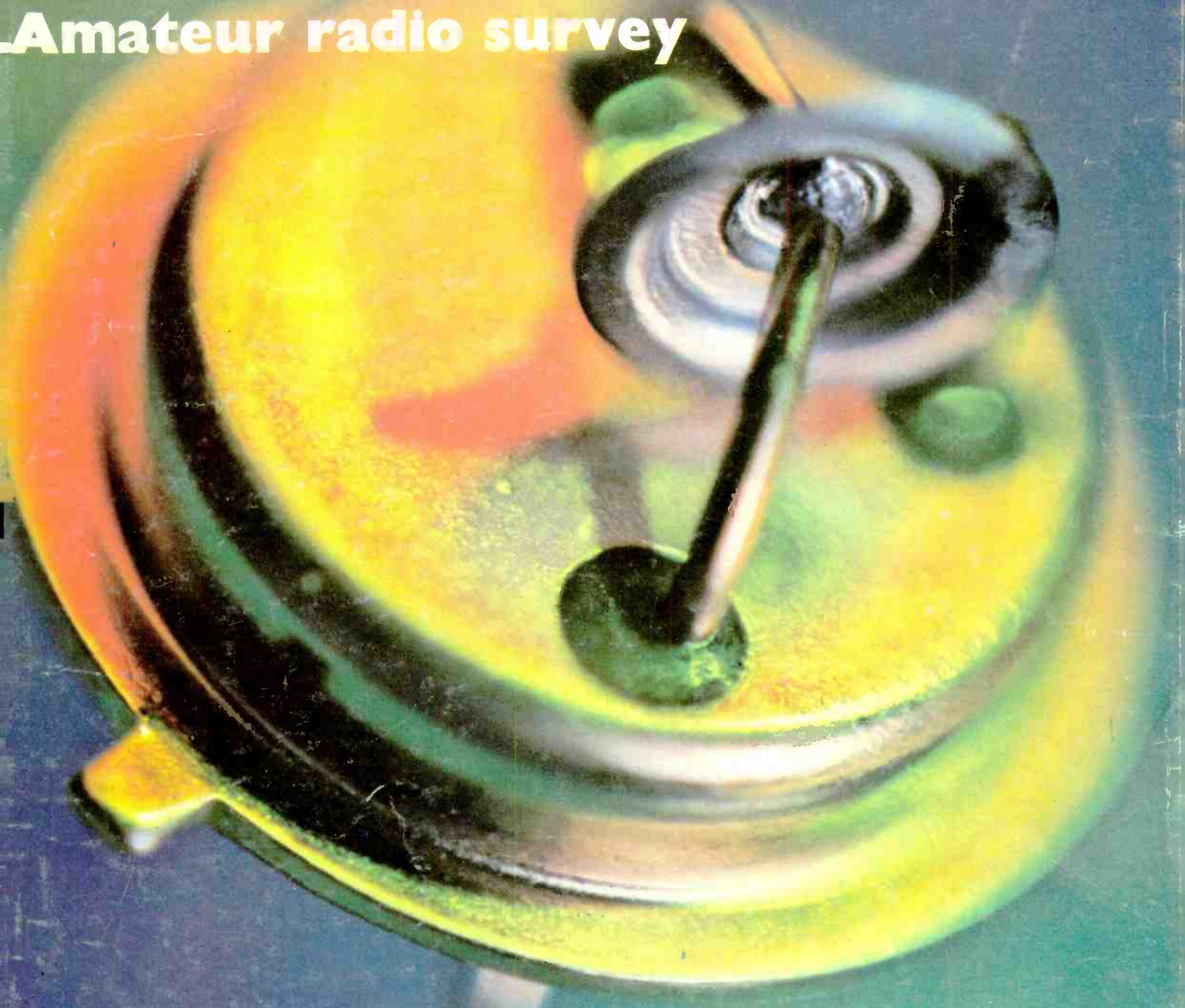
wireless world

AUGUST 1977 40p

Distortion in amplifiers
Amateur radio survey



Power transistor

Australia $A1.25
Canada $1.75
Denmark Kr. 11.00
Germany Dm. 4.50
Greece Dr. 47.00
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Italy L. 1100
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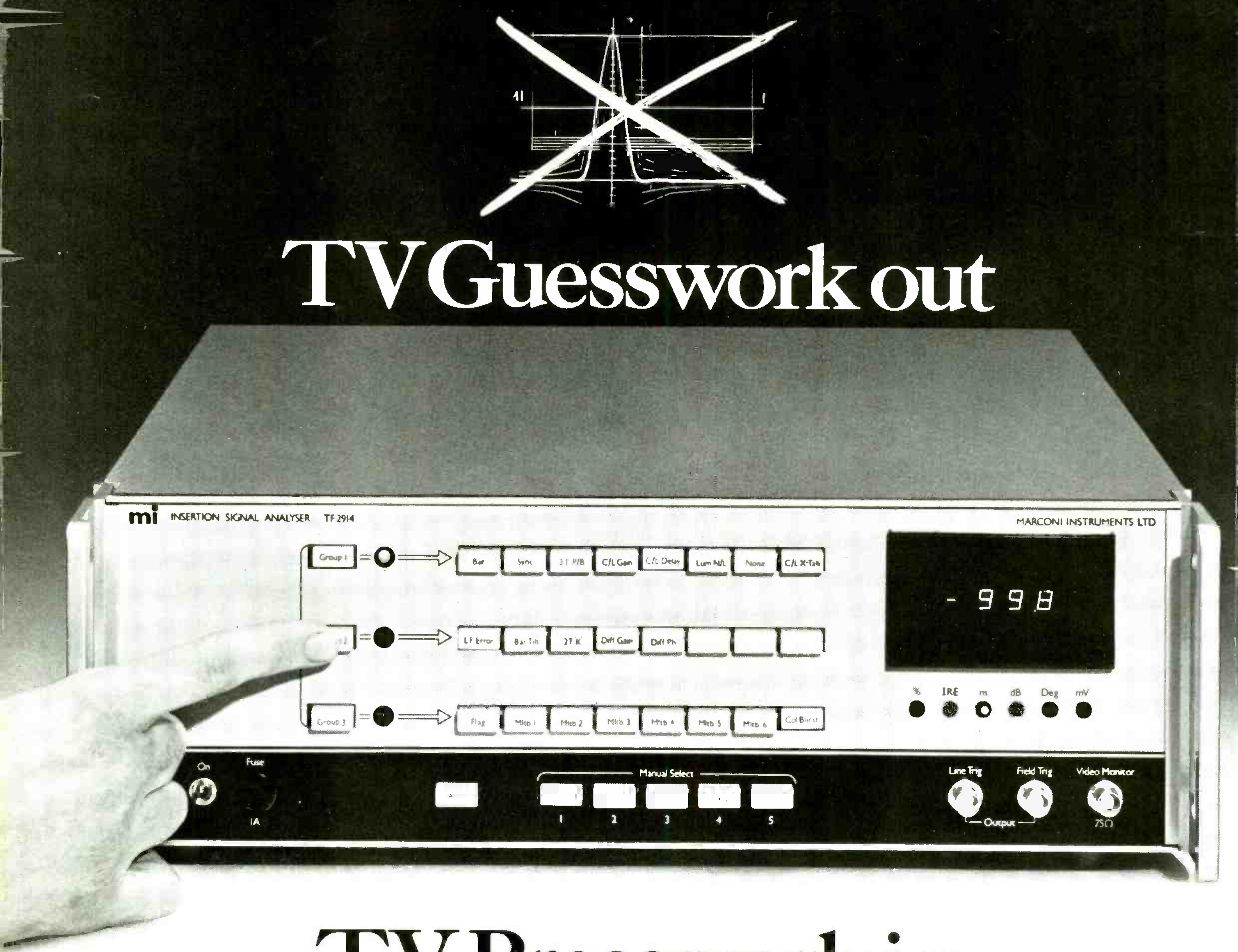

TV Presswork in

If your system is PAL, SECAM or NTSC and you use ITS, the TF2914 Insertion Signal Analyser is the answer to your measurement problems whether you are involved in broadcasting, programme production or PTT networks. The fast, push button action puts clear, unambiguous digital readout of 24 accurate television measurements at your fingertips. No more time-consuming subjective tests using an oscilloscope.

Versions are available for all national and international ITS formats including CCIR; NTC 7; CBC and UK national.

What is more, the TF2914 can form the nucleus of a fully automatic TV monitoring system which can be as simple or as comprehensive as desired. This can provide instant, fully automatic scanning of system parameters, selection of video inputs and executive action whenever distortion exceeds pre-set limits. Data outputs can be used for recording and interrogation of the system either on site or at a remote station.

Ask for full information and throw away your oscilloscope graticules.

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WW—001 FOR FURTHER DETAILS

wireless world

Electronics, Television, Radio, Audio

AUGUST 1977 Vol 83 No 1500

Contents

Current issue price 40p, back issues (if available) 50p, at Retail and Trade Counter, Paris Garden, London SE1. By post, current issue 55p, back issues (if available) 50p, order and payment to Room 11, Dorset House, London SE1 9LU.
Editorial & Advertising offices: Dorset House, Stamford Street, London SE1 9LU.
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Subscription rates: 1 year: £7.00 UK and overseas ($18.20 USA and Canada). Student rate: 1 year, £3.50 UK and overseas ($9.10 USA and Canada).
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Subscriptions: Oakfield House, Perrymount Rd, Haywards Heath, Sussex RH16 3DH. Telephone 0444 59188. Subscribers are requested to notify a change of address.
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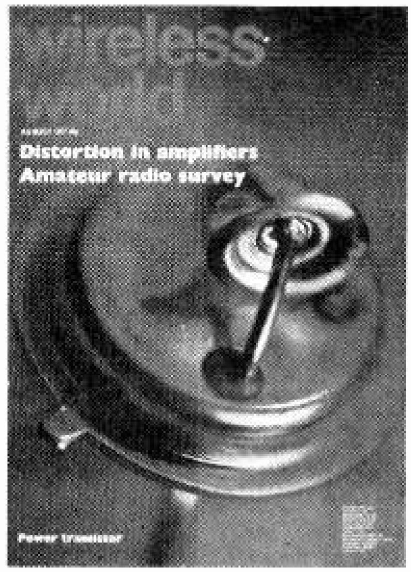


Photographer Paul Brierley

Front cover shows the interior of a power transistor made by Newmarket Transistors Ltd

IN OUR NEXT ISSUE

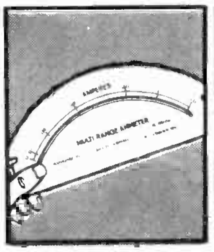
Low-distortion audio oscillator. Constructional design for 10Hz to 100kHz instrument using i.cs and suitable for distortion measurements on audio equipment. Distortion at 1-5kHz less than 0.005%.

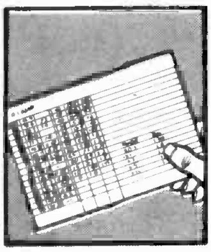
Band II ferrite aerial — eliminating the telescopic whip aerial of v.h.f./f.m. portable radio sets. A unit developed for the industry by the BBC.

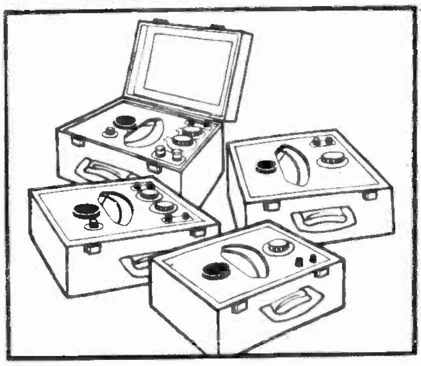
Amateur radio transmitters and transceivers, the second part of the survey of amateur equipment started in this issue.

ISSN 0043 6062

Sullivan AC Test sets are designed for the precise measurement of ac voltage (10-500V); current (0.5-30A) and power (up to ¼ million watts when coupled with a current transformer). They can also measure dc voltage over an exceptionally wide range.
The accuracy and reliability of our AC Test Sets is assured by our manufacturing techniques.
Components are hand fitted and subject to a series of searching checks. The coil and pointer, for instance, goes through a delicate test of balance known as poising. We're the only manufacturer who does this.
Every hair spring is cropped to match the coil.
Every scale is hand calibrated, too, matching it precisely to the individual instrument.







Every resistor is aged to ensure long term stability–so there is no need for frequent recalibration.
At the end of the process, you get an instrument of high accuracy that is suitable for either workshop or laboratory.
Sullivan also produce Precision Multi-range Voltmeters, Wattmeters and Ammeters. All built to the same high standards.
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H. W. Sullivan Ltd.,
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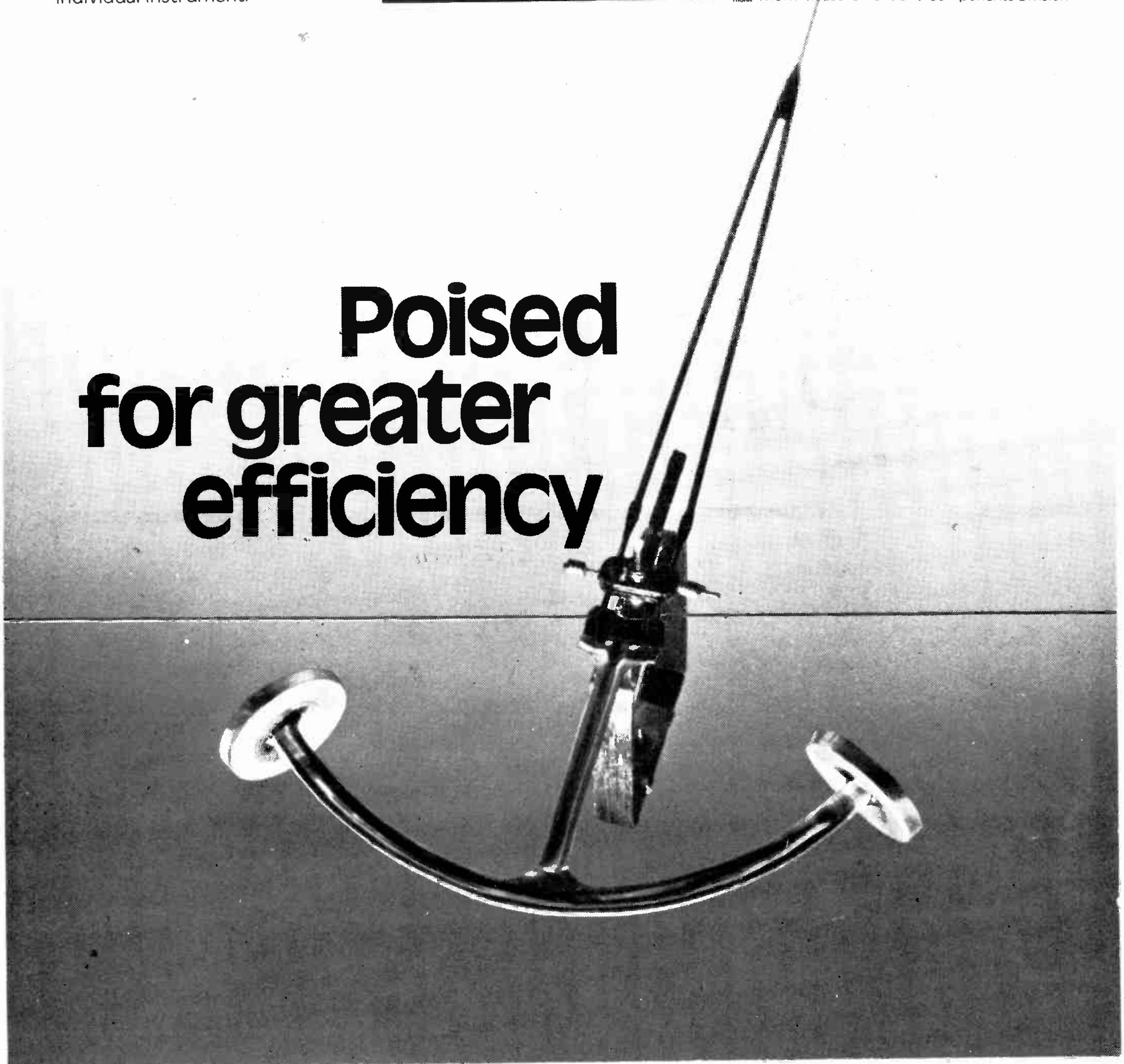
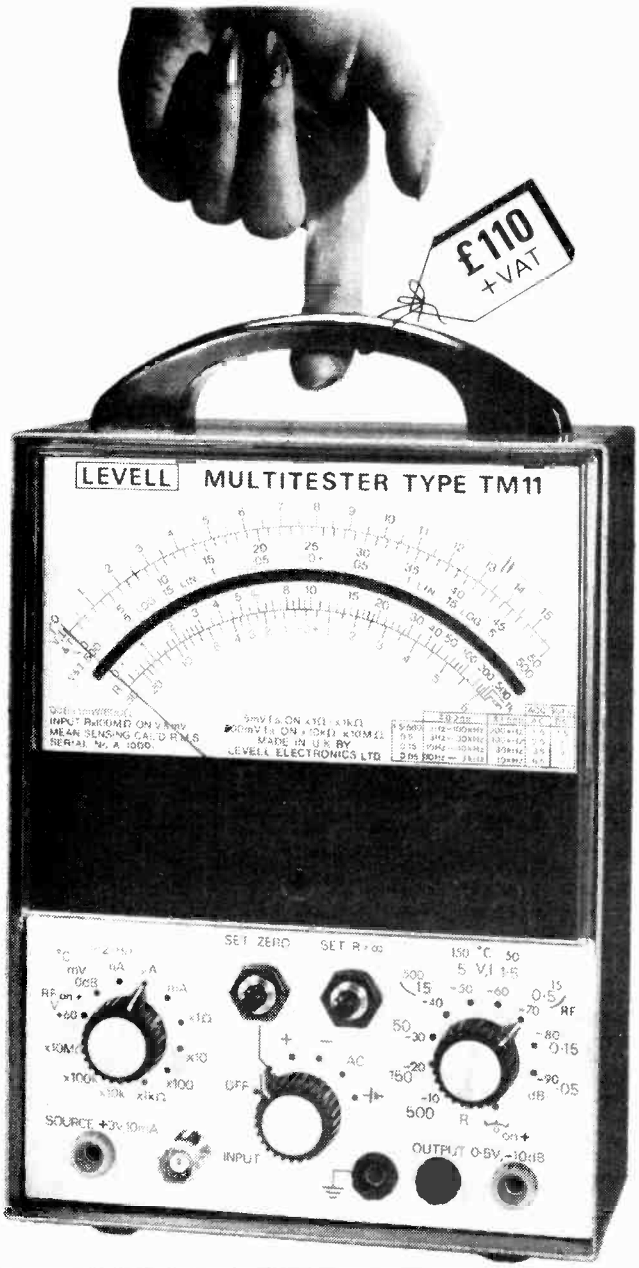
Thorn Measurement and Components Division



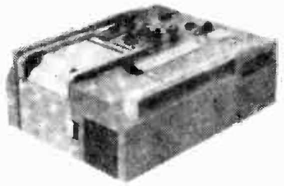
WW—050 FOR FURTHER DETAILS


£110 +VAT
LEVELL MULTITESTER TYPE TM11

FAST RESPONSE STRIP CHART RECORDERS

Made in USSR

Series H3020

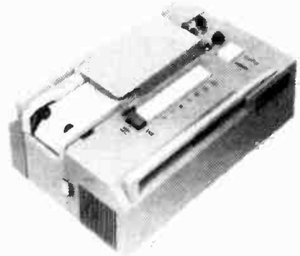


Basic error 2.5%
Sensitivity 8mA F.S.D.
Response 0.2 sec.
Width of each channel
Single and three-pen recorders: 80mm
Five-pen recorders 50mm

Chart speeds, selected by push buttons 0.1-0.2-0.5-1.0-2.5-5.0-12.5-25 mm/sec.
Chart drive 200-250V 50Hz
Recording: Syphon pen directly attached to moving coil frames. Curvilinear co-ordinates.
Equipment: Marker pen, timer pen, paper footage indicator, 10 rolls of paper, connectors, etc.

H3020-1 (Single pen): 285mm wide x 384mm deep x 165mm high .... **PRICE £108.00**
H3020-3 (Three pen): 475mm wide x 384mm deep x 165mm high .... **PRICE £160.00**
H3020-5 (Five pen): 475mm wide x 384mm deep x 185mm high .... **PRICE £295.00**

Series H327



Polarized moving iron movements with syphon pens directly attached. Built-in solid state amplifier (one per channel) provides 8 calibrated sensitivity steps. Two marker pens are provided.
Basic error 4%. Frequency response from DC to 100Hz 2dB.

Sensitivity 0.02 - 0.05 - 0.1 - 0.2 - 0.5 - 1 - 2 - 5 volts/cm
Width of each recording channel 40mm
Chart drive 220-250V 50Hz
Chart speeds 1-2-5-10-50-125-250mm/sec.

