOCKET. Our Ref. PSO2. For bringing live leads to equipment. All brown bakelite construction, rated 10A. 250v. Price **35p** per pair.

1 R.P.H. MOTOR. Smiths. 240v. 50 cycle mains working. Ideal motor to drive clock mechanisms. Price **£1** each or 10 for **£9**.

13 AMP JUNCTION BOXES. Made to take 7029 cables so ideal for ring mains. Price **8p** each or 10 for **72p**.

PORCELAIN FUSE AND CARRIER. 20A. 250v. MEM Ref. No. 15LBB/15LRHW. Make your own fuse board. Price **20p** per pair.

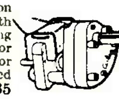


AUTO TRANSFORMER. Primary 220-240v. Secondary 110-120v. Wel built and varnish impregnated. 250 watt intermittant rating. 150w. continuous rating. Size approx. 3¼ × 3 × 3in. **£1** plus 20p post and insurance.

30KV EHT UNIT

This unit is self contained and on wheels. It stands approx. 6ft. high and 3ft. square. On the front panel is a Variac, Voltmeter, a 60 second Timer as well as the normal overload trip on/off switch and cut outs etc. The transformer itself is oil filled and rated at 7 kVa 30 kV. The Variac is in the primary so all voltages up to 35kV are available. We believe the normal use for such a unit would be a breakdown and flash tester. 1 only—not new but in good order. Price **£150** carriage extra at cost.

INSTANT START UNITS. For 2ft. tubes. Philip's or Smart & Brown in a tray complete with tube clips and tube ends. Price **£1·50** each or 10 for **£13·50**.



SPIT MOTOR. 200-250v. Induction Motor, driving a carter gear box with 1½in. of output drive shaft running at 5 revs. per minute. Intended for roasting chickens, also suitable for driving models: windmills, coloured disc lighting effect, etc., etc. **£1·85** plus 20p post and insurance.

WIRE ENDED FUSES. Useful where you want a quick solder-in fuse. Rated 2A. 250v. These are about the size of a resistor. Price **5p** each.

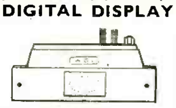
PANEL NEON INDICATOR. Our Ref. No. P101. Oblong type, self-fixing in oblong hole, suitable for 200/250v. Price **13p** each.

THERMOSTAT WITH PROBE. Our Ref. No. TH01. Made by Ranco. Range 0-107°C. 16A. 250v. switch. Joined to a 0in. probe by approx. 40in. of capillary tubing. 1 hole fixing. Normal control spindle, **85p** each.

THERMOSTAT WITH PROBE. Our Ref. No. TH02. As TH01 but the range is 0-120°C. and the capillary tube is approx. 46in. long. Price **95p** each.

FLUORESCENT TUBES. Standard types—Bi pin ends, ideal pelmet lighting as well as for standard replacements—18in. 15 watt. 24in. 40 watt, 36in. 40 watt, 39½in. 40 watt. All first grade tubes offered at one price—**£3·50** per box of 24—i.e. less than 15p each. If not collecting then please add 50p per box per 200 miles.

DIGITAL DISPLAY



Panel mounting unit measuring approx. 3½in. × 1in. × 1½in. deep. Size of the display aperture is approx. 1¼in. × 1in. Light up to 0-9. Ex equipment but unused and in perfect order. Price **£1** each.

DIGITAL SWITCHES. Small type S.T.C. number SW21/630CAA. These are s snap in fit hole approx. 1¼ × ½in. Knob engraved 0-9. Gold plated contacts 1 pole 10 way. Thumb wheel operation. These are designed so that they may be stacked in rows. Price **75p** each.

6 DIGIT COUNTER. Operated by 240v. A.C. mains through resistor or direct from 115v. A.C. or from 80v. D.C. Made by Veeder-Root of America. Metal encased for surface mounting. Size approx. 3¼ × 1½ × 2½in. Price **£1** each. 10 for **£9**.

COLOURED 13 AMP SOCKETS. Standard Flush mounting available in the following colours:— Yellow, green, grey These are a good quality socket with porcelain interior made by Ward and Goldstone. Useful on control panels. Price **20p** each, 10 for **£1·90**.

REED SWITCH COILS. These are solenoids wound on moulded formers of the correct shape and dimensions to take standard reed switches. They have printed circuit board mounting. Six types available:—
RC1 takes 1 reed—Operates 10-15v. 600 ohms. **30p**.
RC2 takes 2 reeds—Operates 10-15v. 180 ohms. **25p**.
RC3 takes 1 reed—Operates 15-30v. 1K ohms. **32p**.
RC4 takes 2 reeds—Operates 15-30v. 300 ohms. **45p**.
RC5 takes 1 reed—Operates 45-70v. 6500 ohms. **35p**.
RC6 takes 2 reeds—Operates 45-70v. 3500 ohms. **40p**.
Standard reed switches available **10p** each or 10 for **90p** 100 for **£8·50p**.