Type H3271-1. Single pen: Dimensions 259 x 384 x 165mm Weight 15 kilos .... **PRICE £265.00**
Type H327-3. Three pen: Dimensions 335 x 384 x 165mm Weight 20 kilos .... **PRICE £520.00**
Type H327-5. Five pen. Dimensions 425 x 385 x 165mm Weight 25 kilos .... **PRICE £770.00.**

Note Prices are exclusive of VAT

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WW—046 FOR FURTHER DETAILS

HIGH POWER DC-COUPLED AMPLIFIER

- ★ **UP TO 500 WATTS RMS FROM ONE CHANNEL**
- ★ **DC-COUPLED THROUGHOUT**
- ★ **OPERATES INTO LOADS AS LOW AS 1 OHM**
- ★ **FULLY PROTECTED AGAINST SHORT CCT, MISMATCH, ETC.**
- ★ **3 YEAR WARRANTY ON PARTS AND LABOUR**

The DC300A Power Amplifier is the successor to the world famous DC300 which is so widely used in Industrial, and Research applications in this country. It is DC-coupled throughout so providing a power bandwidth from DC to over 20,000Hz.The ability of the DC300A to operate without fuss into totally reactive loads while delivering its full power, and maintaining its faithful reproduction of Pulse or complex waveforms has established the DC300A as the world's leading power amplifier. Each of the two channels will operate into loads as low as 1 ohm, and the amplifier can be rapidly connected as a single ended amplifier providing over 650 watts RMS into a 4 ohms load, and still providing a bandwidth down to DC. Below is a brief specification of the DC300A, but if you require a data sheet, or a demonstration of this fine equipment please let us know.

Power Bandwidth	DC-20kHz @ 150 watts + 1db. 0db.	Slewing Rate	8 volts per microsecond
Power at clip point (1 chan)	500 watts rms into 2.5 ohms	Load impedance	1 ohm to infinity
Phase Response	+0, −15° DC to 20kHz, 1 watt 8Ω	Input sensitivity	1.75 V for 150 watts into 8Ω
Harmonic Distortion	Below 0.05% DC to 20kHz	Input Impedance	10K ohms to 100K ohms
Intermod. Distortion	Below 0.05% 0.01 watt to 150 watts	Protection	Short, mismatch & open cct. protection
Damping Factor	Greater than 200 DC to 1kHz at 8Ω	Power supply	120-256V, 50-400Hz
Hum & Noise (20-20kHz)	At least 110db below 150 watts	Dimensions	19" Rackmount, 7" High, 9¾" Deep

Other models in the range: D60 — 60 watts per channel D150A — 150 watts per channel

Other models available from 100 watts to 3000 watts

MACINNES LABORATORIES LTD.
Macinnes House, Carlton Park Industrial Estate
Saxmundham, Suffolk IP17 2NL. Tel: (0728) 2262 2615

MACINNES FRANCE
18 Rue Botzaris
Paris 75019, France
Tel: 206-60-80 or 206-83-61

WW—029 FOR FURTHER DETAILS

THE DYNAMIC DUO

The C15/15 is a unique Power Amplifier providing Stereo 15 watts per channel or 30 watts Mono and can be used with any car radio/tape unit. It is simply wired in series with the existing speaker leads and in conjunction with our speakers S15 produces a system of incredible performance.

A novel feature is that the amplifier is automatically switched on or off by sensing the power line of the radio/tape unit hence alleviating the need for an on/off switch.

The amplifier is sealed into an integral heatsink and is terminated by screw connectors making installation a very easy process.

The S15 has been specially designed for car use and produces performance equal to domestic speakers yet retaining high power handling and compact size.

C15/15
15 Watts per channel into 4Ω
Distortion 0.2% at 1KHz at 15 watts
Frequency response 50Hz - 30KHz
Input Impedance 8Ω nominal
Input sensitivity 2 volts R.M.S. for 15 watts output
Power line 10 - 18 volts
Open and Short circuit protection
Thermal protection
Size 4 × 4 × 1 inches

C15/15 Price £17.74 + £2.21 VAT P & P free

Data on S15
6" Diameter
5¼" Air Suspension
2" Active Tweeter
20oz Ceramic magnet
15 Watts R.M.S. handling
50 HZ - 15KHz frequency response
4Ω Impedance

S15 Price per pair £17.74 + £2.21 VAT P & P free

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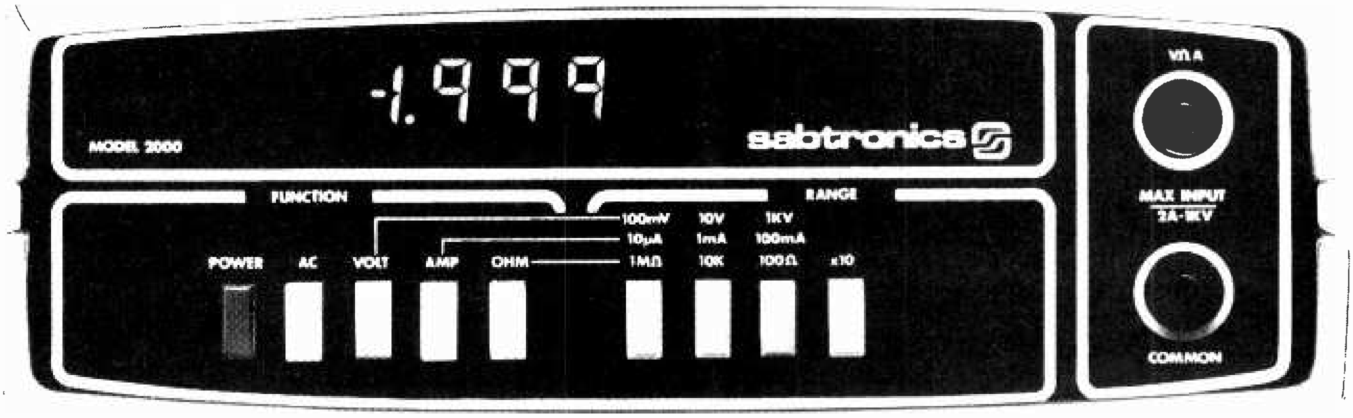
WW-086 FOR FURTHER DETAILS

We've just made the impossible . . . a professional 3½ digit DMM Kit for less than £70



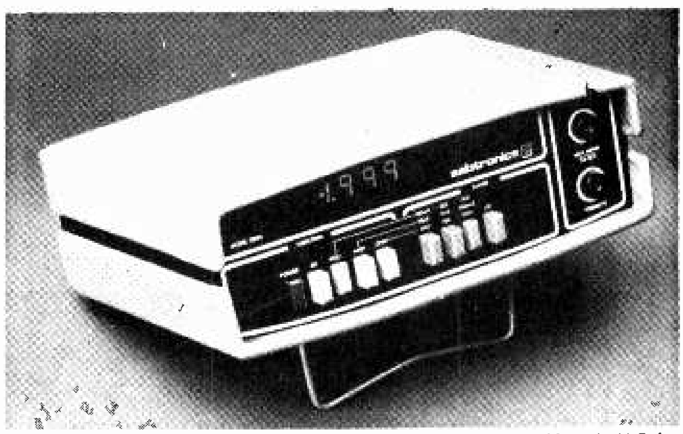
The Sabtronics Model 2000 is an impossible £69.95!
And that price still includes phenomenal accuracy, range and professional features.

This all-new bench/portable multimeter, reading to ±1999, has a basic accuracy of 0.5% ± 1 digit, and has five functions giving 28 ranges, 100% overrange and overload protection. So you know it's no toy!

Besides, what toys are as automatic as the 2000? With automatic overrange indication, automatic polarity, even automatic zeroing!

Yet the 2000 is easy to assemble. We send you all the parts you need, even the high-impact case. We also send you clear, step-by-step assembly instructions.
So you end up with a professional quality 3½ digit DMM for the unheard of price of less than £70.
From Sabtronics, specialists in digital technology. And manufacturers of the impossible.

Order yours today!



Made in U.S.A.

sabtronics USA

Sabtronics (U.K.) Ltd.
50 Galton Road
Westcliff-on-Sea
Essex

SPECIFICATIONS: (condensed)

DC volts in 5 ranges: 100μV to 1000V.
AC volts in 5 ranges: 100μV to 1000V.
DC current in 6 ranges: 10nA to 2A.
AC current in 6 ranges: 10nA to 2A.
Resistance in 6 ranges: 1Ω to 20MΩ.
Input Impedance: 10MΩ.
Display: 9mm (.36") LED.
Power requirements: 4.5 VDC to 6.5 VDC. (4 "C" cells - not included).
Size: 8"W × 6.5"D × 3.0"H. (203W × 165D × 76H mm).

ORDERING INFORMATION FOR READERS OUTSIDE THE U.K.

The price listed is for readers in the U K. only which includes import duties and V A T

For readers in overseas countries the price is £49.95 plus £5 00 for Handling and postage, not included are any import duties or other taxes levied upon receipt of goods overseas Payments from overseas customers should be made only by Bank drafts or International money orders and payable to Sabtronics International Orders should be sent to

Sabtronics International Ltd.
Winkelriedstrasse 35
6003 Luzern
Switzerland

WW7

To: Sabtronics (U.K.) Ltd.
50 Galton Road
Westcliff-on-Sea, Essex

Please send me . . . . . Sabtronics Model 2000 DMM Kit(s) at £69.95 each incl. V.A.T. and Postage.

Total enclosed herewith: £ . . . . . .

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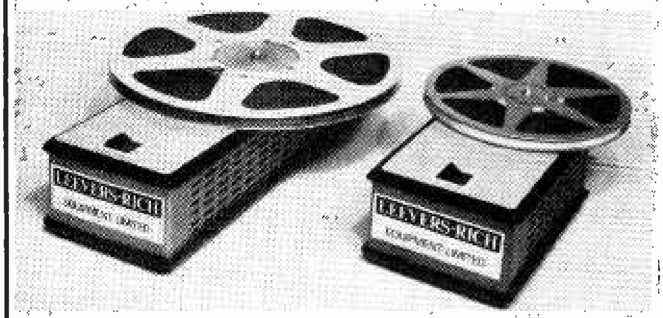
Address . . . .

City . . . . County . . . .

Readers Overseas please see ordering Information.

BULK ERASURE PROBLEMS?



LR71
MAX REEL SIZE 11½"

LR70
MAX REEL SIZE 8¼"

If it's personal we can only advise a diet or joining weightwatchers. If it's to do with tape, then why not consider the LR70/71 bulk tape erasers. They are simple to operate and will erase cassettes, cartridges and reels of tape up to a maximum reel size of 11½" and tape width of 1", quickly and efficiently within the time it takes to read this advertisement.

The LR70/71 bulk erasers are currently used in Broadcast Companies, Recording Studios, Government Departments, Educational Establishments and the Computer Industry.

Moderately priced and available from:

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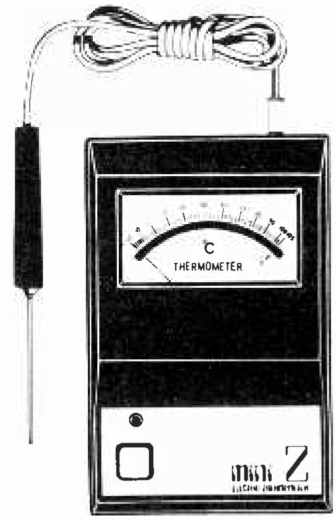
INCORP. BIAS ELECTRONICS
319 Trinity Road, Wandsworth, London SW18 3SL
Telephone 01-874 9054
Cables: Leemag London SW18. Telex 923455 Wembley

WW—031 FOR FURTHER DETAILS

ELECTRONIC INDUSTRIAL THERMOMETER



THE MODERN WAY TO MEASURE TEMPERATURE

A Thermometer designed to operate as an Electronic Test Meter. Will measure temperature of Air, Metals, Liquids, Machinery, etc., etc. Just plug-in the Probe, and read the temperature on the large open scale meter. Supplied with carrying case, Probe and internal 1½ volt standard size battery.

Model "Mini-Z 1" measures from—40° C to + 70° C. Price £25.00
Model "Mini-Z 2" measures from—5° C to + 105° C Price £25.00
Model "Mini-Z Hi" measures from + 100° C to + 500° C £27.50
(VAT 8% EXTRA)

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138 GRAY'S INN ROAD, LONDON, WC1X 8AX
(Phone 01-837 7937)

WW — 008 FOR FURTHER DETAILS

seen from the professional angle

the 201 is something quite personal...

The M 201 Hypercardioid moving coil microphone is designed for recording or broadcasting. The M 201 offers excellent separation characteristics in extreme accoustical conditions.

Specifications:
Frequency Response: 40-18000 Hz. Output Level at 1 kHz: 0,14 mV/μ bar ≙ -56 dbm (0 dbm ≙ 1 mW/10 dynes/cm2). EIA Sensitivity Rating: -149 dbm. Hum Pickup Level: 5 μ V/5 μ Tesla (50 Hz). Polar Pattern: Hypercardioid. Output Impedance: 200 Ω. Load Impedance: > 1000 Ω. Connections: M 201 N (C) = Cannon XLR-3-50 T or Switchcraft: 2+3 = 200 Ω., 1 = ground. M 201 N = 3-pin DIN plug T 3262: 1+3 = 200 Ω. 2 = ground. M 201 N (6) = 6 pin Tuchel.
Dimensions: length 6", shaft Ø 0,95".
Weight: 8,60 oz.

BEYER DYNAMIC (GB) LIMITED
1 Clair Road, Haywards Heath, Sussex.
Tel: Haywards Heath 51003

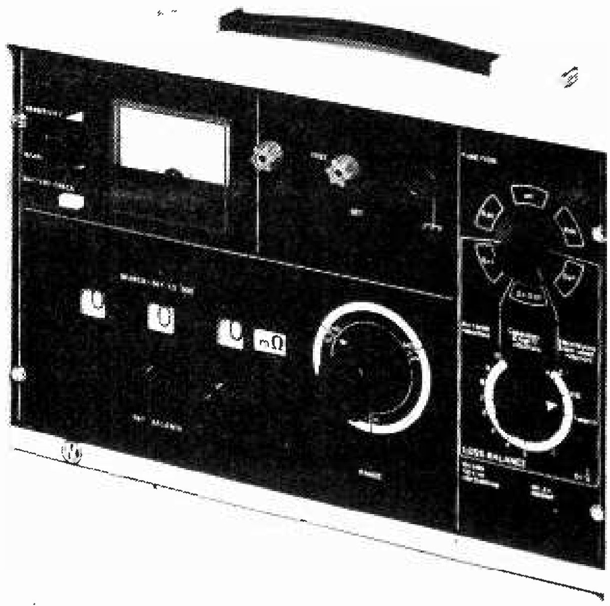
WW — 065 FOR FURTHER DETAILS

"Where can I get a Universal Bridge that's good enough for the labs, simple to use and tough enough for the shop floor and doesn't cost a fortune?"

"Here"– AVO's Universal Bridge B150 Mk. 3 gives you measurement of resistance, capacitance, inductance accurate to 1%, can be used anywhere, it's battery powered. And anyone can use it, connections are simple and readings easy to take – with no calculations thanks to the mechanical in-line digital display and interlocking units selector.

The B150 Mk. 3 – for use in production, quality control, development labs – even at goods inwards. Tough metal cabinet, and the AVO guarantee of reliability, serviceability and accuracy, all at a price that's a pleasant surprise. From good distributors everywhere.

Ring us for the name of your nearest stockist or for fuller details of AVO's Universal Bridge B150 Mk. 3.

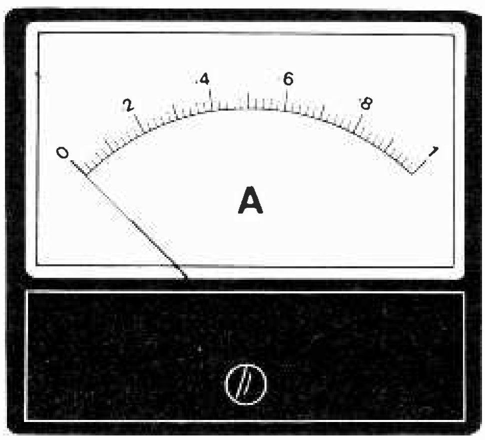


Avo Limited, Archcliffe Road,
Dover, Kent. CT17 9EN.
Tel: 0304 202620 Telex: 96283.

Thorn Measurement Control and Automation Division

WW — 007 FOR FURTHER DETAILS

METER PROBLEMS?



137 Standard Ranges in a variety of sizes and stylings available for 10-14 days delivery. Other Ranges and special scales can be made to order.

Full Information from:

HARRIS ELECTRONICS (London)

138 GRAYS INN ROAD, W.C.1 Phone: 01/837/7937

WW—009 FOR FURTHER DETAILS

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Discount Hi-Fi, etc., at 5 Swan Street and 10 Swan Street

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WW—011 FOR FURTHER DETAILS

Unique full-function 8-digit wrist calculator... available only as a kit.

A wrist calculator is the ultimate in common-sense portable calculating power. Even a pocket calculator goes where your pocket goes – take your jacket off, and you're lost!

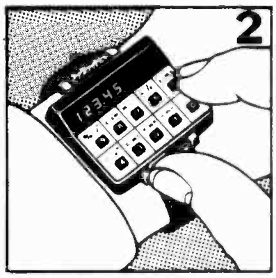
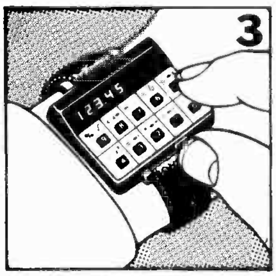
But a wrist-calculator is only worth having if it offers a genuinely comprehensive range of functions, with a full-size 8-digit display.

This one does. What's more, because it *is* a kit, supplied *direct* from the manufacturer, it costs only a very reasonable £9.95 (plus 8% VAT, P&P). And for that, you get not only a high-calibre calculator, but the fascination of building it yourself.

How to make 10 keys do the work of 27

The Sinclair Instrument wrist calculator offers the full range of arithmetic functions. It uses normal algebraic logic ('enter it as you write it'). But in addition, it offers a % key; plus the convenience functions $\sqrt{x}$, $1/x$, x^2; plus a full *5-function memory*.

All this, from just 10 keys! The secret? An ingenious, simple three-position switch. It works like this.

1. The switch in its normal, central position. With the switch centred, numbers – which make up the vast majority of key-strokes – are tapped in the normal way
2. Hold the switch to the left to use the functions to the left above the keys...
3. and hold it to the right to use the functions to the right above the keys.

The display uses 8 full-size red LED digits, and the calculator runs on readily-available hearing-aid batteries to give weeks of normal use.

Dimensions:
1 13/16" (46 mm) wide,
1 7/16" (37 mm) deep.
Weight:
less than 1 oz (28 g).

Assembling the Sinclair Instrument wrist calculator

The wrist calculator kit comes to you complete and ready for assembly. All you need is a reasonable degree of skill with a fine-point soldering iron. It takes about three hours to assemble. If anything goes wrong, Sinclair Instrument will replace any damaged components *free*: we want you to enjoy assembling the kit, and to end up with a valuable and useful calculator.

Contents

Case and display window.
Strap.
Printed circuit board.
Switches.
Special direct-drive chip (no interface chip needed).
Display.
Batteries.

Everything is packaged in a neat plastic box, and is accompanied by full instructions. The only thing you need is a fine-point soldering iron.

All components are fully guaranteed, and any which are damaged during assembly will be replaced free.

The wrist-calculator kit is available only direct from Sinclair Instrument. Take advantage of this 10-day money-back undertaking.

Send the coupon today.

KIT ONLY £9.95 PLUS VAT, P&P

Sinclair Instrument Ltd,
6 Kings Parade, Cambridge,
Cambs., CB2 1SN.
Tel: Cambridge (0223) 311488.

To: Sinclair Instrument Ltd,
6 Kings Parade, Cambridge, Cambs., CB2 1SN.

* Please send me .1. (qty) Sinclair Instrument wrist-calculator kits at £9.95 plus 80p VAT plus 25p P&P (Total £11).
* I enclose cheque/~~PO/money order~~ for £11..............
* Complete as applicable.

Name A-HILEY
Address

(Please print)
I understand that you will refund my money in full if I return the kit undamaged within 10 days of receipt. WW 8

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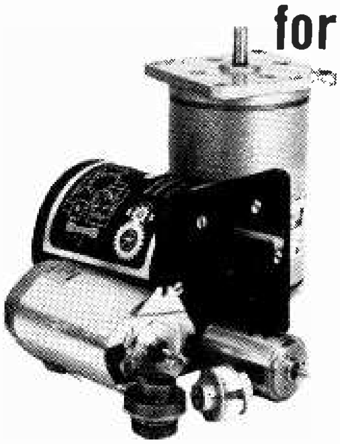

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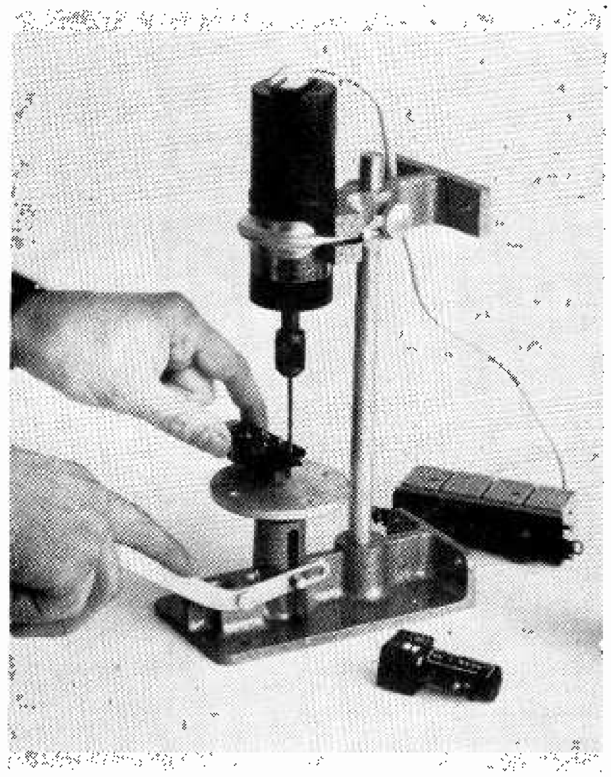

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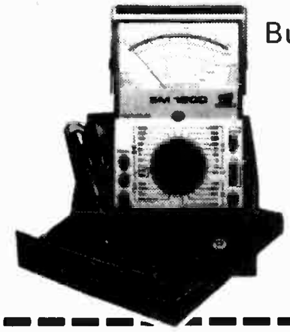

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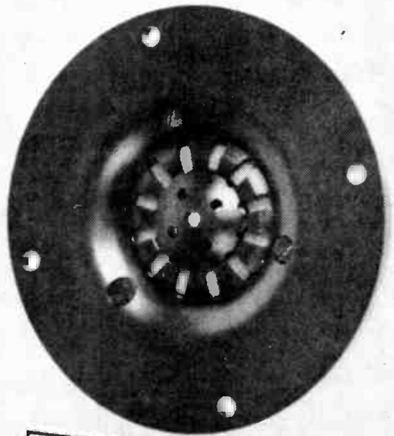

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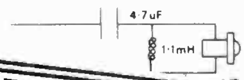

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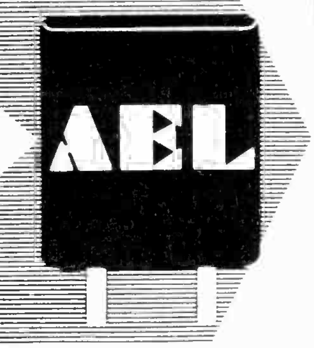

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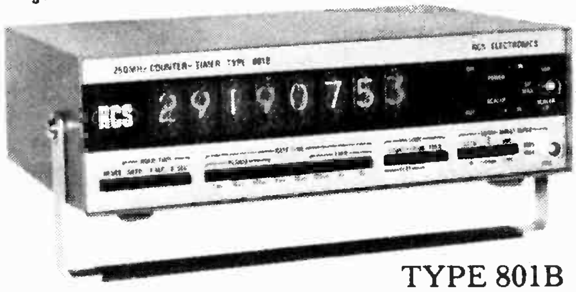

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Can sound quality be quantified?

Anyone who has read that curious book *Zen and the art of motorcycle maintenance* will recall that the narrator apparently drove himself into a mental hospital by his obsessive attempts to discover by pure reason the essence of "quality". Even Socrates had trouble with such universals. It is still difficult when one descends to particular, concrete instances. Those who design audio equipment have the problem that even after the application of the most precise, thorough and foolproof engineering their products are still finally submitted to the vagaries of subjective assessment. They would really like to have an objective measure of sound quality, perhaps a figure of merit obtained from measurements of electrical and/or acoustic variables, which would be causally independent of personal preferences but at the same time correlated with subjective experience.

A correspondent writing in this issue (letters) is right to assert the primacy of subjective evaluation but perhaps a bit harsh in condemning the concept "loss of information" because it cannot at the moment be expressed in engineering terms. Engineers certainly do follow Lord Kelvin's dictum that you can't properly understand a phenomenon until you can express it in numbers. Galileo, though, after saying something similar, added "what is not measurable, make measurable". "Loss of information" presumably could be measured on the basis of quantisation (as in p.c.m.) and information theory. "Musicality" is more difficult.

Apart from the variations from listener to listener depending on circadian rhythm, degree of tiredness etc., a big problem with subjective assessment is that hearing is not merely a passive registering of impressions but an active process of attention and even *in*tention. (See C. A. Malcolm, *Hi Fi News*, June 1977, on this.) To some extent you hear what you want to hear. An engineer may listen for a particular type of distortion and suppress the emotional or intellectual effect of the programme content. A musician may listen for features of musical performance and "not hear" quite obtrusive distortion. Whereas an engineer carries in his mind a distinct *a priori* concept of frequency, which he may regard as the primary characteristic of sound, it is possible for a musician to say "I cannot accept the distinction between tone colour and pitch as it is generally stated. I find that tone makes itself noticed through colour, one dimension of which is pitch." (Arnold Schoenberg in his *Harmonielehre.*)

Attempts to arrive at a numerical index which correlates with subjective evaluation of sound quality have already been made but nothing workable has emerged yet. It's interesting to note, though, that parallel searchings have been going on in other fields such as linguistics and the behavioural sciences. The most recent is an attempt to formulate and measure value judgments of the kind made in ethics, religion, politics and aesthetics (J. Pearl, "A framework for processing value judgments", *Trans. IEEE*, vol. SMC-7, No. 5, May 1977). The paradigm in this case is that "value judgments and probability statements are the same thing". Both are "codes of experiential data . . . constructed by the same mental procedures".

Probability may be a clue. One approach to measuring sound quality might be based on the principles of pattern recognition, using the known statistics of successive values in the waveforms of musical or other sounds as references. (By analogy, in written English the probability of letter "u" coming after letter "q" is some precise value in excess of 0.9.) With integrated analogue-to-digital converters, high density memories and microprocessors, the instrumentation required should not be beyond the capabilities of today's digital electronics.

Shortwave broadcasting efficiency

A method of measuring the success of a broadcasting service in achieving its target coverage

by George Jackson, *Radio Canada International*

Before doing an analysis of how successful we can be in reaching our listeners, we must know what it is we are up against. We could go into great detail and list such factors as type of listener, his habits, his tastes and so forth, but these are parameters which we can assume are taken into consideration by those who are providing the programmes for the region involved. This analysis is based on the need to reach the target in the first place. If you do not reach your audience physically, it is impossible to stimulate them mentally, no matter how good your programmes are.

Considering this fact, then, we must ask ourselves three main questions about our shortwave service:

- How well do we overcome the inconsistent nature of shortwave reception?
- How successful are we in overcoming interference to our broadcasts caused by severe crowding of the high-frequency broadcasting bands?
- How well do we tailor our transmissions to the best possible listening periods in our target area?

These questions relate directly to the three major factors influencing shortwave broadcasting. These are: ionospheric propagation; band crowding; and programme timing. The degree to which a broadcaster can control these factors will determine the success or failure of his target service.

A broadcaster can successfully overcome, or at least diminish, the negative effects of the major influencing factors by carefully manipulating four variables. These parameters are completely within his power to control and, used correctly, can make a second-rate broadcaster into a dominating force on shortwave. The four variables are: programme timing; frequency diversity; transmitted power; and transmitter location. This article shows how to best combine these four parameters to achieve a ninety to one hundred percent *probability of success* which we shall call "efficiency".

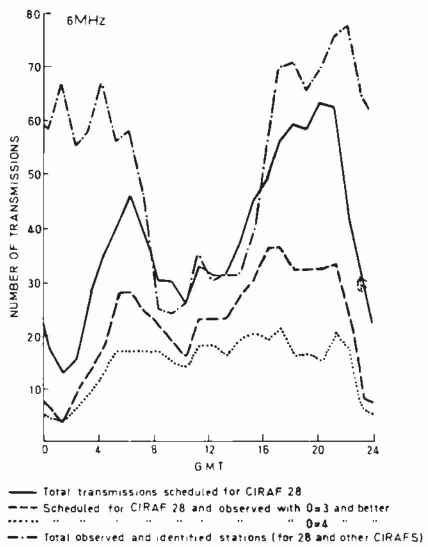


Fig. 1. Comparison of number of transmissions in the 6MHz band of scheduled and observed shortwave stations in CIRAF zone 28 (see footnote) over a twenty-four hour period.

Programme timing

We will define prime listening times as 0600-0900 and 1800-2400 hours local. Although, admittedly, these times vary for certain regions according to working hours and listening habits, audience research and current broadcasting practice* indicate that this definition is correct.

Outstanding programmes can draw listeners to periods outside the prime hours, but only if the other variables are combined in such a way as to produce a highly "receivable" programme. Such occurrences as this are quite rare and usually happen in conjunction with an event of special interest to a certain target area or group of areas.

Length of programmes within prime times is the next factor to consider. It has been generally established that a broadcaster's "presence" in a given target area need not be excessively long to be effective. Surveys have shown that a two-hour presence (not necessarily continuous) during prime time would be sufficient to either hold audience interest or to capture the greatest number of listeners†. Longer periods tend to become repetitive and tedious while shorter periods make it difficult to programme all available information. Also, the chances of losing an entire day's programmes due to interference or propagation become greater as presence is decreased.

Individual programme lengths can vary within the two hours according to the material to be aired and the policies of the broadcasting organization. Radio Canada International uses half an hour as its basic block because this time is manageable, because it best uses, and to a degree compensates for, staff limitations, and because it permits us to fit our multiplicity of languages into the desired prime time segment. On the other hand, Radio Netherlands uses an eighty-minute format which can be easily handled by an adequate technical plant and relatively few languages.

Even after a timing format has been developed by a broadcaster, he cannot be sure the plan can be followed. Technically, a transmission may not be propagated from the transmitter location to the target at the desired time. Interference patterns may be such that programmes are not heard at the desired times due to inadequate technical facilities. This is why it is important that the second, third and fourth variables (above) be considered in conjunction with programme timing when one is considering a target service.

To summarize then, we have outlined prime time (0600-0900 and 1800-2400 local), language or broadcasting presence (two hours ideal), optimum programme length (15 minutes to two

*A graph prepared by the Deutsche Welle (shortwave service of the Federal Republic of Germany) representing current use of the 6MHz band in CIRAF zone 28 is shown in Fig. 1 to illustrate current broadcasting practice. (CIRAF stands for Conferencia Internacional Radiodifusion por Altas Frequencias, an ITU conference for h.f. broadcasting at Mexico City during which the world was divided up into a number of zones).

†This, of course, does not apply in the case of a world service format such as that used by the BBC. Their programming is prepared with different ultimate goals from those of most other international shortwave broadcasters.

hours) and technical limitations to programme timing.

Frequency diversity

The factor which can be varied the most and which can have the greatest single effect on the success or failure of a transmission is that of frequency. In general, frequencies between 2 MHz and 30 MHz can carry, with varying degrees of success, voice or data transmissions over long distances. International broadcasting has been allotted bands of frequencies within the 2MHz to 30MHz spectrum. These areas occur in the 6, 9, 11, 15, 17, 21 and 26 MHz bands and comprise some 40 to 70 discrete frequencies in each band. The 7MHz band is also used, although not in the western hemisphere.

A shortwave transmitter can be tuned to any one of these discrete frequencies. The antenna system associated with the transmitters is, on the other hand, constructed on the basis of one or more antennas per shortwave band per target area. The number of discrete frequencies allotted to each programme is therefore directly related to the number of transmitters and antennas available for use at that particular time. The importance of this fact cannot be over-emphasized in that our analysis will define the optimum amounts of hardware and their ideal dispersion based on our overall priorities.

It is relatively easy to put a frequency on the air — but which one, or indeed, which ones? Ionospheric theory and past results have shown that the ability of a certain frequency to reach a given target depends on the time chosen for its operation. The ability of the ionosphere to support a given frequency depends on time of day, season of the year and period of time within the 11-year cycle of sunspot activity. (See, for example, H.F. Predictions in this journal.)

To determine correct frequency usage, a frequency manager will consult his charts for a certain time of day and season of the year and come up with a maximum usable frequency (m.u.f.) for a given path. He will check his records for a similar period in the preceding year and then select a frequency band which should allow transmission to the target area desired. Depending on available transmitters, he will then select one or two other bands below that m.u.f. band. The purpose in doing this is to allow for m.u.f. variation throughout the season he is planning. Once he has chosen the bands, he will begin the difficult task of choosing discrete frequencies within each band.

The frequency manager then goes to his transmitter plant and surveys his equipment. If he has enough transmitters and antennas he will assign a minimum of two and as many as five or six frequencies to that particular programme. Diagrams will show that the more frequencies you have, the better are your chances of being received.

To use Sackville to Western Europe as an example of a route, let us suppose we wish to broadcast a German programme at 1800 local time. All the data available show that 15MHz is the m.u.f. at that time. The frequency manager would then choose two 15MHz, two 11MHz and two 9MHz frequencies. Say these were 15.280, 15.325, 11.875, 11.860, 9.680 and 9.625 MHz. He would then look at his available transmitters and find, say, four were free at that time. Next, he would look at his antennas. There he would find one European antenna array capable of transmitting one frequency only in each of the 6, 9, 11, 15 and 17 MHz bands. His only option then is to use 15.280, 11.875 and 9.680 MHz even though six frequencies would have been ideal and four could have been used with the available transmitters. This time the limitation was antennas. Another time it could be transmitter or frequency availability.

One can easily see that management of frequencies goes far beyond choosing correct operating bands for a given programme. Propagation, interference patterns and equipment availability all play their roles in allowing frequency diversity. The next step is to consider the equipment requirement.

Transmitted power

It is said, and rightly so, that one or two watts of transmitted power on the correct high frequency, if it is completely clear, will permit communication between such far-flung regions as the Middle-East and North America, Europe and Australia, or South America and the Soviet Union. This type of communication was successfully used by both broadcasters and radio amateurs in the early days of short waves. As time passed however, and more institutions began using the h.f. spectrum, the possibility of finding a completely clear frequency became increasingly difficult. The only alternative, once one is sure one is using the correct frequency, to finding a clear channel, is to increase the radiated power of the transmissions. In this way, the communicator can out-muscle other users of his frequency and achieve his end.

This situation has been developing in h.f. broadcasting over the past three decades and has now reached crisis proportions. The broadcasting bands are now so crowded that there can be up to ten listings on any one shortwave frequency. This makes for fierce competition and, ultimately, a transmitted power race.

Transmitted power is, of course, the result of two variables, the output power of the transmitter and the gain of the antenna. The product of these variables is the effective radiated power of a transmitting location. For example, a broadcaster could be transmitting a programme with a 250kW transmitter and an antenna with gain of 12dB. Since 12dB is an amplification factor of approximately 16, this means that the effective radiated power of the transmission is $250{,}000 \times 16 = 4$MW. This is mentioned just to illustrate the point which broadcasters have now reached in the power struggle. Where 1 watt of power was effective in the early '30s, we now require power in the order of 10 megawatts just to compete.

Broadcasters today are using antennas whose gains vary anywhere from 16 to 23 dB with the average being around 18 or 19 dB (amplification factors of 63 to 80). Radio Canada International is in the process of constructing one antenna array for each target area which will be of this magnitude.

At the same time, broadcasters are, little by little, increasing their transmitter power. Whereas in the 1950s, transmitters of 50 and 100kW were adequate, the 1970s and '80s will require 250 and 500kW transmitters. Already, most broadcasters are using 250kW and 300kW for their long-haul circuits (BBC, Voice of America, Deutsche Welle and Radio Netherlands among others are in the 500kW club) and 100 to 200kW for their shorter distance circuits. In the case of RCI, we have been using our new 250kW transmitters for European programmes and the old 50kW transmitters for our North American, South American and African circuits. Ideally, 500kW with 20dB antennas are needed for Europe, Africa and South America, while 250kW with 16dB antennas would serve North America.

Transmitter location (programme source)

The last of the engineering considerations involves the source of the transmitted programme.

As already discussed, the aim of a shortwave broadcasting service is to put the strongest possible signal into a target area. Good frequency selection and powerful and diversified transmitting equipment are two ways of accomplishing the objective. The third and perhaps most significant way to "out-muscle" competitors is to be within one "hop" of your target. That is to say the strongest shortwave signal occurs in the area approximately 1500-3000 miles from the transmitter. Depending on antenna specifications and the frequency chosen, this distance represents the landing area of a wave which has been transmitted upwards and has been reflected **once** from one of three or four layers of the ionosphere. Obviously, the mixture of good frequency selection, high transmitted power and proximity to the target will allow for the optimum received signal strength.

Larger organisations such as Voice of America, BBC and Deutsche Welle have used the "one-hop" formula to advantage by installing relay stations around the world which are a distance of one hop from the transmitter or from each other. RCI is not in a position, financially, to provide such a relay system for its listeners, although over the years, co-operation with the BBC and DW has resulted in relay exchanges with those broadcasters. This has resulted in a viable service to the USSR for RCI which, even with high power and good frequency selection, would not otherwise have occurred from Sackville.

Efficiency calculation

The purpose of this analysis is first to determine the degree to which a broadcaster is successful in overcoming the largely uncontrollable factors of ionospheric inconsistencies and interference caused by overcrowding of the shortwave bands, and second to produce a plan by which this degree of success can be enhanced by intelligent manipulation of resources.

We will use a system of weighting for the various factors over which we have some control in order to derive a formula which we can use to calculate a numerical efficiency which will indeed be a measure of our success in overcoming the odds. To put it more simply, how great a chance are we giving ourselves to place a competitive signal in our target areas? Further, how much greater can these chances be if we change a few things? These are the questions we hope to answer in this brief.

The controllable factors are those outlined in the preceding sections and can be listed as follows: programme timing (controllable, but constrained by operating finances, possible deployment of manpower and propagation); number of frequencies (controllable, but limited by equipment availability and band crowding); transmitted power (controllable, but limited by equipment availability, hence finances); and location of transmitters (programme source) (controllable, but subject to political and financial considerations).

We can assign points to these various factors in proper combination with one another. Programme timing can be measured against its "presence" within defined prime times locally. Number of frequencies and transmitter location in relation to target area must be considered together as they are directly related, as are transmitted power and transmitter location in relation to target area. The point system is constructed, then, as follows:

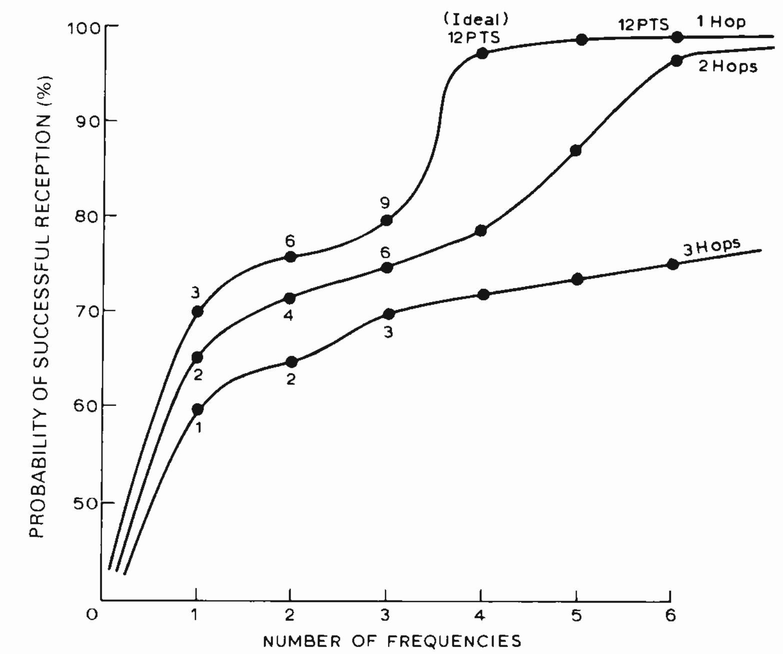


Fig. 2. Probability of successful reception vs. number of frequencies. (Power constant at 250kW).