ROCKER SWITCH. Our Ref. RS02. 13 amp. self fixing into hole approx. 1in. × ⅜in. Made by the Carr Fastener Co. Very reliable. Price **8p** each.

PHOTO TRANSISTOR. OCP70—ideal for burglar alarms and similar applications. Price **50p** each, 10 for **£4·50**.

EXIT SIGNS

One of our customers has pointed out how easily our box signs can be converted to exit signs. These are illuminated having a 20W fluorescent lamp with associated control gear. The front is very thick clear plastic. Directly onto this you can stick down the letters available at most stationers. There is room inside the box for a battery and low volt lamp in the case of power failure. Size of sign is 2ft. high × 14in. wide × 5in. deep. Solidly made from sheet steel and hammer finished in enamel. Price **£3·50** plus 50p carriage per 200 miles.

MUTUAL INDUCTANCE COIL. Laboratory type. M = 0·001H. Inductance of coils 0·0022H and 0·0021H. Coil resistance 0·53 ohms and 0·51 ohms respectively. Maximum current through coils = 3 amps. Completely encased with 4 screw down terminals. Overall size 6in. diameter by 3in. deep. Price **£4** each.

Where postage is not stated then orders over £5 are post free. Below £5 add 20p. S.A.E. with enquiries please.

J. BULL (ELECTRICAL) LTD.

(Dept. W.W.) 7, Park Street, Croydon, CR0 1YD
Callers to 102/3, Tamworth Road, Croydon

Henry's
Your Complete Audio-Electronic Stores

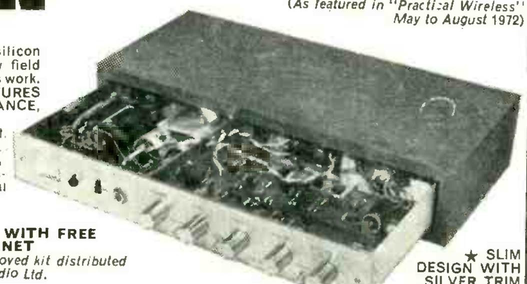
BUILD THE TEXAN
20 + 20 WATT INTEGRATED I.C. STEREO AMPLIFIER

(As featured in "Practical Wireless" May to August 1972)

★ **FREE TEAK CABINET** with complete kits!

FEATURES. New slim design with 6 - IC's IC Sockets, 10 silicon transistors, 4 rectifiers, 2 zeners. Special Gardeners low field slim line transformer. Fibre glass PC panel. Complete chassis work. HIGH QUALITY & STABILITY ARE PREDOMINATE FEATURES —DEVELOPED BY TEXAS ENGINEERS FOR PERFORMANCE, RELIABILITY AND EASE OF CONSTRUCTION.

FACILITIES. On/off switch indicator, headphone socket, separate treble, bass, volume and balance controls, scratch and rumble filters, mono/stereo switch. Input selector; Mag. P.U. Radio Tuner. Aux. Can be altered for Mic. Tape. Tape-head. etc. (Parts list Ref. 20 on request). Constructional details (ref no 21) 30p.



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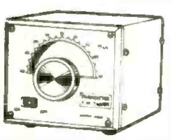

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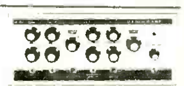

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CRS 5/400	400	60p
SEVEN AMP (TO48)		
CRS 7/100	100	60p
CRS 7/200	200	65p
CRS 7/400	400	70p
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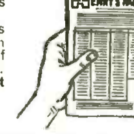