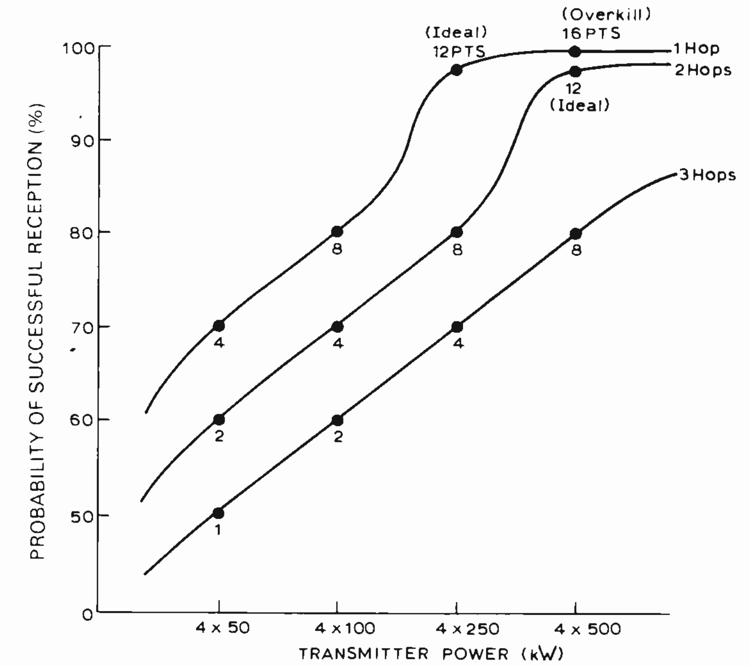


Fig. 3. Probability of successful reception vs. transmitter power. (Number of frequencies constant at 4.)

Programme timing ● 6 points are allotted if the target area service (by language) occupies a "presence" of 2 hours within prime time. ◗ 5 points are allotted if this "presence" is 1½ hours. ◗ 4 points are allotted if it is 1 hour. ◗ 3 points are allotted if it is ½ hour.

Frequencies transmitted as a function of programme source (Fig 2). ◗ 3 points are allotted for each frequency transmitted, one "hop" from the target (1,500-3,000 miles). ◗ 2 points are allotted for each frequency transmitted, two "hops" from the target (2,500-4,000 miles). ◗ 1 point is allotted for each frequency transmitted, three "hops" from the target (3,500-5,000 miles).

Transmitted power as a function of programme source (Fig 3). ◗ 4 points are allotted for each 500kW transmitter, one "hop" from the target. ◗ 3 points are allotted for each 500kW transmitter, two "hops" from the target; also each 250kW transmitter, one "hop" from the target ◗ 2 points are allotted for each 500kW transmitter, three "hops" from the target; also each 250kW transmitter, two "hops" from the target; also each 100kW transmitter, one "hop" from the target. ◗ 1 point is allotted for each 250kW transmitter, three "hops" from the target; also each 100kW transmitter, two "hops" from the target; also each 50kW transmitter, one "hop" from the target.

We can now define three specific measurable categories for our transmissions. These are: (A) Evaluation of individual programmes. (B) Evaluation of a language service to a target area. (C) Evaluation of the overall service (several languages) to a target area.

In category (A) only "frequency/source and power/source points" can be assigned as "programme timing" is based on overall language presence during prime time and therefore is not applicable to individual programmes. In category (B) all factors can be assigned and a language efficiency calculated. In category (C) all factors can be averaged and a target area efficiency can be calculated.

Definition of the "ideal" point total. In order to determine the efficiencies for categories (B) and (C) above, we must define an "ideal situation" combination of factors and hence, an ideal point total for these categories.

For programme timing, it is quite obvious that the ideal score is 6 in that we wish to achieve the two-hour "presence" per language within prime target area time. Any less would compromise the overall objective. The ideal point total is 6.

For the frequency/source factor, an ideal situation would constitute a four frequency service no more than one hop away. Frequency diversity can be used to lessen the effects of the ionosphere and band congestion. The provision of two frequencies in each of the two optimum bands, or two frequencies in one band and one in each of two others will provide an "ideal" situation. Naturally more frequencies one "hop" away would better the situation still further, but overall efficiency would vary only slightly for each frequency added (see Fig. 2). The ideal point total is 4 × 3 = 12.

For the power/source factor, the best situation would occur if each of the frequencies mentioned above were powered by a 500kW transmitter one "hop" away. This situation, however, is considered overkill, as the best use of 500kW is in 2-3 "hop" situations, or for emergency use in congested bands. We will therefore define the ideal as four 250kW transmitters one "hop" away from the target (see Fig 3). The ideal point total is 4 × 3 = 12.

The result of an addition of the three factors (programme timing, frequency/source, power/source) gives us an ideal point total of 6 + 12 + 12 = 30 points. This total we will use as a base for the efficiency calculations which follow.

An example .....

Calculate the efficiency of a shortwave service to Argentina from a transmitter site in Los Angeles, California. The plant consists of two 500kW and two 250kW transmitters and broadcasts

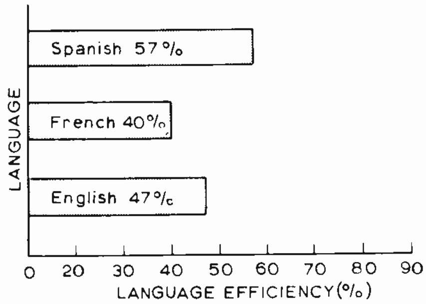


Fig. 4. Language efficiency target of Radio Canada International for North America.

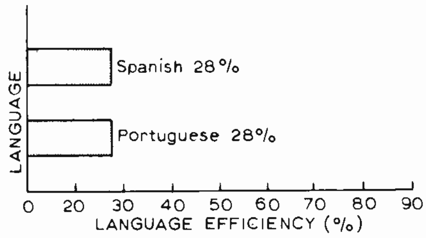


Fig. 5. Language efficiency target of Radio Canada International for South America and Caribbean area.

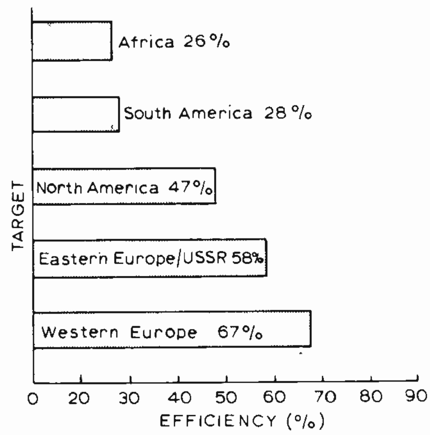


Fig. 6. Overall broadcasting efficiency of Radio Canada International by target area.

occur between 0730 and 0800 local time and between 1930 and 2000 local time.

..... and the solution —

Programme timing score: Both half-hour programmes are within the defined prime times so the total presence is ½ + ½ = 1 hour. Points for 1 hour presence are 4. (Ideal is 2 hours for 6 points.)

Frequency/source score: Argentina is two hops from Los Angeles. We will assume all four transmitters are used for both time periods. This would result in four frequencies, two hops away. Points then are 4 × 2 = 8. (Ideal is 4 frequencies, one hop away for 4 × 3 = 12 points.)

Power/source score: Argentina is two hops from Los Angeles. Assuming again that all four transmitters are used, we have two 500kW transmitters, two hops away for 2 × 3 = 6 points and two 250kW transmitters, two hops away for 2 × 2 = 4 points. Total power/source points then are 6 + 4 = 10. (Ideal is four 250kW transmitters, one hop away for 4 × 3 = 12 points.)

Totalling the points for each of the three factors gives us a grand total for the service of 4 + 8 + 10 = 22 points. The ideal total is 30 points. Thus the service efficiency is 22/30 × 100 = 73.3%.

Summing up

Many conclusions can be drawn from an analysis such as this. Once a level of efficiency has been calculated, a broadcast service can clearly see which of the four major parameters needs to be improved in order to reach the desired ninety to one hundred percent efficiency level.

Radio Canada International, for example, has found that the large number of languages (11) which it broadcasts, coupled with a relatively small number of transmitters (5 owned and operated) have combined to produce low scores in all but one of the key areas, programme timing, frequency diversity, transmitted power, and programme source. An overall efficiency level of forty-five percent was calculated for RCI. This factor, translated into equipment requirements means an additional seven 250kW transmitters are required at the Sackville plant together with associated antennas if current programme levels are to be maintained. These requirements, if maintained, would raise the overall efficiency level to the desired ninety per cent.

The calculation allowed RCI another means of increasing its efficiency. The number of languages broadcast or the number of target areas covered could be reduced, leaving the equipment at present levels. The overall effect would be that RCI would do a better job of broadcasting to fewer targets, thereby again achieving its ninety percent level.

A method, totally divorced from highly subjective audience surveys or inconclusive levels of audience mail, has been developed whereby a shortwave broadcasting organisation can measure itself. It is a device which has been sorely needed by broadcasters, whatever their size. How does your organisation rate?

George Jackson is head of the Engineering Department of Radio Canada International, a post he has occupied for three years.

Distortion in low-noise amplifiers

1 — Distortion analysis

by Eric F. Taylor, *Electrical Engineering Laboratories, The University, Manchester.*

The principles of low-noise circuit design are now well established and have been the subject of several articles in this journal, refs 1 & 2. In comparison the design of low distortion circuits has received relatively little attention. In this article distortion in feedback amplifiers is considered in detail with special reference to the distortion produced by the common-mode input signal in series feedback amplifiers. Distortion resulting from the exponential dependence of the collector current of a transistor on base-mitter voltage is also considered in detail, both theoretically and experimentally, and the analysis can be used to predict the effect of this non-linearity on the distortion performance of an amplifier.

In the second part of the article a preamplifier design will be described which embodies the design guidelines developed. Harmonic distortion, measured with magnetic pickup equalization, is less than 0.005% at all frequencies up to 20kHz and all overload levels up to 30 dB.

The inequality derived in the panel on page 31 expresses mathematically the requirement that a series feedback amplifier should have good common mode performance to minimize distortion. Unfortunately, design for good common mode rejection conflicts with the low-noise design requirements of operating the input transistors at low collector-emitter voltages.

Non-linearity due to common mode input

Operation of a transistor with a low collector-emitter voltage minimizes the noise due to leakage currents[1] but the transistor is obviously more sensitive to changes in the collector-base voltage (which occur as a direct result of a common mode input signal) than if the transistor were operated at a higher collector-base voltage. Changes in the collector-base voltage of a transistor manifests itself as a variation in the input base current and a common mode input voltage to a transistor amplifier therefore results in a common mode input current. The common mode input voltage and input current are related by common mode input admittance and it is the non-linearity of this which is primarily responsible for the distortion which arises from a common mode input signal.

The common mode input current would not be important if the source impedances seen by the inverting and non-inverting input of the amplifier were low or equal. However, in a series feedback amplifier designed for example for use with a magnetic pickup, the impedance seen at the non-inverting input is predominantly inductive whereas the impedance presented by the feedback network to the inverting input is normally kept low so that the equivalent noise voltage generator of the feedback network is small. At the higher audio frequencies therefore there is a serious mismatch in source impedances. Under these conditions the common mode input current can produce a significant differential mode input which is indistinguishable from the input signal. A common mode input voltage is also capable of producing a differential mode input current but with a serious mismatch of source impedances the effect due to the common mode input current will be dominant.

The variation of base current of a transistor with collector-base voltage has been investigated with the circuit shown in Fig. 1 in which, for convenience the collector base voltage is modulated by a transformer in series with the collector d.c. supply. Figure 2 shows the waveform observed at the base of the transistor due to a 20 kHz, 1.0 V r.m.s. sine wave modulation of the collector-base voltage, a modulation level which might well be achieved in a series feedback amplifier when driven by a magnetic pickup at high overload. The waveform was obtained with a quiescent collector-base voltage of 2.0V and a G800E magnetic cartridge used for Z_b to simulate the source conditions of a practical amplifier. Notice that the base voltage waveform contains a high proportion of distortion products and harmonic analysis shows that the total harmonic distortion (t. h. d.) referred to the 1.0V r.m.s. sine wave is 0.17%. If used as an input stage of a series feedback amplifier these distortion products would be indistinguishable from the input signal and no amount of feedback would reduce the t.h.d. of the amplifier to less than 0.17%.

The mechanism primarily responsible for the variation of the base current of a transistor with collector-base voltage is base-width modulation, otherwise

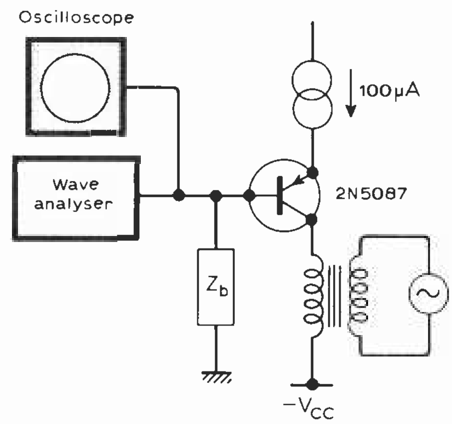
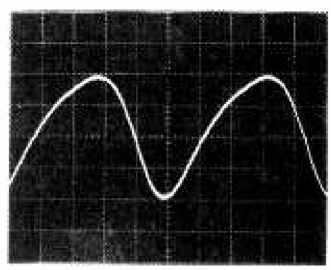


Fig. 1. Arrangement to investigate variation of base current of a transistor with collector-base voltage.



Vertical scale 5mV/div
Horizontal scale 10μs/div

Fig. 2. Voltage developed at the transistor base with a G800E magnetic pick-up cartridge used for Z_b. (Collector modulation 20kHz, 1.0V r.m.s. sinewave. V_{CB} 2.0V.)

known as the Early effect. Base-width modulation occurs because of changes in the width of the depletion layer of the collector-base junction as the collector-base potential is varied. Thus an increase in reverse bias causes the depletion layer to extend further into the base region of the transistor which reduces the effective base width and results in an increase in β because of increased base transport efficiency. The increase in width of the depletion layer is also accompanied by a decrease in the collector-base junction capacitance which varies according to

$$C \propto V^{-x}$$

where V is the reverse bias on the junction and x normally has a value between ½ and ⅓ according to the impurity profile across the junction.

The relative contributions of these two effects to the base current modulation have been investigated with the circuit shown in Fig 1 and the results are presented in Fig. 3 in which the fundamental and distortion products of the base current are plotted as a function of frequency for various values of I_c, and constant V_{CE} of 5.0V. At low frequencies base current modulation is independent of frequency but varies with collector current and it is reasonable to attribute this behaviour to variations in β of the transistor. At higher frequencies however base current modulation is independent of one collector current and approximately proportional to frequency which indicates that the collector-base capacitance is the dominant mechanism.

The break point in the characteristics at which the effects of the collector base capacitance starts to dominate over the effect of variations in β shifts to higher frequencies as the collector current is increased as would be expected if the mechanism described above are responsible for base current modulation. At the collector current levels normally encountered in the first stages of low noise audio amplifiers (10 to 100μA) and for frequencies greater than 500 Hz, the variation of the collector-base capacitance is primarily responsible for the distortion products present in the modulated base current.

Base current modulation has been plotted in Fig. 4 as a function of the quiescent collector-emitter voltage modulated by a 10 kHz sinewave. At this frequency and a collector current of 100 μA the collector base capacitance is the dominant base current modulation mechanism. Qualitatively the results agree with the prediction that base current modulation decreases with increasing V_{CE} and although a power-law dependence is indicated it has not been possible to obtain quantitative agreement with the distortion that would be expected from the non-linearity of the collector-base junction capacitance.

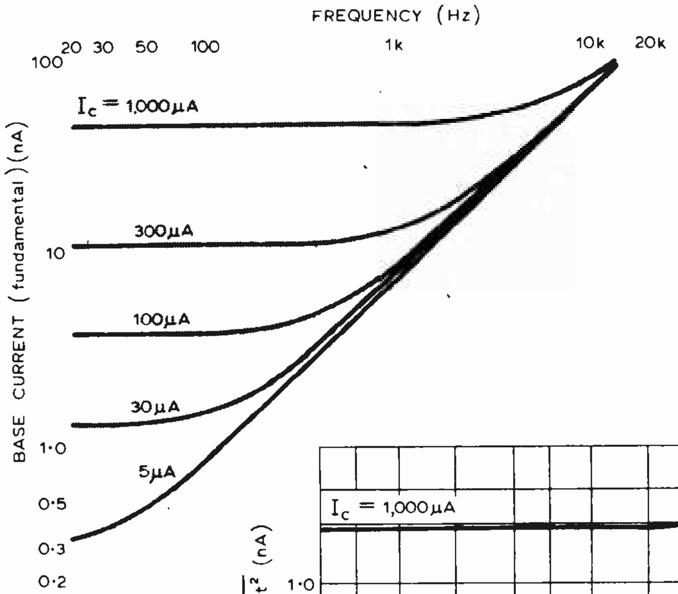


Fig. 3(a). Variation of the fundamental component of base current with frequency of the collector-base modulating voltage. (Modulation amplitude 1.0V r.m.s., V_{CE} 5.0V.)

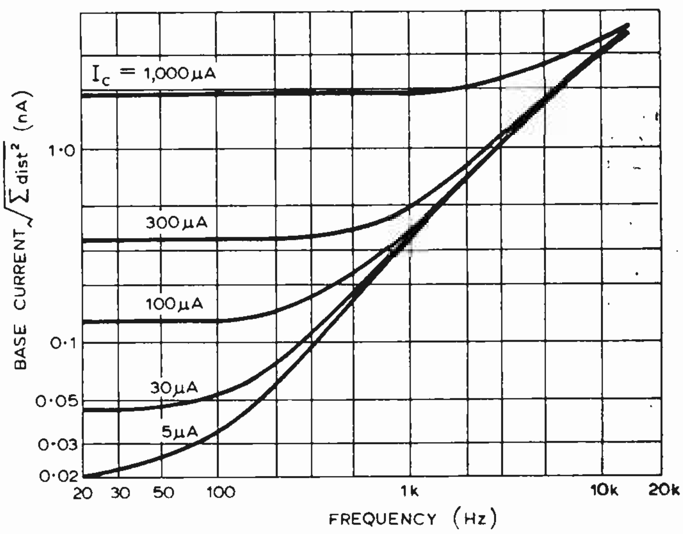


Fig. 3(b). Variation of the distortion components of base current with frequency of the collector-base modulating voltage. (Modulation amplitude 1.0V r.m.s., V_{CE} 5.0V.)

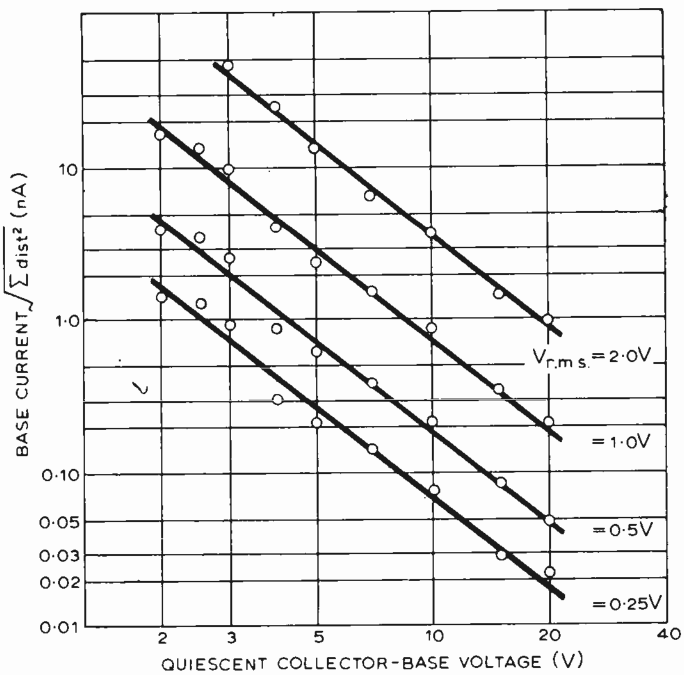


Fig. 4. Variation of the distortion components of base current with quiescent collector-base voltage. (Collector-base voltage modulation frequency 10kHz.)

Reduction of the common mode input signal

The common mode input signal present in a series feedback amplifier can produce distortion by generating harmonic components at the input which are indistinguishable from the input signal. Differential negative feedback can do nothing to reduce this type of distortion but common mode feedback can give an improvement. As the name implies common mode feedback uses the common mode output signal to reduce the common mode signal at the amplifier input. The application and advantages of common mode feedback, which is fully treated elsewhere,[4] will not be pursued in this article as a very simple technique for reducing the common mode signal which is more relevant to audio applications is to use the feedback connection shown in Fig. 5. In this connection the input signal is introduced in the feedback path of the amplifier so that the differential negative feedback subtraction process is performed external to the amplifier and the common mode signal at the amplifier input becomes identical with the common mode signal which occurs in the shunt feedback configuration. This circuit therefore has the overload capability of the shunt feedback connection but retains the noise performance of the series feedback connection.

This type of connection does of course require that the signal source is floating. Fortunately this is normally the case in audio applications as the use of series feedback can only be justified in pre-amplifier stages for use with low-level signal sources, e.g. magnetic pickup or tape head.