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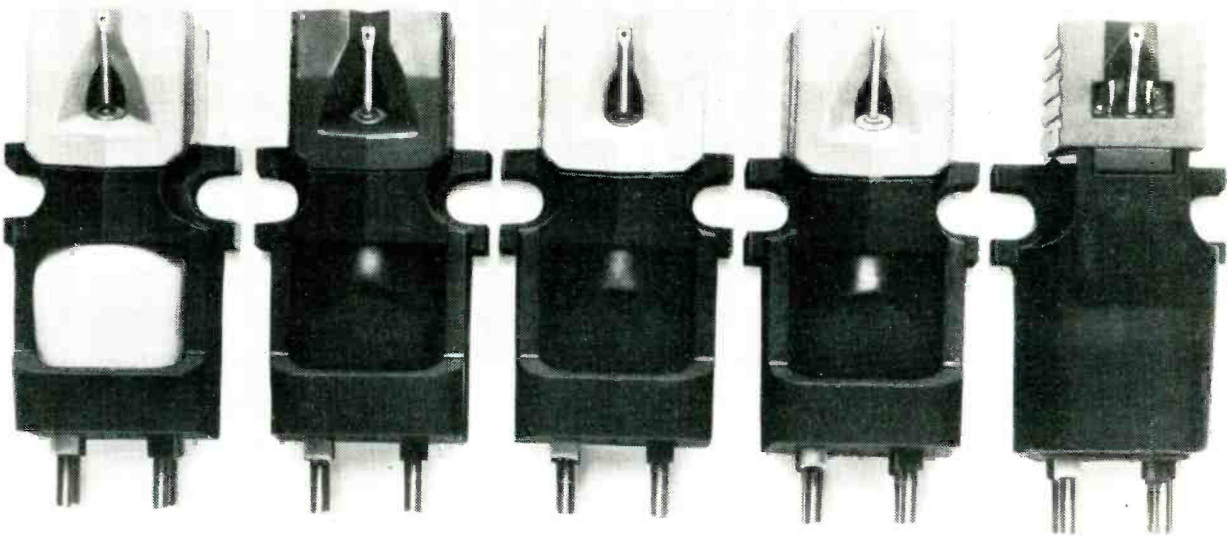

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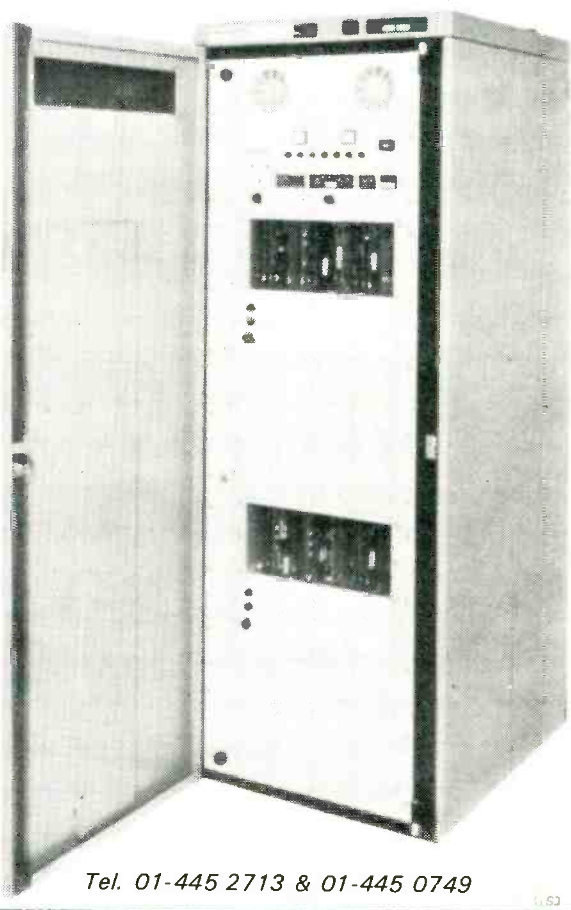

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You will be concerned with (a) the design of telecommunications buildings incorporating suitable air-conditioning plantand (b) providing mains and emergency power for telecommunications. You should have at least seven years' experience in telecommunications and hold relevant qualifications.

(2) (a) Switching (b) U.H.F. & H.F. Radio (c) Transmission

These appointments will be based at the Headquarters of the Zambian Post Office. You will consider existing and new methods in telecommunications engineering and recommend and implement improvements where necessary. You should have Intermediate C & G certificate in Telecommunications plus considerable experience in one of the above fields.

(3) Mechanical

You will be responsible for the day-to-day operations of G.P.O. Headquarters Workshop in Ndola. The Workshop mainly deals with mechanical engineering projects with additional interests in carpentry light electrical work and painting. You will need O.N.C. or equivalent in Mechanical Engineering plus five years' suitable experience – some of which in a supervisory role.

Line Technicians

There are several posts, some at supervisory levels, and you should have relevant qualifications plus extensive experience of one or more of the following:

(1) The routing, construction and maintenance of heavy overhead cables.
(2) Installation and maintenance of subscribers' apparatus including PABX's.
(3) Jointing and laying of lead and P.V.C. covered cables.
(4) Construction and maintenance of open wire routes.

Equipment Technicians

You will carry out maintenance and installation work of various types in all parts of Zambia. You should have final C & G certificate in Telecommunications plus at least 4 years' experience with emphasis in one of the following areas:

(1) Storage type exchanges.
(2) Crossbar type exchanges.
(3) Automatic exchanges and multiplex equipment and subscribers apparatus at 'mixed load' small stations.
(4) Microwave radio relay systems.
(5) H.F. radio equipment up to international standards.
(6) Multiplex and V.F. telegraph systems.
(7) Creed and Siemens Teleprinters.

Rigger

You will construct, erect and maintain H.F., V.H.F., and U.H.F. aerials and aerial arrays and train Zambian staff in this work. You should have C & G certificate in Line Plant Practice and Radio or equivalent plus about 5 years' relevant experience.

ONE ZAMBIA ONE NATION

Write now giving brief details of your qualifications and experience to date. In return you will receive full descriptions of relevant appointments and details of salaries and general employment conditions.
Recruitment Officer (K),
Zambia High Commission, 7/11 Cavendish Place, London W1.

2516

Design Engineer

Video Equipment

MATTHEY PRINTED PRODUCTS LIMITED need an experienced engineer to lead the design and development of ancillary video equipment for use in TV broadcasting systems.

This is a new and challenging appointment. The successful candidate will be responsible for projects from inception to production. The work will include circuit design at video frequencies employing integrated circuits and discrete devices. The job will entail frequent contact with TV broadcast system manufacturers and broadcasting authorities.

Matthey Printed Products Limited, Stoke-on-Trent – part of the Johnson Matthey Group – are established manufacturers of professional grade electronic components which include "Silver Star" silvered mica capacitors, video delay lines, filters, and ancillary video units for a worldwide market.

The job is located at a modern expanding factory site within easy reach of pleasant countryside and reasonably priced housing.

Conditions of service are in keeping with large practice and include a contributory pension fund and free lunches. Applications giving details of age, qualifications, experience and present salary should be addressed to:

The Company Secretary,
Matthey Printed Products Limited,
William Clowes Street, Burslem, Stoke-on Trent ST6 3AT

Matthey

SYSTEMS PROJECT ENGINEER (CCTV)

We are an expanding company in the field of business communications equipment and we have a requirement for a skilled engineer to assist in our Systems Engineering Department.

The essential requirement for this attractive post is a good working knowledge of digital logic control design for application to CCTV systems, particularly in traffic and industrial surveillance.

Applicants must be versatile and able to undertake design work in other spheres of CCTV systems which will involve different forms of control, including educational studios and process control.

The successful candidate will probably hold an HNC or equivalent but applications from others with suitable experience will also be considered.

Please write giving brief details of your background and experience to:

John Bell, Personnel Manager,
Pye Business Communications Limited,
Cromwell Road,
Cambridge CB1 3HE.
Tel: Cambridge 45191 (Ext. 293/4).

PYE Pye rely on people!

2483

Videodisc Recording Engineers

The Decca Record Company are extending their activities in the Videodisc Recording field at their laboratories in a pleasant part of North London. To do this, we must recruit additional qualified and experienced engineers. The work covers source and monitoring facilities with professional colour TV; technology associated with electron scanning microscopy and the development of disc recording techniques using electro-mechanical devices. Although primarily concerned with development, it will include some operation. The appointments will have attractive salaries and conditions of service.

We would like to talk to engineers whose education and experience background are specifically relevant to at least one of the engineering aspects described. If this interests you please write to:

Group Personnel Officer,
Decca Limited,
Decca House,
9 Albert Embankment,
London, SE1 7SW

DECCA

AUDIO PRODUCTS ENGINEERS

RADIO — UNIT AUDIO — HI-FI

Due to the continuing rapid expansion of its 'Audio Products' activity, both in European and worldwide markets, B.R.C. require additional Engineering staff in many of its Laboratories.

The vacancies cover most grades and offer excellent opportunities to all from school leavers, through to professionally qualified men.

	Colwick Nottingham	Harold Hill Essex	Southend Essex	Chigwell Essex
Lab. Juniors	X			
Test Equipment Engineers	X	X	X	X
Lab. — Production Liaison Engineers	X	X	X	X
Mechanical Design Draughtsmen (Senior and Junior)				X
Electrical Design Engineers (Senior and Junior)				X

Lack of recent experience will not prevent an otherwise suitable applicant from succeeding in any but the most senior appointments. Salaries, which will be discussed at the time of interview, will reflect the importance of the position applied for.

Applicants wishing to investigate the possibility of a future with one of Europe's most creative Engineering teams in this field should write in the first instance giving relevant career details to:

PERSONNEL MANAGER,
BRITISH RADIO CORPORATION (CHIGWELL) LTD.,
62/70 FOWLER ROAD,
HAINAULT,
ILFORD,
ESSEX.
THORN **Tele: 01-500 1080**

2465

GUILDFORD COUNTY TECHNICAL COLLEGE

Senior Technician

required in the Educational Television Unit.