The pre-amplifier design which is presented in the second part of this article utilises series feedback and the input can be connected conventionally as shown in Fig. 6 or in the feedback path as shown in Fig. 5. With the amplifier equalized for a magnetic cartridge, the last-mentioned connection gives a reduction in t.h.d. by a factor of 40 at high frequencies and high overload levels.

Non-linearity of the differential mode gain

A voltage-driven transistor is an inherently non-linear device because of the exponential relation between collector current and base-emitter voltage. A more linear mode of operation results if the transistor is current driven, but as most audio signal sources approximate to voltage sources the distortion arising from the exponential relation of the input transistor of an amplifier can be significant. Large signal levels can also produce distortion because of the dependence of many transistor parameters on collector current and collector-emitter voltage but these problems can, with suitable design, be confined to the output stage of the amplifier.

Local negative feedback can be used to linearize the output stage of a pre-amplifier but this same technique cannot be used on the input stage without compromising the noise performance. Distortion due to the input stage is therefore a limiting factor in the gain linearity of a low noise pre-amplifier because in theory, if not in practice, the output stage can be made as linear as required simply by increasing the feedback. Information concerning the distortion resulting from the exponential i_c-v_{BE} characteristic of a transistor is therefore necessary to allow the ultimate distortion performance of a pre-amplifier to be predicted.

The distortion of a transistor can be found by expressing the collector current as a function of the input signal and then expanding the expression in a Fourier series which enables the distortion terms to be identified. Thus for the common-emitter stage shown in Fig. 6.

$$i_c = i_S \left| \exp\frac{e}{kT}(V_B + V\cos\omega t) - 1 \right|$$

$$\approx I_c \exp\frac{e}{kT}$$

where i_S is the reverse saturation current of b-e junction, e electron charge, k Boltzmann's constant, T temperature in Kelvins, and I_c quiescent collector current.

This equation now has to be expanded as a Fourier series by writing

$$\exp\frac{e}{kT}(V\cos\omega t)$$

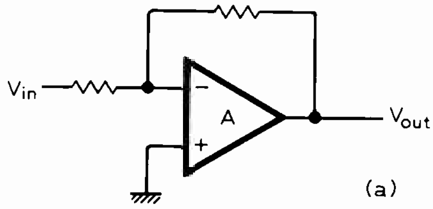
$$= a_0 + a_1\cos\omega t + a_2\cos 2\omega t + \dots$$

Unfortunately this expression cannot be solved analytically and it is necessary to resort to numerical methods.

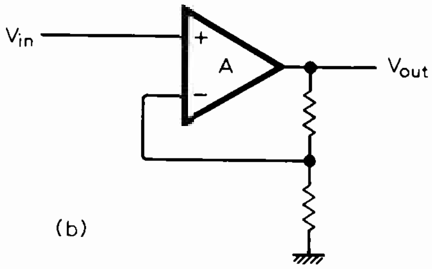
The method adopted takes the first ten terms of the Fourier series and gives $\cos\omega t$ ten equally spaced values between 0 and 1.0 thus enabling a set of ten simultaneous equations with ten

Use of feedback

Negative feedback can be applied to an amplifier by feeding back to the input an antiphase current or voltage which is derived from the output. The inverting amplifier shown in Fig. (a) uses current feedback in what is generally referred to as a shunt feedback configuration, whereas the non-inverting amplifier in Fig. (b) uses voltage feedback in a series feedback configuration.



(a)

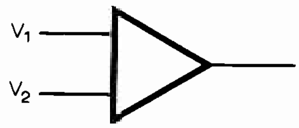


(b)

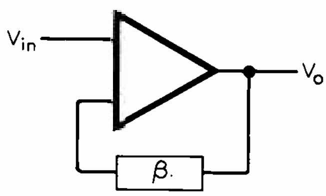
The relative merits of shunt and series feedback in low-noise pre-amplifiers has been the subject of many letters to this Journal.[3] Walker has shown conclusively[1] that with the source impedances associated with a magnetic cartridge, the thermally limited signal-to-noise ratio of the series feedback connection is 13.5dB better than that of the shunt feedback connection. It is generally agreed, however, that the shunt feedback connection has a better overload capability, i.e. lower distortion at high signal levels.

The inferior overload capability of the series feedback connection is a result of the large common mode signal which appears at the amplifier input terminals with voltage feedback but which is not present in the shunt feedback connection. To understand the effect of this common mode signal on the amplifier performance it is necessary to characterise the amplifier by a differential gain A_d and a common mode gain A_c. Thus for the basic amplifier shown in Fig. (c) the output voltage is

$$V_0 = A_d(V_1 - V_2) + A_c(V_1 + V_2)$$



(c)



(d)

If series negative feedback is now applied to the amplifier as shown in Fig. (d) this equation becomes

$$V_0 = A_d(V_{in} - \beta V_0) + A_c(V_{in} + \beta V_0)$$

$$\therefore A_f = \frac{V_o}{V_{in}} = \frac{A_d + A_c}{1 + \beta(A_d - A_c)}$$

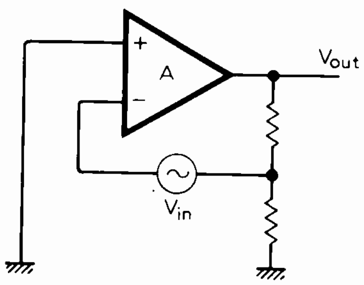


Fig. 5. Series feedback connection with reduced common-mode input signal.

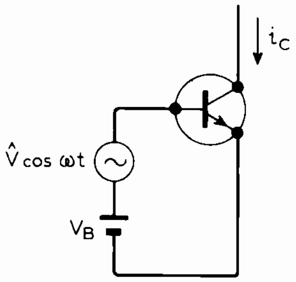


Fig. 6. Equivalent circuit used for distortion analysis of a common-emitter stage – see Fig. 7, curve (g).

where A_f is the closed loop gain. The equation for V_0 can be rearranged in the form

$$V_o = A_d V_{in}\left[\frac{1-2\beta A_c}{1+\beta(A_d-A_c)}\right]$$

$$+A_c V_{in}\left[\frac{1+2\beta A_d}{1+\beta(A_d-A_c)}\right]$$

which allows the differential mode signal V_d and the common mode signal V_c at the amplifier input to be identified in terms of the signal input voltage V_{in}. Thus

$$V_d = \frac{(1-2\beta A_c)V_{in}}{1+\beta(A_d-A_c)} \approx \frac{V_{in}}{1+A_d\beta}$$

$$V_c = \frac{V_{in}}{2}\left[\frac{1+2\beta A_d}{1+\beta(A_d-A_c)}\right] \approx V_{in}$$

The approximations in these two equations make the assumptions $A_d\beta \gg 1$, $A_d \gg A_c$ and $2A_c\beta \ll 1$. Comparison of the two equations shows that in an amplifier with series negative feedback the common mode signal is approximately equal to the input signal and is greater than the differential mode signal by a factor $(1 + A_d\beta)$. In an amplifier with a high differential gain and a large amount of negative feedback the common mode signal can therefore be very much greater than the differential mode signal and the effect of the common mode gain on the amplifier performance may not be insignificant despite an apparently high common-mode rejection ratio.

The effects of non-linearities in the differential and common mode gains on the closed-loop gain can be found by partial differentation of the equation for A_f which gives

$$\frac{\partial A_f}{\partial A_d} \approx \frac{1}{1+A_d\beta}\cdot\frac{A_f}{A_c} \text{ and } \frac{\partial A_f}{\partial A_c} \approx 2\frac{A_f}{A_d}.$$

The approximations make the same assumptions as before. Using the relation

$$\delta A_f = \frac{\partial A_f}{\partial A_d}.\delta A_d + \frac{\partial A_f}{\partial A_c}\delta A_c \text{ gives}$$

$$\frac{\delta A_f}{A_f} = \frac{\delta A_d}{A_d}\cdot\frac{1}{1+A_d\beta} + \frac{2A_c}{A_d}\cdot\frac{\delta A_c}{A_c}$$

This equation gives the well-known result that differential negative feedback reduces the effect of changes in differential gain on the closed-loop gain by a factor $(1 + A_d\beta)$. However, differential negative feedback has no effect on the non-linearity of the closed-loop gain due to changes in the common mode gain and the resulting distortion ultimately limits the closed-loop performance of the amplifier. Thus, if the non-linearity of the common mode gain is of the same order as the non-linearity of the differential mode gain, any increase in differential negative feedback is only worthwhile in reducing distortion provided

$$1 + A_d\beta < \frac{A_d}{A_c}$$

In a practical amplifier design the useful limit of negative feedback will probably be reached well before this as some consideration will have been given to obtaining a linear differential gain characteristic.

unknowns to be generated. The solution of these equations is relatively painless with a digital computer and the Fourier coefficients have been evaluated for values of the peak input signal amplitude, $\hat{V}$, incremented in 1.0mV steps up to a maximum of 25mV. The t.h.d. is then readily calculated from the Fourier coefficients and the results of this analysis are presented graphically in Fig. 7(g). Experimental points plotted on the computed curve were determined from measurements made with a Marconi Instruments wave analyser type TF2330A on a 2N5087 transistor operating at a collector current of 100μA. There is excellent agreement between the theory and the experimental results.

Fig. 7(g) clearly confirms that the transistor is an inherently non-linear device; even with input signal amplitudes as low as 1.0mV the t.h.d. is 1% whereas at 10mV the t.h.d. has risen to 10%. The application of this distortion characteristic to the prediction of the distortion performance of an amplifier is perhaps best explained by an example. Consider an amplifier with a common-emitter input stage designed for a maximum output level of 2V peak with an open-loop gain of 2000 and a closed-loop gain (with feedback) of 200. Under these conditions the differential input signal to the amplifier is 1.0mV and the distortion generated in the input stage is, from Fig. 7(g), 1%. The amplifier has a loop gain of 10 and as feedback reduces the distortion by a factor $(1+A\beta)$, the distortion of the amplifier with feedback will be approximately 0.1%.

If better distortion performance is required the simplest design change is to increase the open-loop gain which, in addition to increasing the amount of feedback available to correct the overall non-linearity of the amplifier, reduces the input differential signal with a corresponding reduction in input stage distortion. (The effect of increasing the open-loop gain on the amplifier distortion is analysed in more detail in Appendix 1). Ultimately, however, the maximum open-loop gain is limited by stability requirements and the distortion cannot be reduced indefinitely. In any case if very low distortion is the primary specification of an amplifier a better approach is to design for low inherent distortion rather than to try and straighten everything out with negative feedback.[5]

An alternative to the single transistor input stage is the two transistor long-tailed pair input stage. This type of transistor configuration has the advantage of being symmetrical so that

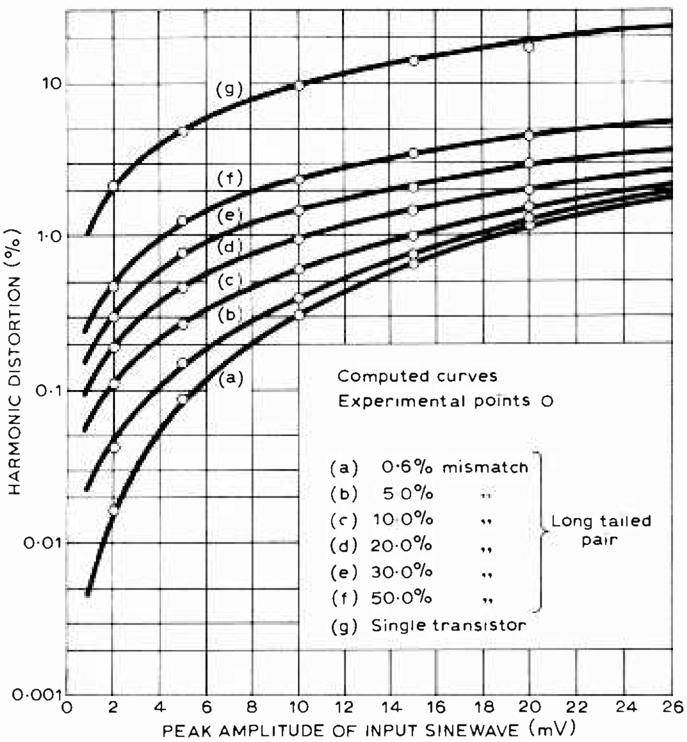


Fig. 7. Distortion curves calculated from coefficients in Fourier expansion of collector current as a function of input signal. Experimental points were measured on 2N5087 transistors with circuits of Figs. 6 and 8.

even-order harmonics are not generated and therefore second harmonic distortion, which is the predominant distortion component in the case of a single transistor, is eliminated.

Analysis of the long-tailed pair stage shown in Fig. 8 is given in Appendix II and the relation between collector current of Tr_1 and input signal has been Fourier analysed using a similar technique to that used for the single transistor stage and the results are presented in curves (a) to (f) of Fig. 7. If the collector currents of Tr_1 and Tr_2 are equal, i.e. $\lambda = 1$, second harmonic distortion is virtually eliminated and for input levels of less than 3mV the distortion is two orders of magnitude lower than that of a single transistor. Thus if a balanced long-tailed pair stage were substituted for the single transistor input stage in the design example previously described the t.h.d. would now be 0.0004%, a very respectable performance considering the small amount of feedback employed.

An interesting point which emerges from the analysis is that distortion is independent of the V_{BE} match between the transistors and this is confirmed by the close agreement between the computed curves and experimental points which were obtained using two transistors deliberately selected from a batch for the largest V_{BE} mismatch, the mismatch being 24mV at I_c of 100μA and V_{CE} of 5.0V. Matching of the collector currents however is essential to obtain the lowest distortion. Examination of the harmonic content of the collector current shows that the increase in distortion as the collector currents are progressively mismatched is due, almost exclusively, to increased second harmonic generation.

The experimental points plotted on the computed curves of Fig. 7 were obtained from measurements performed at 10kHz but further experiments have verified that the results are valid over the whole audio frequency range.

To be concluded

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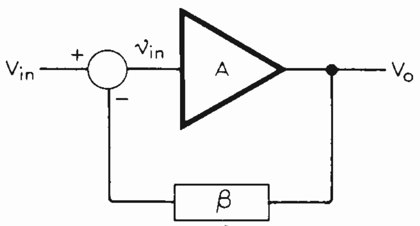
Appendix I — Effect of differential negative feedback on amplifier distortion

Consider an amplifier with a non-linear gain A which can be expressed in terms of the input voltage V_{in} by the Maclaurin series.

$$A = A_0 + v_{in}\frac{dA}{dv_{in}} + \frac{v_{in}^2 d^2A}{2!dv_{in}^2} + \ldots \quad (1)$$

If this amplifier is now incorporated in the feedback configuration shown in Fig. A1 the



closed-loop gain A_f can similarly be expressed as a Maclaurin series of the form

$$A_f = A_{0f} + v_{in}\frac{dA_f}{dv_{in}} + \frac{v_{in}^2 d^2A_f}{2!dv_{in}^2} + \ldots \quad (2)$$

$$\text{Now } A_f = \frac{A}{1+A\beta} \quad \therefore \frac{dA_f}{dA} = \frac{1}{(1+A\beta)^2}$$

$$\text{So that } \frac{dA_f}{dv_{in}} = \frac{dA_f}{dA}\cdot\frac{dA}{dv_{in}}$$

$$= \frac{dA}{dv_{in}}\frac{1}{(1+A\beta)^2} \quad (3)$$

$$\text{Also } \frac{d^2A_f}{dv_{in}^2} = \frac{d}{dv_{in}}\left(\frac{dA_f}{dv_{in}}\right) = \frac{1}{(1+A\beta)^2}\cdot\frac{d^2A}{dv_{in}^2} - \frac{2\beta(dA/dv_{in})^2}{(1+A\beta)^3} \approx \frac{1}{(1+A\beta)^2}\cdot\frac{d^2A}{dv_{in}^2} \quad (4)$$

Substituting equations 3 and 4 in 2 gives

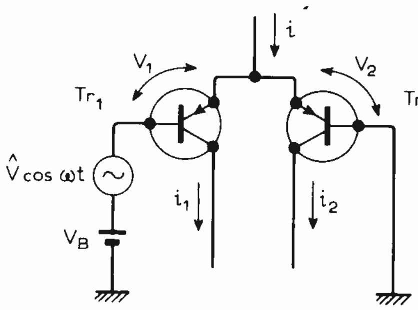
$$A_f = \frac{1}{1+A\beta}\left| A_0 + \frac{v_{in}}{1+A\beta}\cdot\frac{dA}{dv_{in}} + \frac{v_{in}^2}{2(1+A\beta)}\cdot\frac{d^2A}{dv_{in}^2} + \ldots \right|$$

Comparison of this with equation 1 shows that the effect of negative feedback has been to reduce the coefficients of the terms of the power series representing the non-linearity by a factor $(1+A\beta)$ compared with the open-loop configuration.

Increasing the open-loop gain of a feedback amplifier is therefore doubly beneficial in the case of distortion which is dependent on the amplitude of the differential input signal e.g. distortion associated with the exponential $I_c V_{CB}$ characteristic of the input transistor(s); not only is the input differential signal reduced but the amount of feed-back available to correct for non-linearity is increased.

Appendix 2 — Analysis of the long-tailed pair

The collector currents of a long-tailed pair (Fig. A2) are



$$i_1 = i_{s1}\left| \exp\frac{eV_1}{kT} - 1 \right| \approx i_{s1}\exp\frac{eV_1}{kT}$$

$$i_2 = i_{s2}\left| \exp\frac{eV_2}{kT} - 1 \right| \approx i_{s2}\exp\frac{eV_2}{kT}$$

$$\therefore \frac{i_1}{i_2} = \frac{i_{s1}}{i_{s2}}\exp\left| \frac{e}{kT}(V_1 - V_2) \right|$$

$$= \frac{i_{s1}}{i_{s2}}\exp\left| \frac{e}{kT}(\hat{V}\cos\omega t + V_B) \right|$$

When $\hat{V} = 0$, i.e. in the absence of any signal input, let $i_1/i_2 = \lambda$. Then

$$\frac{i_1}{i_2} = \lambda\exp\left| \frac{e\hat{V}\cos\omega t}{kT} \right|$$

But $i_1 + i_2 = i$

$$\therefore i_1 = \frac{i\lambda}{\lambda + \exp - \left| \dfrac{e\hat{V}\cos\omega t}{kT} \right|}.$$

News of the Month

Geos: disappointment and despair

Deep disappointment is being expressed at the failure of the Geos launch following a malfunction in the McDonnell Douglas Thor Delta 2914 rocket during the April 20 launch. Some months after the event European Space Agency scientists are trying to salvage what they can from what would have been a two-year programme.

Geos was to have been the world's first purely scientific geostationary satellite, and ESA's first geostationary satellite. But the rocket began to gyrate after the launch from Cape Canaveral's Eastern Range, losing energy, so the craft went into a lower transfer orbit than intended. Its final orbit, after the firing of the apogee motor to effect the transfer from the transitional orbit, is a highly eccentric 12-hour orbit between 2,000 and 38,000 km above the earth. The planned 24-hour orbit at 36,000 km would have enabled round the clock observation of the data coming into the new ESA ground station at Odenwald from the seven groups of experiments aboard.

The current final orbit was chosen to protect the 7,200 solar cells, marshalling 124W, which were being damaged by particle radiation. There is now a danger that, in the satellite's new position, the circuitry inside the craft, particularly the c.m.o.s. i.c.s., may be damaged by electron bombardment and magnetic storms.

ESA sources stress that the satellite itself, built by the ten-country STAR consortium led by the British Aircraft Corporation, is working perfectly. All seven experiments are supplying data, though its value is reduced because the craft is not in the position that they wanted to measure, the night-time side of the magnetosphere near the earth's aurora, and the data coming back is only available during an eight-hour window. If the scientists want to make measurements in the correct region they will have to wait until the earth moves round the sun to the correct position, which will not happen until next March or April. There was, at one time, some doubt as to whether the satellite could last longer than six months because of the hostile environment in which it is now working. However, ESA are fairly optimistic that they will be getting information from the satellite for at least a year. In addition, had the Geos programme been fully successful, there would have been another mission, this time on ESA's own Ariane rocket, using the flight spare from this mission to carry out experiments in a similar orbit to that now forced on the original satellite, so the information coming back is of some value. Nevertheless it is not backed up by data from a successful Geos mission.

The seven Geos experiments were designed to measure magnetic, electric and particle fields at various fixed longitudes in the Earth's outer magnetosphere. Before the launch ESA said it "will improve our knowledge of the behaviour of the Earth's magnetosphere when perturbed by particles emitted in solar flares. It will also provide a unique opportunity for magnetospheric-ionospheric conjugate experiments." The Geos was to have been used as the reference satellite for the International Magnetospheric Study (IMS), a three-year research programme with experiments launched on sounding rockets, balloons, spacecraft and aircraft by America, Europe, Japan and the Soviet Union.