The Unit operates a well-equipped closed-circuit television studio and mobile system producing and distributing educational material for use within the College and elsewhere in the County. The successful applicant will be responsible to the Chief Technician for the daily operation and maintenance of black and white and colour television equipment, including cameras, monitors, vision and sound mixers, video tape recorders, etc.

Candidates should preferably have had practical experience with vidicon cameras and helical-scan recorders. An interest in photography is desirable, but not essential.

Minimum qualifications: Candidates should have reached the Final Year of the course in Radio, Television and Electronics Servicing (City and Guilds 172) or have completed Part 1 of the Radio, Television and Electronics Technician's Course (City and Guilds 272).

Salary will be on the scale £1311-£1530 or £1530-£1803. The starting point will depend on qualifications and experience (qualification allowance will be paid in appropriate cases).

Send for application form and further particulars (enclosing S.A.E.) from the Principal, Guildford County Technical College, Stoke Park, Guildford, Surrey. [2494

Test Engineers enjoy more variety at Redifon

. . . *and* one of the best-equipped electronics test departments in Britain.

You'll be working on a vast variety of solid-state devices, including — high-power transmitters, communications receivers, military pack-sets, MF beacons, mobile HF, marine VHF and teleprinter terminal equipment.

The job involves a wide area of testing operations—from GO/NO GO sub-assembly testing through to fault-diagnosis on complex systems.

Interesting work with one of the U.K. leaders in electronics expertise—located in London.

To qualify, you'll need to be thoroughly experienced in the field—with considerable knowledge of semi-conductor or logic circuitry.

We pay well—from £1,450 to over £2,200 p.a. (depending on experience) for a 37½ hour week with ample opportunities for overtime. Additional benefits include an excellent company pension scheme and generous sickness allowances.

Please write, including full details of your past experience, to:

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To take an active part in expanding my small London based outfit. This is an excellent opportunity for a person who has a thorough technical background in audio. Must be willing to contribute in accordance with the demands of an exciting and challenging business manufacturing professional quality high power sound systems.
Substantial remuneration offered to the right person.
Write giving full background to:

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LONDON WC2 E8BE

[2428

Visual and Aural Aids Technician

Suitably qualified and experienced person required to assist in the installation, repair and maintenance of radios, tape recorders, record players, projectors, televisions etc. in schools and other educational establishments. Wages £30.80p plus bonus for a 5 day 40 hour week.

CROYDON

Applications to or further particulars may be obtained from:
The Stores Assistant, London Borough of Croydon, Services Centre, Princess Road, Croydon, CR0 2QZ. Telephone: 01-684 4918.

[2462

W. & C. FRENCH (CONSTRUCTION) LTD.

require a

Service Electronic Engineer

The position is based at Harlow Workshops and the successful applicant will service all radio telephones and electronic equipment. He will also carry out any necessary site servicing and must therefore be prepared to travel anywhere in the U.K.

Permanent position, attractive salary, generous holidays, Annual Bonus, excellent contributory Pension and Assurance Scheme.

All enquiries treated in strict confidence.

Apply for Application form to:

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Administrative Manager, Personnel,
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50 Epping New Road, Buckhurst Hill,
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Tel. 01-504 4444.

[2493

Electronic Test Engineers

RACAL Communications are employed in the design and manufacture of professional communications equipment, employing the most up-to-date techniques. Applicants should have previous Electronic Testing experience of sophisticated equipments and have a long term interest, and desire to progress in the field of Test Engineering.

The range of equipment covers high power Linear Amplifiers Frequency Synthesised Solid State Receivers, Digital Instrumentation and complex communications systems.

These positions are permanent and progressive. In addition to competitive salaries you can also significantly increase your earnings by a productivity bonus. New Town Housing may be available to married men.

Applications in writing please, enclosing brief details of previous experience.

Communicate with Racal

Mr. A. Franklin, Personnel Manager
Racal Communications Limited, Western Rd, Bracknell, Berks RG12 1RG.

RACAL
The Electronics Group

UNIVERSITY OF YORK

Department of Chemistry

Applications are invited for the post of

Chief Technician

for the Electronic and Electrical Workshop. The work involves the maintenance and development of specialised equipment including NMR, ESR, and mass spectrometers, spectrophotometers, gas and liquid chromatographs. The Chief Technician will also assist in the design and construction of research equipment with academic and other technical staff.

A Grade 6 post (£2229 x £81-£2715) will be offered to a person with suitable experience and qualifications. Assistance with house purchase and removed expenses is available if necessary. Further details may be obtained from the Laboratory Superintendent.

Applications, together with one copy of a curriculum vitae and the names of two technical referees should be sent to:

**The Laboratory Superintendent,
Department of Chemistry,
UNIVERSITY OF YORK,
Heslington,
York YO1 5DD,
by 30th April, 1973.**

[2514

AUDIO MAINTENANCE ENGINEER

Required by Major Label Recording Studio. Electronic and Mechanical knowledge essential, experience preferred, but will consider trainee age over 25. Please ring 262-5495 for interview.