What is remarkable about the Geos experiments is that the fields they are examining are so weak: the instruments aboard can detect magnetic variations, for instance, one thousand millionth of the strength of the Earth's magnetic field. Indeed, one of the difficulties of designing Geos was that the experiments would interfere with one another. For that reason, once in orbit, Geos sprouted four axial, two long radial and two short radial booms each carrying different sensors. Thus each experiment has least effect on its fellows. The long radial booms carrying the two electric sensors, for example, are 25m long, and had to be extended over a period of a fortnight.

A decision will be taken in September on whether or not to launch a second Geos, depending on whether the money can be found — the NASA contract frees NASA of any liability and the satellite was not insured — and bearing in mind that the next launch date would be at around the same time as Geos I will prove most useful, Spring next year.

A spokesman for one of the experimenters said that he thought the rocket malfunction was "fishy". The launches of ESA and other satellites planned for this year have had to be rescheduled by NASA following damage caused in May to another American Delta rocket, allegedly by a sheared bolt. This has affected ESA's Orbital Test Satellite (OTS), which was ready for luunch on June 16. The spokesman said it was strange that these accidents should be happening in a launcher which had had so much success in the past.

IEE urges Home Office to discuss spectrum allocations in open forum

Saturation of frequency bands up to at least 20GHz may be approached in the next ten years, the Institution of Electrical Engineers says in a report to the Home Office on the use of the radio spectrum. "This is a major matter of public concern and steps should be taken to widen the recognition and understanding of this problem beyond those directly concerned with the allocation of this resource." The IEE proposes that, to overcome the shortage, users should no longer have the right to assume that, once allocated, a frequency or set of frequencies is theirs in perpetuity. "Assignment of frequencies should be carried out in a similar way to the leasing of land. Any frequency assignment would be made for, say, ten to 30 years . . . but reviewed every, say, five years . . ." Charges could be levied depending on location in the spectrum, aerial coverage, radiated power, time-bandwidth product and nature of service. The revenue could be used to develop and, if necessary, replace equipment.

The IEE also recommends that "the problems of frequency allocation should be considered in open forum by an advisory body which comprises sufficient independent members to provide a wide range of expert opinion." The body would have six tasks.

- To review demands for radio services,
- To review technical developments which might alter the use of the spectrum,
- To recommend long term policies on spectrum use,
- To show how long and short term use of the spectrum can be balanced,
- To say what research could help make better use of the spectrum. The report adds that international bodies like the International Telecommunications Union could encourage other countries to take much longer term view of the allocation of radio frequencies.

The Institution stresses that land mobile radio is one of the most important parts of the radio service: "It can be argued that this is the major service for which complete justification of spectrum allocation can be made." The report also says: "Mobile Services and navigational aids should have a high priority compared to services such as broadcasting to fixed locations where alternatives to radio communication, like cable transmission, are available." Television should abandon the frequencies between 41 and 68 MHz (Band 1) in favour of the mobile services, though these might have to share frequencies with rural radio services. Band 2, however (87.5 to 100MHz) should be allocated exclusively to f.m. sound broadcasting because of congestion on medium wave and the expanding needs of education, but the broadcasters should, in general, be more ready to share channels. "Cable is not at present a viable alternative for nationwide coverage," though it could be considered an alternative means to distribute sound programmes in towns. "It would be technically possible to accomplish most tv broadcasting by cable, including optical fibre, but it would not be economically feasible in the near future. If the demand for frequencies ultimately forced a change to cable for tv the change would be most practicable in urban areas where the requirements for frequencies for mobile services is (*sic*) also most acute. The freeing of spectrum for mobile services in urban and suburban areas, while still providing a broadcast service in rural areas, will provide a severe challenge for the planners of the future. Meanwhile cable is likely to be the means of providing additional services without making extra demands on the spectrum." Where cable is suitable its use should be encouraged if it will be economic in the long term.

The report was initiated by the IEE Electronics Divisional Board long before the Home Secretary asked for submissions on the 1979 WARC. But although work began a year ago the authors seem pleased that its publication coincided with submissions from other sources as part of a widening campaign for more openness in the Home Office. The report contains no information about its authors, at least one of whom did not want to be named, and this may tend to weaken its argument about more open transactions elsewhere. However, at the meeting to publish the report some of its authors did identify themselves. The chairman of the working party was Mr Charles Sandbank of STL, and its membership included Mr Charles Hughes of Post Office Research, Mr David Withers, also of the Post Office, and Dr Kenneth Milne of Plessey. Total permanent membership was nine, with two or three occasional additions. The BBC, for example, say they took part in only one meeting.

At the meeting Mr John Brinkley of Redifon said the leasing idea held dangers for radio users, and Mr James Redmond, the director of BBC Engineering, said he would be taking it very seriously because, if adopted in whatever form, it would cost the Corporation a lot of money. This recommendation seems likely, then, to cause some controversy.

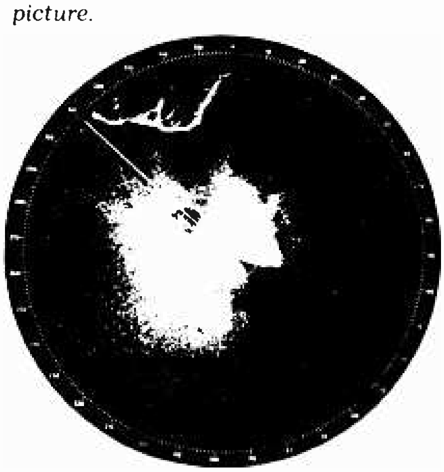
But the reaction to the proposal about openness was universally welcomed. Mr Sandbank told *Wireless World* that the working party had encountered "strong feeling" in favour of the open forum approach to both frequency allocation in this country and on the British attitude to the World Administrative Radio Conference. He said those in favour of opening up the discussion had been very vociferous.

Radar: without clutter, and with better legibility

Forty years after Watson-Watt helped to develop radar its marine users are beset by six main problems: sea clutter, caused by reflections from rough seas or patches of shallow water; rain clutter; radar interference from other vessels; receiver noise from the user's own ship, giving poor contrast; weak echoes, faint at any range and hard to see; and small echoes, which are difficult to see at long range. Some of these can be overcome by the now standard provision of manual gain, sea clutter and rain clutter controls. However, these need constant and skilled adjustment, and all echoes may be reduced in level, some being lost entirely.

Now Decca have developed a new radar technique called Clearscan which appears to reduce these considerably.

Photographs show the improvement obtained with Decca's new Clearscan radar circuitry. Above, the improved picture.



To begin with the sea and rain clutter are reduced by electrically disconnecting the normal gain, sea clutter and rain clutter manual controls. The gain of the video amplifier now has an adaptive signal superimposed upon it. The signal is slow acting but, according to Decca, "generally follows the shape of the clutter returns on the incoming video while being largely unaffected by the normal wanted signals from ships, navigational marks and coastlines." In effect the adaptive signal varies with the amount of clutter about. Large blocks of echoes are thus broken up. This thins the coastline, but enables the navigational features to be picked out. The slow response of the adaptive signal is such that it has to be supplemented by a further signal to reduce clutter in the first mile. This is derived from the amount of the clutter on the previous radar pulse.

The next step, the VP2 circuitry, is to make reductions in the other causes of illegibility. First, receiver noise is suppressed by a threshold circuit. Second, signals above the noise threshold are amplified to a nearly-uniform brightness level, causing weak echoes to become almost as bright as strong ones. Interference is then removed by pulse correlation circuits which compare succeeding echoes with the stored previous echo. Only echoes shown on both and at the same range are displayed. This filters out interference from transmissions by other ships, since these do not usually occur at the same range on successive pulses.

Finally, to make small echoes more discernible, particularly on the long-distance ranges, any pulses longer than half a microsecond beyond 2.5 miles are enlarged by the addition of an internally-generated artificial pulse to the real one.

The basic circuitry is added to the equipment merely by replacing the existing video board with one which contains the normal video amplifier and a marine radar processor which contains the appropriate automatic circuitry. This will be standard on all new equipment. The VP2 is an optional extra, available from early next year, say Decca, for around £500. Existing equipment can be adapted, but the VP2 is not available by itself.

APRS attracts even more visitors

Each year the elaborateness of concert sound reinforcement equipment, particularly that used by rock groups, approaches what has been taken for granted in recording studios for a long time. This becomes rapidly apparent as you walk round the exhibition organised by the Association of Professional Recording Studios. This year's, held at the Connaught Rooms on June 15 to 17, was the tenth. Cadac, for example, had a photograph on their stand of a mixing console they had built for live performances by Jethro Tull that would do credit to any studio, and the thought occurs that moving such equipment around must be difficult and costly, especially when the power levels used, according to an engineer on the Gauss stand, are typically around 10kW for a Pink Floyd concert. Gauss have long specialised in high power speaker equipment. Their design includes a cone suspension that seems unique to this company in that there are two spiders, separated by a light spacer, so that the cone is supported at three places instead of the normal two. This means that the speakers are much easier to assemble, and that the cone is more stable, according to Cetec Audio, who import the speakers. Just as last year, they were also showing the 1200 series tape duplicating system, also from Gauss.

In contrast with the sound reinforcement equipment, that used by the broadcasters seems to grow more compact in certain applications. Alice, for example, were showing a portable mixer with six channels and two groups which measured only 0.5m by 0.4m, yet it managed to combine microphone or line inputs, three equalisation ranges, echo or foldback send and panning on each input channel, and limiting with variable threshhold and bypass on the outputs. There is an internal power supply which Alice say has a 400% current overload margin. It's also well-finished and thoroughly British.

Tweed Audio were showing similar mixers. Some of those on the stand were already marked out for delivery to such customers as radio Monte Carlo and Border TV, and other orders are coming from Tyne Tees and Yorkshire TV, they say. While Alice have been making mixers for many years, however, Tweed's product has been around for less than a year, and the firm is making only its third appearance at APRS. They are now also moving into the test equipment market, and were showing for the first time a microvolt meter with IEC, DIN, CCITT and CCIR filters, average, true r.m.s, peak and slow reading. Its range is between $110\mu V$ and 110V and there is a self calibration facility and outputs for oscilloscope and pen recorder. Tweed say they will next produce a low distortion oscillator.

Another instrument on show, this time by Court Acoustics, was a real time spectrum analyser, the RTA C2. This is a suitcase design with an l.e.d. display showing relative levels at 28 points along the frequency scale from 31.5Hz to 16kHz at 1/3 octave intervals. Eleven levels are shown. In addition there is a full range l.e.d. meter which reads r.m.s. or p.p.m. for voltage (dBm) or sound pressure level measurements. There are two line and one microphone inputs, and a built in pink or white noise generator which can drive either speakers from an internal amplifier or a balanced line.

The 1977 show was an occasion for looking back as well as forward, since this year is the 100th of recorded sound. For many the industry has become obsessed with technology at the cost of the musical content. The technical distance covered was well-illustrated on the Neve stand, where they also looked back, but only fifteen years, to the first console they built. This was displayed with the information that it had been bought by Recorded Sound Ltd, which about five years ago changed its name to Nova Sound. Neve say that to date their consoles have been sold into 58 countries. In contrast they also showed the Neve Computerised mixer, which we described in March, 1977, p.39.

AKG, at their first APRS since the recent management changes, showed a number of new products, including a two-diaphragm, variable-pattern condenser microphone; a series of multichannel mixers and a new portable model, the SM2000, in six and 16 channel versions; and a family of five new disc cartridges.

BASF seemed to be going all out to promote their Unisette quarter-inch tape cassette. As always in such a case their main difficulty is in providing the machines in which the cassettes can be used, but such a machine was on display on the BASF stand. The Unimatic machine, shown for the first time in the UK, was made by Nordisk.

Among the tape machines on display was a bright yellow multitrack from Telefunken, available from Hayden Laboratories. The M15A can accommodate up to 32 tracks and a built-in Telcom C4 compander, but the model on show was a quarter-inch version.

Easy tape location is now a standard requirement in studios, either from add-on locator units, or built in. The Studer A80, for example, shown by F. W. O. Bauch, is a well-established machine, with an automatic tape position locator. A less well-known name in studio than in broadcast and semi-professional use is Technics, a National Panasonic brand name. They were concentrating on showing disc turntables, amplifiers and cassette machines from their 1977 range, but they did show the RS1500 reel to reel machine, a three speed, three motor unit with an iso-loop capstan and head layout which may be familiar to those who have watched 3M professional tape machines over the years. National say the RS1500 has a wow and flutter figure of 0.018% r.m.s. at 38cm/s. Certainly it was very effectively demonstrated at a recent seminar in Japan.

To commemorate the centenary the organisers had arranged an exhibition of items borrowed from the London Science Museum, some with spoken commentaries giving examples of the sound from the early sound machines, such as the voice of Florence Nightingale. This appears to show a change, however slight, in the organiser's policy of discouraging any activity which might siphon potential customers away from the exhibition. The APRS committee has even got as far as discussing whether or not to change the venue in future to a place where they could also present papers, a development that many would welcome, and would go some way to convincing the APRS's critics that it was interested in more than delivering customers to the manufacturers.

That the show was well-attended is shown by the fact that the catalogue was sold out by the third day. APRS committee chairman Jacques Levy told *Wireless World* that he estimated the number of foreign visitors at over a quarter of the total, some 2,400. Last year the number of foreign visitors was about 14%, then a record. This year's visitors saw over 80 exhibitors on more than 100 stands. For the recording industry the APRS is still, as one exhibitor put it, "The only major exhibition in this country".

"Blumlein lived here"

The first electronics engineer to be honoured with a "lived here" plaque is the prolific Alan Dower Blumlein, 1903-1942, inventor of stereo recording and reproduction, a form of negative feedback pre-dating Black, the cathode follower, the so-called "Miller" integrator, the inductively-coupled ratio-arm bridge, the long-tail pair — which are only a few of his 128 patents. The blue and white plaque was put up by the Greater London Council on Blumlein's one-time home at 37 The Ridings, Ealing, and was unveiled on June 1 by Sir Alan Hodgkin, Fellow of Trinity College, Cambridge, who had worked with Blumlein on radar during the 1939-45 war.

Most of Blumlein's inventions were made while he was working for EMI (which he joined in 1929 as the Columbia Gramophone Company) and it was EMI who organized the unveiling ceremony. They say they hope the plaque "will belatedly bring to the public's notice Blumlein's historic achievements in the field of electronics." The whole event was the result of a petition to the GLC by Mr F. P. Thomson, a one-time colleague of Blumlein at EMI, who is writing a biography of the inventor.

Blumlein was killed in an aircraft accident in 1942 while testing an H_2S radar prototype. A full account of his work was written by M. G. Scroggie, "The Genius of A. D. Blumlein" in September 1960 issue, pp.451-456.

We record the death of Percy Wilson, long associated with the *Gramophone* and an early audio experimenter and writer. He was responsible for what is recognised as the first book on audio, "Modern Gramophones and Electrical Reproducers," written in 1929 with G. W. Webb. He was born in Halifax on March 8, 1893, went to Oxford and had a distinguished career in the Navy, during the first World War, at the Board of Education and at the Ministry of Transport. He was technical adviser to the *Gramophone* from its founding in 1924 until 1938 and technical editor from 1953 to 1966. He was a leading figure in the Audio Engineering Society, the British section of which he chaired when it began. He was made an honorary member of the AES in 1972 and was on the Awards Committee for several years. He leaves a widow, Winifred, and two sons.

EEA soldiers on — courtesy of the USSR

The latest annual report of the Electronic Engineering Association underlines the heavy reliance of the industry on military contracts. No detailed figures are available, but unofficial estimates put the proportion of EEA members' total sales of capital equipment for military use at around a quarter. The proportion of radio and radar equipment thus sold is much higher.

The annual report for 1976 stresses that, like the other European countries and America, "much of our industry relies heavily on defence work to advance the state of the art." A recent agreement between the US Department of Defense and our Ministry of Defence enabling British manufacturers to sell to the American market means that the dependence of those manufacturers on defence projects is likely to increase. Even though British military projects, in the words of the report, "bear more than their fair share of public expenditure cuts," it concedes that the electronic content of British defence spending is increasing, and the industry is anxious that imports of defence equipment be avoided where possible.

As a supplement to the main report EEA has published a statistical analysis of the industry's performance during last year. Sales in every sector increased and, though once again no figures are available, military spending overshadows the accounts. "The value of exports," the report says of the Aerospace industry, "of complete new aircraft remained at just over £103 million, but home deliveries of aircraft and helicopters appear to have doubled in value from the £183 million of 1975 and sales of guided weapons and parts have risen by about one quarter from £109 million." While the civil aircraft industry continues to decline, "a number of military aircraft and helicopters are in full production."

Exports of new airborne radar and navigational equipment, partly influenced by demand for weapons systems, rose a staggering 164% to nearly £50 million. Yet UK deliveries of medical equipment to the home market fell despite a surge of private donations of computerised axial tomography equipment. Imports of medical equipment rose 40% to £22.8 million, and exports went up to £50 million as a result of scanner sales. The positive trade balance in medical equipment was £19 million.

Altogether EEA members sold £806.3 million worth of radio and radar equipment and £629.4 million of computers. Exports were £295.2 and £318.8 million respectively, or 47% when account is taken of work done. This compares with total sales of £1097.2 in 1975, £438.3 million of which was exported, or 43.8% accounting for work done.

The new president of the EEA is Mr R. H. Newham, leader of the UK delegation to the NATO industrial advisory group. As at March this year the EEA had 40 full and five associate members.

BBC, NRDC move closer

The two paths followed by the BBC's matric H development and the NRDC-sponsored Ambisonic work are not yet merged despite a recent press statement from the BBC, which said the two parties involved had agreed "to share their knowledge and experimental experience . . ." But it is progress, for at least it means the two are now talking to each other.

The announcement follows periods of difficulty in getting the two together: their relationship with overseas interests has been better than between themselves. As pointed out in our January issue, the Ambisonic scheme was not included in the BBC tests — results of which were given in the May issue — because of a last-minute change in terms of reference. It took contact at the top level to bring about tests of certain aspects of the Ambisonic scheme.

The position of the BBC in surround sound changed when, prompted by suggestions that the BBC was holding back introduction of a service even though tests had reportedly shown a preferred system, it decided to go ahead with matrix H. Since then the pace has quickened and the BBC has been engaged in a public relations exercise to promote H at home, in Europe and in the U.S.A.

With a meeting of Working Party S of the EBU technical committee due (June 14-17), the BBC was anxious to avoid appearance of a split in the UK camp, especially with the IBA in the midst of evaluating the Ambisonic 45J system, as well as H.

The statement does however appear to mark an interesting alteration in the BBC's terms of study of surround-sound systems. It says the object is to obtain "the optimum unified coding specification for a system which can be used with both *gramophone records* and tapes as well as broadcasting". (The italics are ours.)

Acknowledging the similarities between H and 45J, the BBC say, "It is expected that any system refinements that may be agreed will be sufficiently small not to impair the performance of existing matrix H or 45J decoders". This could be an indication that the BBC may decide that the H and 45J options are close enough in two-channel form that there is little to be gained by alteration. Indeed it has been remarked that the BBC is only interested in the NRDC decoding technology.

But the similarities in their two-channel codings tend to cover up that the Ambisonic scheme is an overall technology embodying all parts of the chain and incorporating a range of codes to satisfy differing needs, whereas the H code is a particular one designed to meet the BBC's need.

● As part of Liverpool's jubilee celebrations, IBA station Radio City, specially commissioned a performance of Mahler's Eighth Symphony from the Anglican Cathedral. Using the Ambisonic 45J codel the two-channel broadcast took place on June 23. According to an IBA engineer who listened to the decoded result "it was much better than stereo could have been — it sounded real". The IBA has not made any further formal application for such broadcasts, but it seems almost certain that it will.

It could only happen in the US department. It is now possible *(our American correspondent George Tillett writes)* to buy a computerised, solar-powered tombstone that automatically sprinkles water round the grave of the deceased. And when a visitor comes within range a proximity switch operates a tape recorder and dispenses incense . . .

Microwave intruder alarm — 2

Construction of Doppler radar to detect movement

by M. W. Hosking, M.Sc., M.I.E.E., *British Aircraft Corporation*

Based on the Doppler frequency shift principle, this domestic intruder alarm system uses straightforward and simple techniques, together with materials that are readily available to everyone and brings what has hitherto been a costly and professional system within the reach of a domestic budget. Most of the components can also be used to make a simple voice communications link, with the main addition of an audio modulator. Construction of a voice link, including the microwave transmitter and receiver will be described in a later article.

The Dopper transmitter/receiver module described so far uses a separate detector diode in what is really a single-ended superhet receiver, with the transmitter playing the role of local oscillator and mixing with the reflected signal at the detector. Mixing and the extraction of the Doppler beat frequency takes place by virtue of the non-linear voltage-to-current relationship of the Schottky barrier detector diode. Mixing would take place whatever type of semiconductor device were used as the detector so long as it had a non-linear characteristic. The Gunn device transmitter has a decidedly non-linear current/voltage relationship and thus may be used as a self-oscillating mixer, thereby eliminating the detector diode and associated waveguide cavity.

A means of achieving this is shown in Fig. 7(a) wherein the Doppler frequency is extracted from across a suitable resistor, R_{26}, inserted in the Gunn bias circuit. For best results and stable performance, R_{26} has been chosen as 56 ohm. As the full Gunn drive current also passes through this

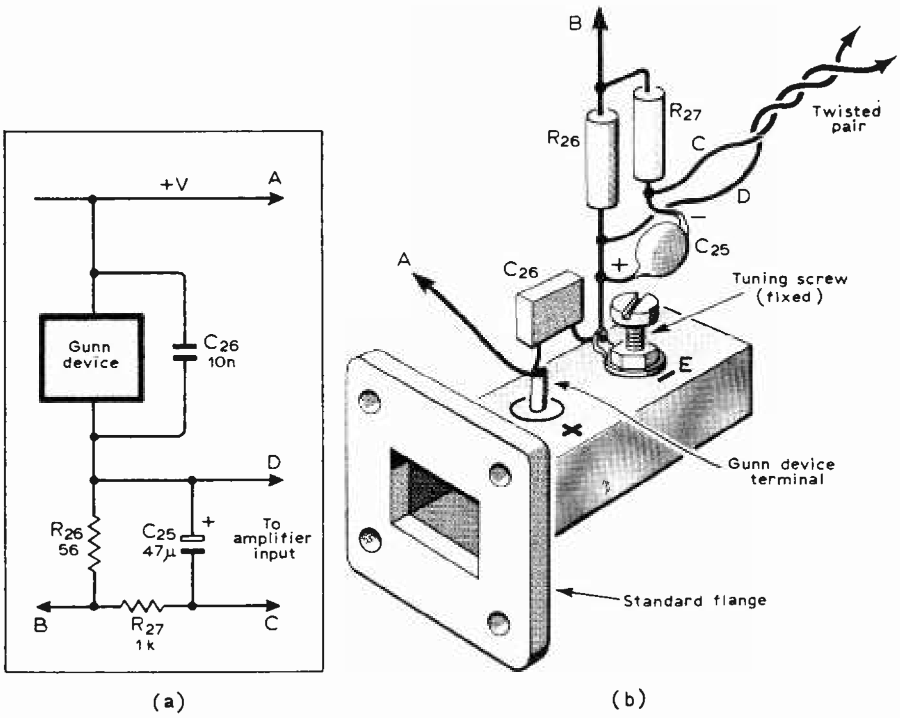
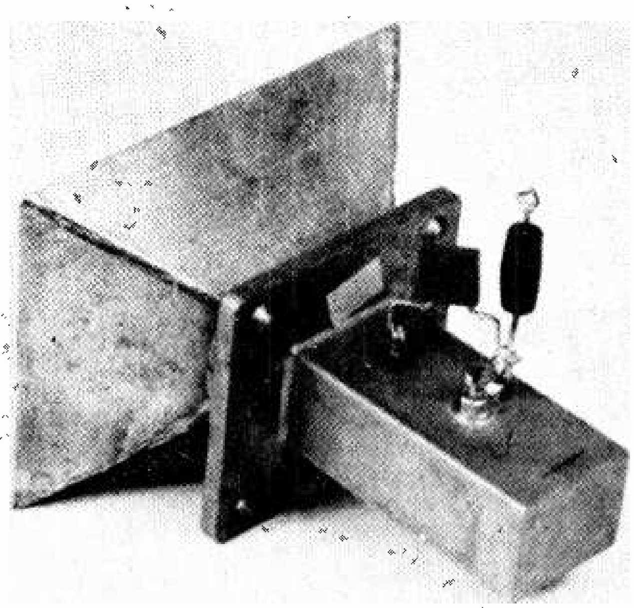


Fig. 7. Gunn device can be used as a self-oscillating mixer and (a) shows how the Doppler signal can be extracted from a series resistor in the supply line. A general view of the transmitter/mixer is shown in (b).



resistor, the supply voltage V must be increased to compensate for the resulting voltage drop. With the chosen value of R_{26}, the new supply requirements can be provided by the existing circuitry and no changes are needed other than adjusting the voltage with R_{30}. At the nominal supply current of 140 mA, the voltage drop across R_{26} will be almost 8V and thus V must be adjusted to about 15V to maintain the necessary 7V across the transmitter.

A further consequence of this technique is that the power supply ripple, albeit small, appears across the input terminals of the amplifier by virtue of their being connected across R_{26}. This ripple lies within the Doppler passband and, as the returned Doppler signal is of the order of microvolts, the signal-to-noise ratio will be degraded. The additional components R_{27} and C_{25} provide further filtering of this rectified ripple. If this system is used, do not fit R_{10} to p.c.b.

The Gunn device is, of course, designed primarily as a microwave signal generator and lays no claim to fame as a low-noise detector of microwave signals. Consequently, its receiver noise figure is very high and its effective range is much less than that of the previous transmitter/receiver module. For this reason, it is best to operate with a higher gain antenna than the 5dB one used before. As a compromise between a higher directivity to give greater range and a wide beamwidth to give angular coverage, a gain figure of 13dB has been chosen, giving a 3dB beamwidth of about 22°. Fig. 8(a) shows constructional details of the antenna and Fig. 8(b) gives a general picture of the complete assembly.

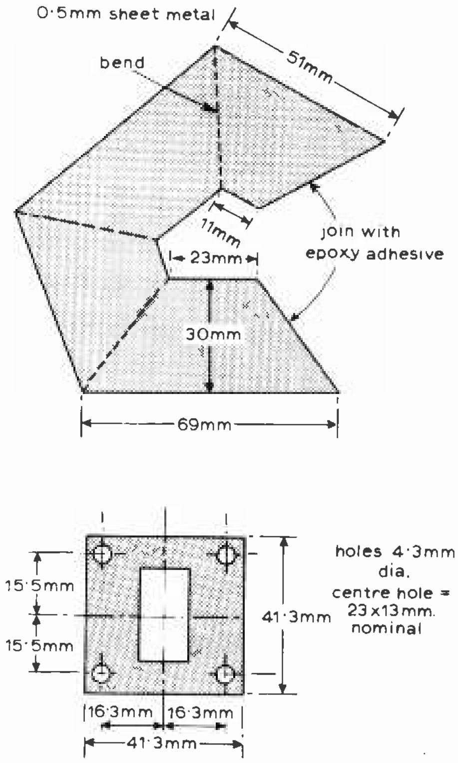


Fig. 8. Small horn antenna can be fabricated as in (a) to increase the s/n ratio and is fitted as in (b).

For use as a self-oscillating mixer, the preferred Gunn transmitter assembly is the Mullard CL 8630S. This has an almost identical transmitter specification to the CL8960 given previously; it is supplied set to the correct frequency (without antenna) and is fully compliant with the Home Office transmission regulations. The cost of the CL8630 is approximately half that of the CL8960 but the trade-off is a greatly reduced range. Successful operation of this alternative system with the 13dB antenna was obtained up to a range of about 3m which is good enough for the protection of a medium-sized room, a hallway or the stairs.

For those who wish to construct their own transmitter module, then the design for the voice link transmitter could be used. The cost, however, would not be very much different and the final unit would have to be vetted by the Home Office. As the frequency tolerance on radar intruder alarms is only ± 12MHz as opposed to ± 200MHz for the voice link, home construction of the microwave cavity in this instance is not advocated unless suitable frequency measurement is available.

Power supply

Due to the sensitivity of the amplifier and trigger, together with the low Doppler voltages, it is important to have ripple-free, well-regulated supplies to

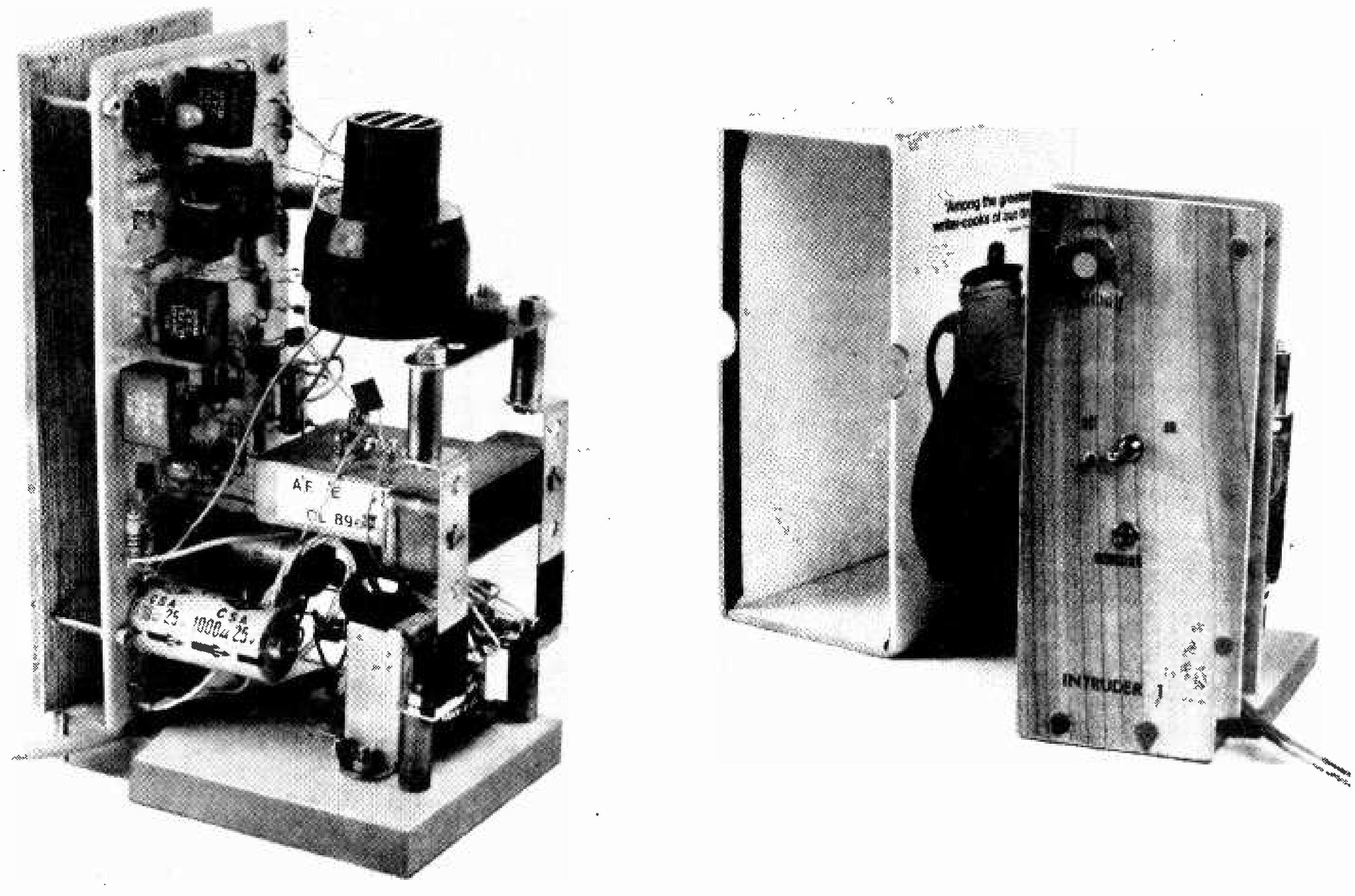


Fig. 9. Complete intruder alarm system, designed to fit in a book sleeve is shown in (a) and a view of the controls on the back panel in (b).

the Gunn transmitter and electronics. The transformer has two independant secondary windings, each rated at 3VA and an interwinding screen which is taken to mains earth. Use of the i.c.-Tr_7 series regulator combination has several advantages: it is relatively cheap, it allows fine adjustment of the Gunn supply voltage via R_{30} and it gives about 70 dB of mains ripple rejection. Ripple on the ±8V supplies to the amplifier is very small as only about 5mA per rail is consumed under quiescent conditions.

When connected to the Doppler module, the negative side of the Gunn supply is automatically joined to the 0V rail of the amplifier. This is because one terminal of the Gunn device and one terminal of the detector diode are both connected to the casing of the module. It was also found preferable, from the point of suppressing mains transients, to have the 0V rail floating and only the transformer screen actually earthed.

The prototype was constructed in the style of a book and has operated from my own bookshelf for weeks without trouble. Fig. 9 gives a general view of the final assembly which in the case of the prototype fitted very neatly inside the covering of a well-known cookery book set. A printed circuit board has been designed for the electronic components; overall size of the board is about 80mm x 115mm. Construction of the intruder alarm is straightforward and the following sequence os operations is suggested.

- Select a suitable material for the back panel such as 3mm hardboard or plywood and cut it out to the same width as the printed circuit board but about 20mm longer. Lay the blank p.c. board on the panel, aligning one end of each and mark out the four fixing holes. Drill out these holes in the panel, together with those for the controls as shown in Fig. 10.
- Cut out the base from 12mm thick plywood or wood to the same width as the back panel and 110mm long.
- Position the mounting structure for the Doppler module and transformer as shown in Fig. 9 and drill out the fising holes. Ensure that the front face of the Doppler module is 10 or 11mm back toward the back panel from the edge of the base.
- Attach the Doppler module, alarm and transformer to the base using countersunk bolts with the mains input tags on the transformer closest to the back panel.
- Assemble the panel-mounted components and screw the panel to the base.
- Assemble the components onto the p.c. board bearing in mind that care and neatness at this stage can save hours of frustration later with dry joints and mistakes.
- Solder the connecting wires to the components on the back panel and the mains lead to the transformer. Clamp the mains lead to the baseboard with an insulated wire staple to avoid strain on

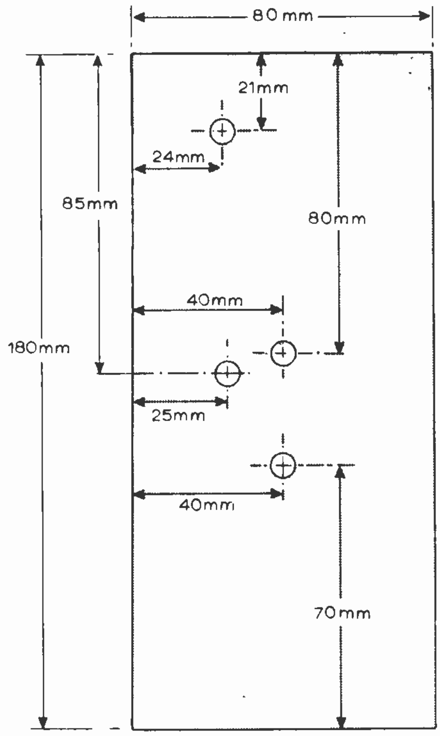


Fig. 10. Back panel control layout showing hole positions.

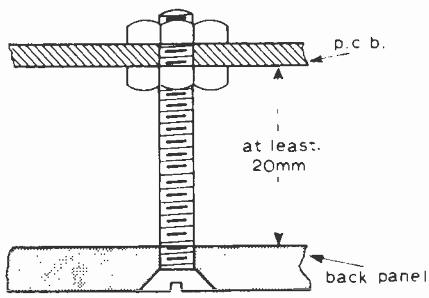


Fig. 11. The p.c.b. is clamped in position to the back panel as shown leaving a clearance for the panel controls.

the transformer tags. Solder the earth lead to the transformer screen terminal and connect with a piece of wire to one of the bolts securing the transformer down.

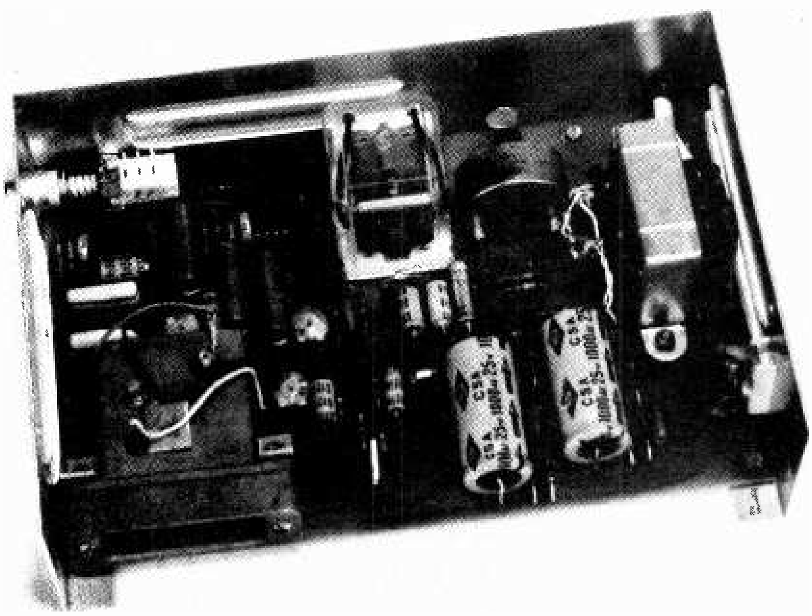
- Bolt the main board to the back panel as shown in Fig. 11, leaving at least 20mm clearance between the two.
- Solder the connecting wires to the main board and to the transformer and check that the l.e.d. is properly located in its clearance hole on the back panel.

It is very important to keep connecting lead lengths to the absolute minimum to avoid interference pick-up. If preferred, a piece of heavy-gauge aluminium sheet could be used as the back panel and base; in which case this would be earthed via the transformer clamping bolt.

The kit available for the system contains a suitable enclosure, but some constructors may wish to design their own. Complete freedom of choice is possible as regards style, materials and shape except for the area immediately in front of the transmitter/receiver module. No electrically conducting material, in any form, must cover any part of the radiating aperture or the performance will be impaired. Dielectrics such as paper, cloth, wood, plastic can be used, but the material in front of the antenna should be less than 1mm thick and should come no closer than the 10mm mentioned above. A complete enclosure will muffle the alarm, so either the top of the box should be left off or else cut a 25mm diameter hole above the alarm.

Operation

The intruder alarm has been designed to sit neatly and unobtrusively on a table or shelf for long periods of time and to operate reliably when required. This type of radar Doppler system is superior in all-round performance to most other systems and thousands per year are installed in professional and commer-



cial premises. The cost is high, but this project brings a well-proven, professional technique within reach of domestic budgets.

The electrical supplies to the circuits are activated on plugging in to the mains supply and, in view of the low power consumption, it is recommended that a 500mA fuse be fitted into the mains plug.

Two controls are possible with the system to suit various sensitivity requirements and to give some choice over the size of reflection needed to trigger the alarm. Firstly, R_{28} controls the voltage gain of the second stage which, in effect, determines the range at which a given moving object will trigger the alarm. Secondly, R_{29} can be used to set a voltage threshold which must be exceeded before the Tr_3, Tr_4 combination will switch on.

Control R_{29} is useful as a supplement to the gain control and also to offset interference such as refrigerators switching on and off.

After assembly carry out the following procedure:

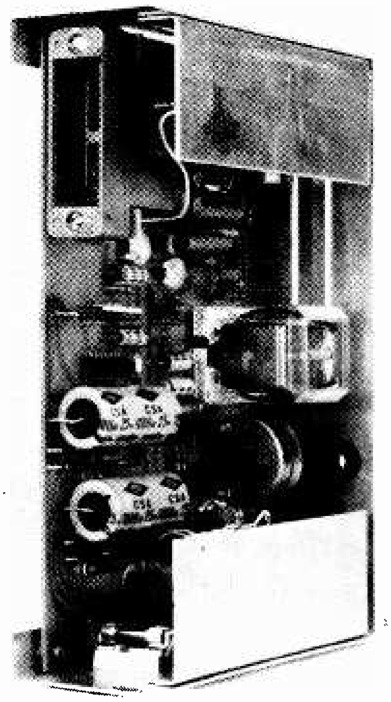
- Leave the supply lead disconnected from the Gunn device and check the $\pm$ 8.2V supply rails to the p.c. board.
- Connect a 47 to 56-ohm, 1-watt resistor across the Gunn supply in place of the Gunn device and adjust R_{30} to give 7 $\pm$ 0.1V across this resistor.
- Connect the + 7V line to the Gunn terminal, applying the soldering iron for no longer than five sconds.
- With R_{28} set to give minimum gain, adjust R_{29} to maximum sensitivity, that is minimum resistance between D_{10} and emitter of Tr_3.
- Turn the gain up with R_{28} until a level is reached when self-oscillation occurs; indicated by the l.e.d. being permanently lit. At this point. turn the gain down with R_{28} until the l.e.d. goes off and remains off. The system is now at maximum sensitivity and the l.e.d. will flash only when something is moving – a point to observe when setting up.

If the system is to operate close to a source of interference, then R_{29} can be adjusted to set a threshold level to prevent false triggering.

The on-off control to the alarm is a matter of personal choice. Either the switch on the back panel can be used with the built-in delay, or else an extension switch connected via the jack plug and socket.