[2478

Harrow College of Technology and Art

Technician School of Photography up to £1908

Technician/Engineer in Television and Sound is required for a new post in the Film and Television Department. Duties will include the technical operation and routine maintenance of a CCTV Studio requiring electronic and mechanical skills and knowledge in the television field. Relevant City and Guilds or HNC qualifications are desirable and further in-service training will be considered.

Additional £72 qualification Allowance payable where applicable.

Application form from Registrar, Harrow College of Technology and Art, Watford Road, Northwick Park, Harrow, Middlesex. (Tel: 864 4411, ext. 31).

[2498

UNIVERSITY OF SURREY

Department of Electronic and Electrical Engineering

ELECTRONIC ENGINEER

A trained engineer, experienced in modern electronics, is required to carry out advanced design and development in support of research work and industrial contracts. Broad based experience in both modern analogue and logic circuitry is desirable and the ability to take projects from design concept to prototype construction.

The appointment, in the Experimental Officer grade, will be made within the salary ranges below, according to age and experience:

Assistant Experimental Officer £1764-£2079
Experimental Officer £2238-£3033
Membership of FSSU optional.

Applicants must be academically qualified in the appropriate field and must have had at least 2/3 years experience in a research and/or development environment.

Application forms may be obtained from the Staff Officer, University of Surrey, Guildford, Surrey. Tel: Guildford 71281, Ext. 452, and to whom they should be returned by: 2 April 1973.

[2467

RADIO OFFICERS

DO YOU HAVE

PMG 1
PMG 11
MPT
2 YEARS OPERATING EXPERIENCE

POSSESSION OF ONE OF THESE QUALIFIES YOU FOR CONSIDERATION FOR A RADIO OFFICER POST WITH THE COMPOSITE SIGNALS ORGANISATION

On satisfactory completion of a 7-month specialist training course, successful applicants are paid on scale rising to £2,365 p.a.; commencing salary according to age — 25 years and over £1,664 p.a. During training salary also by age. 25 and over £1,238 p.a. 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.

Application 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 (TRO.2.)
Government Communications Headquarters
Room A/1105
Oakley Priors Road
CHELTENHAM Glos GL52 5AJ
Telephone: Cheltenham 21491 Ext 2270

Quality Control Engineer

Required by manufacturers of components for the electronic equipment industry. Applicants should be aged about 30 and have served a craft apprenticeship or recognised period of training, with practical experience. They should possess O.N.C. or equivalent qualification. Some knowledge of D.Q.A.B. Procedures and B.S. Specifications would be an advantage as the successful applicant will be working closely with the company's Chief Inspector.

Apply: Technical Manager,
JACKSON BROTHERS (LONDON) LTD.,
Kingsway, Waddon, Croydon CR9 4DG.
Tel: 01-681 2754 2466

TWO OPPORTUNITIES IN

J BEAM

Senior Research & Development Engineer

Must have some previous experience of antenna design, VHF to Microwave. Qualifications: Membership of recognised Institute or Bsc.

Design & Development Engineer

Some Antenna theory desirable. Previous experience in the Telecommunication industry essential.

Salaries: Negotiable according to experience and qualifications.

Occasional visits to Government sites for technical liaison will be required. All applicants must have a current driving licence.

Applications, in writing, to: **The Managing Director, J. BEAM ENGINEERING LIMITED, Rothersthorpe Crescent, Northampton. Tel. 63531 (10 lines)**

UNIVERSITY OF SUSSEX

School of Applied Sciences

ELECTRONICS TECHNICIAN

There is a vacancy for a Grade V Technician, to work on a Contract for a period of up to three years.

Candidates should have considerable practical experience of electronic circuits employing solid state devices, and be not less than twenty-five years of age.

Technical qualifications to HNC or Advanced C & G Certificate are normally required.

Salary according to age and qualification in the scale £1881-£2241 per annum.

Applications, giving full details of age, qualifications and experience should be sent to the Laboratory Superintendent, School of Applied Sciences, University of Sussex, Brighton, BN1 9QT. [2461

ULSTER: THE NEW UNIVERSITY

MAGEE UNIVERSITY COLLEGE, LONDONDERRY

Institute of Continuing Education

Applications are invited for the following technical posts:—

Ref: 73/129/148/30
TECHNICIAN: Duties: Language Laboratories, recording studio and ancillary audio services.

Ref: 73/130/149/31
TECHNICIAN: Duties: Operation and maintenance of CCTV services and preparation of programme material.

Qualifications: HNC, or equivalent, plus at least seven years previous experience.
Salary scale: £1,881-£2,241 per annum.

Application forms and further particulars should be obtained from The Registrar, The New University of Ulster, Coleraine, Co. Londonderry, Northern Ireland (quoting appropriate reference number) to whom completed applications, including the names and addresses of three referees, should be returned not later than 31st May, 1973.

[2489

TECHNICIAN

DEPARTMENT OF PHYSICS

Technician required for construction and maintenance of specialised electronic equipment for the Department of Physics Design Group/Electronics Workshop. At least three years working experience with City & Guilds Technician's Certificate or equivalent, required.

Salary: up to £1,794 p.a.

Reference: 113/B/598.

Apply: Assistant Secretary (Personnel),
University of Birmingham,
P.O. Box 363,
Birmingham, B15 2TT.

[2476

Junior Television Engineer

To assist in the operation and maintenance of Colour Telecine and allied equipment in Major Advtg. Agy. Applicant must have a basic knowledge of electronic equipment and experience in its use, although experience of colour television is not essential as we are prepared to train the right applicant. Salary approx. £1,000 according to experience etc. Day release considered. Write or phone Colin Forster, Leo Burnett Ltd., 48 St. Martin's Lane, London, W.C.2. Tel.: 01-836 2424.

FOR CLASSIFIED ADVERTISING

Ring Allan Petters 01-261 8508 or 01-928 4597

TECHNICAL TRAINING OFFICER
(COMMUNICATIONS)

The Company

We are an expanding company within the Pye of Cambridge Group and offer a wide range of products including public and private address systems, telephone equipment, time control, fire alarm and CCTV. Our field service engineers and technical salesmen are provided with an extensive support service which includes product training in a market of rapidly changing technology.

The Job

This is a new position to assist the Personnel and Training Department in the analysis of product training needs, and the development of means of meeting those needs including off the job instruction. The Training Officer will specialise in intercom and telephone systems.

The Man

Preferably with previous experience as a training officer or instructor
Will have an extensive knowledge of electronics
Preferably will have experience in the communications industry
Willing to spend time away from home
Age 28+

He will report to the Personnel Manager.

Please write giving brief details of your career and background to:
John Bell, Personnel Manager,
Pye Business Communications Limited,
Cromwell Road, Cambridge CB1 3HE.
Tel: Cambridge 45191 (Ext. 293/4).

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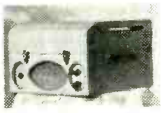
2482

CASED AMPLIFIERS £3



Chassis 12 x 5 x 3" with 2 x ECC83, EL84, EZ80 in wooden cabinet 14 x 13 x 9" with 7 x 4" 3 Ω speaker and single motor solenoid operated non-standard cassette tape deck. Low impedance 20μV 1/P for 2W O/P. Standard mains operation, tested with circuit £3 (£1). Cassettes now available in limited quantity £1 each. Spare tape heads 40p each.

1000 Rs & Cs FOR £3.00.

Amazing variety of resistors, inc. carbon, carbon film, metal oxide, histabs, 1, 2 & 5%, ¼, ½, 1 & 2W types from a few ohms to a few megohms. Capacitors included in this parcel: Mica, Ceramic, foil, paper, electrolytic mylar, polystyrene, etc. etc. from a few pF to 1000μF. All told about 1000 components for £3.00 (30p). Sample 150 60p (15p).

REED UNITS

Contain 31 250V 1½A Reed switches (normally open) mounted round a drum with a magnet inside. Strong chassis 9½ x 6½ x7" also contains resistor sockets, tag boards etc. £1 (25p) or 2 for £1.65 (35p).

FERRIC CHLORIDE

Anhydrous technical quality to mil-spec in double sealed 1lb packs. 40p (15p) 10lb £3.50 (50p).

Post in brackets, small parts 3p S.A.E. List.

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Solartron oscilloscopes type CD6435 DC-15MHz Bandwidth. Re-calibrated in new condition £45.

Other 'Scopes at shop for callers TF144G Sig. Gen. 85KHz-25MHz 1μV 1V O/P in excellent condition £20. Others from £12. Audio Oscillator. Bfo type. Covers 50Hz-20KHz in 2 bands 10Ω or 600Ω metered O/P. £10. Elliott synchronous amplifier £20. Portable scope with circular timebase. Contains 17 B9A valves 3" C.R.T. Only £6. working. Marconi FM deviation testset no. 3 in new condition. 2 ranges 20-100mhz. Deviation range 100, 200 or 400 KHz £45
EHT unit type 532D by Isotope Developments. Brand new. List price £185. Only £50.

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£1 BARGAIN PACKS

Each pack £1 post free.

3 2N3055	£1	8 BFY51	£1
4 741C	£1	10 2N1613	£1
14 BC107	£1	4 BD163	£1
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Surplus capacitors, μF-V: 1000+500/18 12p; 80+80+20/350, 80+40+20/350, 32+100/300, 32+32/300, 10p; 2/150, 25/150, .02/350, .01/350, .005/350 2p; 4/25, 4/200, 8/12, 8/150, 25/25, 75/6 4p.
Lots of others Available:

GREENWELD (W1)
24 Goodhart Way, West Wickham, Kent.
Tel 01-777 2001.
Shop at 21 Deptford Broadway, SE8.
Tel. 01-692 2009.
Lots of odd units at shop for callers.
2484

TECHNICIAN

DEPARTMENT OF PHYSICS

Technician required for construction and maintenance of electronic equipment for the Applied Nuclear Science research group: ability to use light machine tools required desirable. At least three years working experience with City & Guilds Technician's Certificate or equivalent.

Salary: up to £1,794 p.a.

Reference: L13/B/597.

Apply: Assistant Secretary (Personnel),
University of Birmingham,
P.O. Box 363,
Birmingham, B15 2TT.
[2477

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For Ferguson 850, 900 Chassis, but adaptable for most D/STD Chassis. **£2.50** each, C.W.O., postage included.
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FREE CATALOGUE ON REQUEST
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GOVERNMENT SURPLUS WIRELESS EQUIPMENT HANDBOOK. Contains circuits, data, illustrations for British/USA receivers, transmitters, trans/receivers. With modifications to sets and test equipment. Latest impression **£3.25** Including postage.
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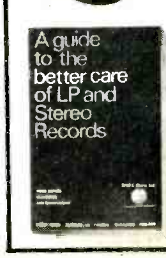

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12V x 2	4A x 2	MT 108 AT	£2·92	34p
12V x 2	5A x 2	MT 72 AT	£3·33	42p

30 volts. All tapped at 0-12-15-20-24-30 V.

Output Amps	Ref. No.	Price £	P.P.	Output Amps.	Ref. No.	Price £	P.P.
500 mA	MT 112 CT‡	1·12	16p	4A	MT 21 AT	3·10	40p
1A	MT 79 AT‡	1·55	29p	5A	MT 51 AT	4·31	42p
2A	MT 3 AT	2·23	30p	8A	MT 88 AT	6·32	50p
3A	MT 20 AT	2·64	32p	10A	MT 89 AT	7·19	50p

50 volts. All tapped at 0-19-25-33-40-50 V.

500 mA	MT 102 AT‡	1·45	24p	3A	MT 105 AT	3·91	41p
1A	MT 103 AT	2·00	32p	4A	MT 106 AT	5·06	41p
2A	MT 104 AT	3·10	32p	6A	MT 107 AT	7·47	50p

60 Volts. All tapped at 0-24-30-40-48-60 V.

500 mA	MT 124 AT‡	1·46	30p	2A	MT 127 AT	3·16	41p
1A	MT 126 AT	2·24	32p	3A	MT 125 AT	4·59	41p

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Power output	Winding tapped at	Ref. No.	Price	P. & P.
20 VA	0-115-210-240	MT 113 CT	£0·89	16p
75 VA	" "	MT 64 AT	£1·72	30p
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200	MT 151 AT*	5·02	42p	500	MT 154 AT*	12·00	72p

	Price	P. & P.
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20-0-20	30 mA	MT 241 CS*†	£0·91	8p
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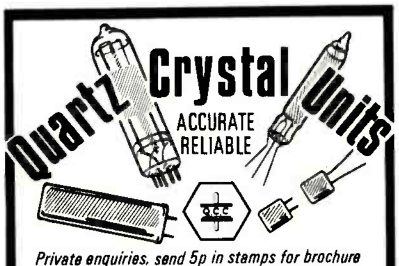

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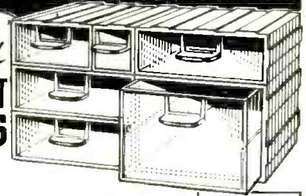

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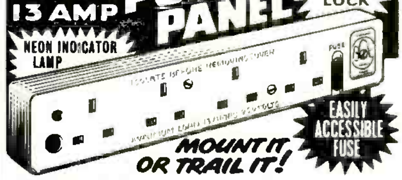

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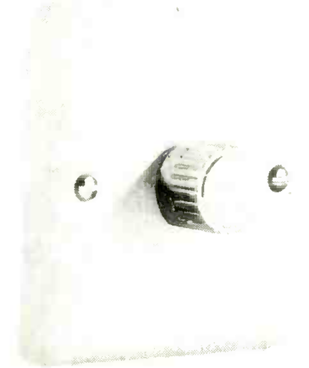

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