Regulations

In common with other devices that transmits radio waves, a licence is required for its operation. The intruder alarm system here, which has been given the name Intruder 1, has been tested by the British Home Office and has been given official type approval. This means that, provided it is built exactly to the design given, the constructor or ready-built purchaser of the Intruder 1, will be granted a licence on application. Cost of the licence is £1.20



Kit version of intruder alarm features different p.c.b. from author's original, as supplied by M. R. Sagin.

and lasts for five years and an application form is included with each kit or ready-built system.

Transmitter specification is	
Frequency	10,687 - 12 MHz
Max. power	10 mW
Antenna gain	less than 20dBi
Out of band radiation greater than 40dB below carrier	
Temperature range	– 5 to + 40 C

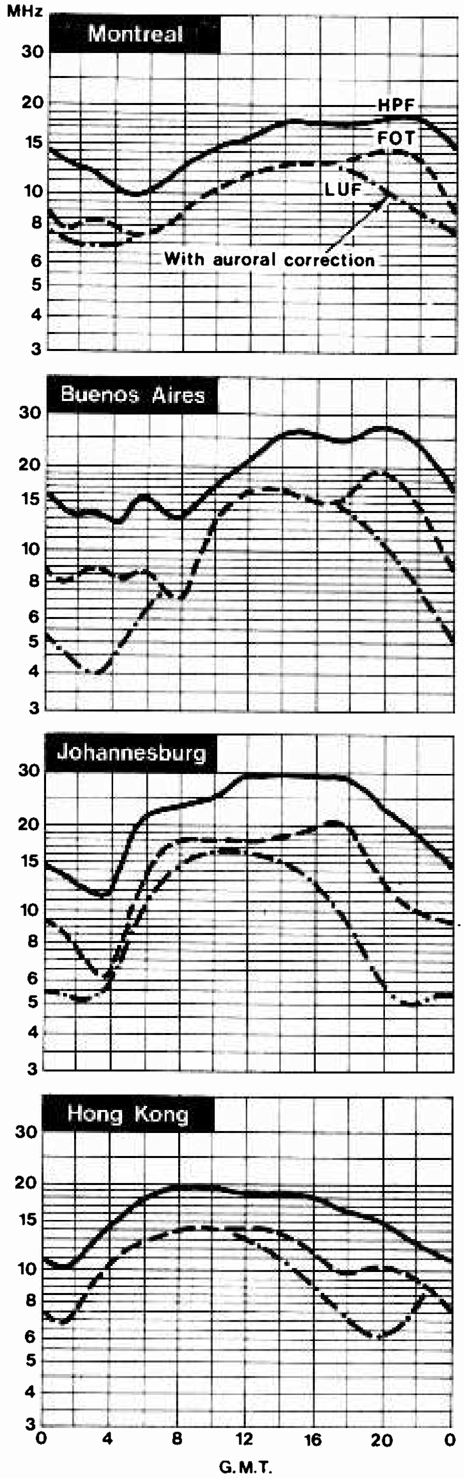
Circuit alteration

Due to the wide variation generally found in s.c.r. holding current and the tolerance on relay resistance, it is possible in some cases for the s.c.r. in Fig.5 to latch due to leakage current through the relay coil while the full rail voltage is building up through the RC delay. This could be caused by the operator moving out of the room and could result in an effective delay of about 10s as opposed to the designed 45-60s. To preclude this inconvenience, an improved delay circuit has been suggested by Tony Haywood of Integrex which prevents latching occurring until the voltage has built up to the vicinity of the board rail voltage. The alarm kit and associated p.c.b. have been changed to take this improvement into account, and the revised circuit diagram will be published in the September issue. A series combination of C_4 and R_4, from the emitter of Tr_1 to 0V, should have been included in Fig.5. Capacitor C_8 should be 1μF not 1nF and C_{13}, shown as 10nF, was incorrectly labelled C_{12}.

ACKNOWLEDGEMENT. I would like to acknowledge the help and advice given by my friend and colleague Ken Griffiths in the design of the electronics circuitry and his unerring knack of fault-finding.

HF predictions

Circuit reliability is the product of the probability of ionospheric reflection and the probability of achieving a desired signal to noise ratio and is thus at a maximum somewhere between FOT and LUF. The term FOT, which is the French equivalent of OWF (optimum working freqency), is thus a misnomer since it relates only to skywave probability. However since LUF is dependent on many factors which cannot be generalised it is found satisfactory in practice to take FOT as being what it says it is.



Letters to the Editor

RADIO AND AIR SAFETY

I was disturbed by your leader in the June issue attacking the quality of air/ground v.h.f. communications, particularly since you appear to have pre-judged the result of an incomplete accident investigation on the basis of unconfirmed "leaks".

It is disingenuous to compare the quality of aeronautical communications with broadcasting, since the requirements are completely different. In broadcasting the aim is high-fidelity music reception with a good signal. The prime requirement for air/ground communications is intelligible speech reception under marginal conditions. The audio bandwidth of 2.5kHz is near optimum for this purpose, and also enables the 60dB adjacent channel rejection requirement to be met with 25kHz channel spacing. (V.h.f. broadcast receivers have minimal adjacent channel rejection with 200kHz channel spacing.) Channel spacing is dictated by frequency planning constraints; the radio horizon of an aircraft at 40,000 ft is 450km, and only 18MHz of the v.h.f. spectrum is allocated to aeronautical communications — less than to sound broadcasting.

The audio quality of the airborne transmitter is limited mainly by the bandwidth and the microphone. The microphone must above all be robust, lightweight, reliable and have good noise-cancelling properties.

The choice of a.m. was made thirty years ago, but the capture effect of f.m. would be undesirable, since it can be important for a weak and distant transmitter to be able to break into a crowded channel.

As for "crude technology," an aircraft v.h.f. transmitter/receiver must be capable of tuning 720 channels at the turn of a switch, with a frequency stability of $\pm 0.003\%$ under extreme environmental conditions. I have not seen comparable capability in broadcasting equipment. In general state-of-the-art technology is employed throughout.

It should be borne in mind that air/ground communications have to cater for all airspace users, from Concorde to a Tiger Moth, without imposing excessive costs on anyone; and that full international standardisation is essential.

The best prospect for improvement in the future is offered by the L-band data link systems currently under development. These will use keyboards and alphanumeric displays to supplement v.h.f. voice communications.

R. A. Keall,
Hawker Siddeley Aviation Ltd,
Hatfield,
Herts.

I read with interest your leader in the June issue "Radio and air safety" and feel obliged to support your remarks regarding the diabolical audio quality of air-ground communications.

A recent search for a reasonable quality 720-channel airborne radio that would produce a little more than muffled noises revealed that none was available of British manufacture and that the complete light and general aviation communications equipment market is dominated by the Americans. I was informed that British manufacturers ignore the civil avionics market because it is too small to support the enormous investment required due to complex Civil Aviation Authority regulations, approvals, environmental tests, requirements for spares holdings and handbooks etc.

Can it really be that British bureaucracy has effectively strangled a prospectively lucrative manufacturing area that could certainly provide better equipment, employment and overseas earnings? If this is so, then we've only got ourselves to blame if the audio quality obtainable from the overpriced imported equipment is below par since the lack of competition promotes the lack of improvement.

T. R. Wiltshire,
Mortimer,
Reading,
Berkshire.

NO CO-ORDINATION ON MOBILE RADIO

In your February 1977 issue, your editorial suggests the need for a public debate of the needs of private mobile radio and the formulation of clear and specific recommendations to be put to those who will represent the UK at the forthcoming WARC 1979.

The debate seems to be taking place; due in no small measure, I suspect, to your own promotional activities. Articles, reports and readers' letters continue to appear in the relevant technical publications; the Mobile Radio Users Association has conducted a survey and published its findings; the Home Secretary has asked for (and presumably received — although we may never be privileged to know) submissions from anyone interested; Pye has made its Pannell Report publicly available. The EEA has reported its findings to the Home Office and it has been reported that the Conference of European Manufacturers' Association has reached some unanimous conclusions also. The academics have not been slow getting into print either, and recently the IEE have held a discussion meeting on spectrum management.

I suppose none of this can be considered to be "public" debate but neither is it secret, classified or held to be confidential.

The problem now is that whilst a researcher might detect a common and vital thread running through all of this activity, no one is picking up the ends and tying them together. There is no coordination. There is no central body for the public production of a distilled viewpoint. The Home Office have opted out of such a role, and perhaps rightly so — after all no other United Kingdom government authority conducts its administrative affairs in public.

John Brinkley recently suggested in the May letters column that as far as mobile radio is concerned, WARC 1979 may turn out to be a non-event. Well, that would be a shame at the least. It will, however, be extremely serious for our economy if it is also the view held by our delegation, in so far as future spectrum management in the UK is concerned.

Perhaps Mr Brinkley has hit upon the underlying principle of the often criticised, yet secret Warden report?

Time is running out, yet all that is needed is recognition of the national value to the community at large which would stem from the increased use of mobile radio and a determination to encourage its expansion by making sure now that adquate frequency space is available in the future.

The only debate required is one seeking common agreement on four major issues: 1. The instrinsic national value of mobile radio; 2. The standard of service required; 3. The expansion rate to be encouraged; and 4. The balance between the cost of technology and the return to the user. The rest will fall into place.

H. W. Whelan,
Ely,
Cambridgeshire.

ADVANCED PRE-AMPLIFIER

I read with interest Mr G. Nalty's contribution in June letters. I should like to refute his imputation that I do not know what I am talking about as follows.

I do not think I have failed to grasp the point of Mr Nalty's letter, as he implies in the June issue. However, he appears himself to be not quite perfect in his grasp of some of the principles of electronics.

Firstly, it is not realistic to regard an amplifier with a finite slew rate as a combination of an infinitely fast amplifier and a subsequent low-pass RC filter. Slew rate limitation normally arises because the main voltage-amplification stage can only drive a finite amount of current into and out of a capacitor (usually that component providing dominant-pole compensation), and hence the normal symptom of a poor slew rate is a linear approximation to the desired output signal rather than an exponential waveform. For example, a sine-wave suffering slew-limiting takes on the shape of a triangle waveform. It is therefore more meaningful to consider a finite slew rate as placing bounds on the maximum positive and negative values of dV/dt, since this is after all the way in which this quantity is usually measured. These constraints may well be different in the positive and negative directions – another factor that Mr Nalty's model does not reproduce.

Secondly, I find it remarkable that Mr Nalty's equations show that increasing the amount of negative feedback on an amplifier *increases* the closed-loop gain. The correct equation for the closed-loop gain of a feedback amplifier with finite open-loop gain is of course:

$$A_{\text{closed-loop}} = \frac{A}{1+bA}$$

where A = open-loop gain and b = feed-back factor

$$= \frac{A}{1+A/G} \quad \text{if } G=1/b$$

I assume that Mr Nalty's point in this section is to show that closed-loop gain is affected by open-loop gain variations. This is of course true, but a simple calculation using ball-park figures of 1000 × for open-loop gain and 10 × for closed-loop gain shows that the gain deviation from the ideal (infinite loop gain) case is less than 0.1dB. I do not think that a gain error of this order can give rise to audible effects, no matter which of Mahler's symphonies is used as a test signal. In the practical case, the tolerances of the equalisation components may well exceed this figure, and this is of course true for both active and passive methods of equalisation.

Finally, having been made aware of Mr Nalty's concern with "very small differences" in subjective effect, I am amazed that he lightly shrugs off the fact that his passive equalisation design is so desperately short of headroom that audible clipping is a common occurrence. This underlines the need to consider disc input overload as a parameter of primary importance in the design of modern audio equipment.

D. R. G. Self,
London E17.

REALITIES BEHIND HIGH TECHNOLOGY

When will engineers and technologists pull their heads from the sand and refuse to perpetrate the industries of death and destruction?

Are the individuals involved so mindless that they cannot imagine the desolation of having a near and dear one ripped to bloody shreds or charred and twisted beyond recognition. Over emotional? Possibly — but these are the realities behind the facade of high technology.

Your leader "The dugs of war" (November 1975 issue) listed "spin offs" of nuclear missile development. I am sure an equally impressive list would follow the development of a totally non-aggressive defence system — a shield. For immediate employment the fields of safety, medicine and energy supply offer an abundance of opportunities for innovation.

Will the technology of the 1970s be remembered as brutal weapons systems and tv games machines? I hope not.

James V. Cousins,
Reading,
Berkshire.

ELECTROLYTIC CAPACITOR TESTER

The article in your May issue by A. Drummond-Murray describing an electrolytic capacitor tester is misleading in its initial, general comment.

While I agree with the statement that the dielectric is formed in the first instance, from this point onwards it is either too general or it totally ignores the existence of the families of capacitors with the prefix "solid."

In the case of the solid tantalum electrolytic, as manufactured by my company, one of the main advantages is its inherent stability and lack of depolarisation. This aspect is continually under proof through a comprehensive environmental programme which includes long-term "shelf life." In addition I have a wide range of samples which have lived in a Stevenson screen on the factory roof since 1965, subject to all the vagaries of an English, industrial, climate: these are checked at three-monthly intervals, without any reforming, and apart from some surface corrosion are as good today as they were in the beginning.

While I cannot speak with authority on the "solid aluminium" I have always been under the impression that it also was resistant to natural depolarisation.

E. Nelson,
Union Carbide U.K. Ltd,
Durham.

Mr Drummond-Murray replies:
I read Mr Nelson's letter with great interest, and broadly agree with his comment. I would, however, point out that a survey of electrolytic capacitors that is contained in 1½ column inches could not reasonably be described as complete. Certainly the opening lines are loosely worded, and I did not wish to imply that tantalum capacitors were especially prone to depolarise, which as Mr Nelson points out is not so with his capacitors.

The capacitor tester was specifically designed for use with the commoner "domestic aluminium" capacitors, as Mr Nelson perhaps suspects. Naturally in any specific application the tester could be modified, but the equipment would lose versatility if the "reform" facility was removed, which on the tester described is bypassed with a switch.

A. J. Drummond-Murray.

"LOSS OF INFORMATION" CONCEPT

Mr Vereker's rather confused letter in the June issue does not seem to introduce any new single thought, let alone concept, on the matter of amplifier evaluation.

In engineering terms a "concept" must be a term of analytic if not synthetic value allowing scientifically valid explanations to be proposed and preferably also predictions to be made. "Loss of information" is not such a concept, being merely the result of a mental slithering on the skid-patch of subjectivity.

Thus we are asked to understand that from Mr Vereker's "wider point of view" (how wide can a point be?) intermodulation distortion does not lead to "loss of information". Then on to his disclosure (para. 7) that "loss of information" occurs during amplification "latch-up" — when, as we all know, periods of 100% intermodulation distortion occur. Such a flexible notion as this is hardly going to appeal to the right people.

Bringing matters more in line with other current discussions, it does seem clear that a purely subjective approach to amplifier performance appraisal can sift out extremes of performance and often also help identify quality groups. In this respect — and to show how truthfully subjective one can afford to be — I am prepared to say that in my experience the very best of transistor pre-amps, when compared with the very best of valve pre-amps, seem to show marked loss of information right across the audio range and an equally important loss of overall realism.

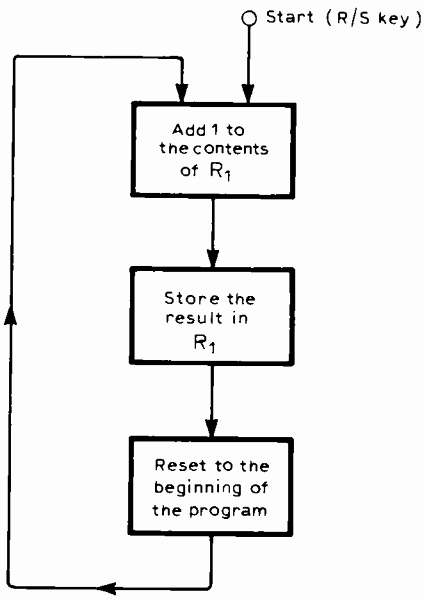
Of course this observation, which I believe to be quite as valid as the claim that Beethoven's 9th Symphony is very good music, has itself no direct impact on engineering as it stands at present.

John Greenbank,
Tangent Acoustics Ltd,
Hardwick,
Cambs.

CALCULATORS AS STOPWATCHES

Your January 1977 issue had a Circuit Idea under the heading "Stopwatch facility for calculators". A multivibrator was applied to a Sinclair Memory calculator. Now that programmable calculators are coming down in price, it may be interesting to consider the stopwatch facilities offered by such calculators, without requiring additional electronics. Here are some available on the Texas SR56:

● **Simple stopwatch (with no display until the end of the programme).** Register 1 (R1) holds a total which increases by unity each time the programme completes a loop. R1 is initially set to zero. When we execute a programme based on the flow chart:

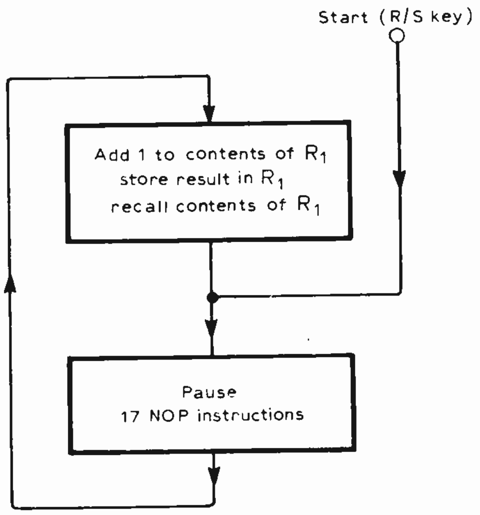


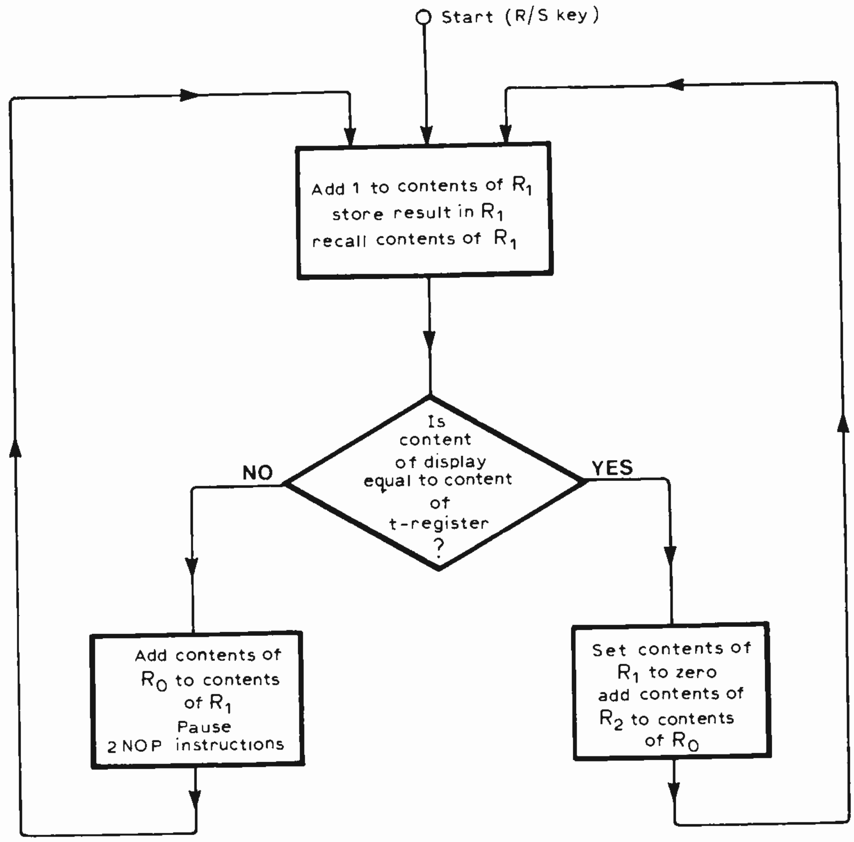
we find that the programme counts to 532 in 60 seconds. When we wish to time an event, we press the R/S key at the beginning and end of the event and then recall the contents of R1. Simple proportion (which can of course be done on the calculator) gives the duration of the event in seconds.

● **Simple digital counter with display of seconds.** Whereas the simple stopwatch above could measure duration in seconds and decimal fractions of a second, but had no display during the event to assure the operator that everything was working correctly, this method gives assurance that all is well, but does not allow time to be measured in fractions of a second. As the seconds go by, the time that has elapsed from the start of the event is displayed in seconds. Initially R1 holds zero. The action begins and ends when we press the R/S key. When we press this key at the end of the event which is being timed, the display may not hold the desired number of seconds, since we may press the key at any step in the programme which is being executed by the calculator; we therefore recall the contents of R1 and read off the duration of the event in seconds.

Before we give a flow chart, we have to refer to the "pause" and "no operation" instructions. When the programme comes to the "pause" instruction, the calculator is instructed to display the contents of the display register for about half a second. It is necessary to kill time so that the calculator may take just one second to run through a loop. The calculator has a "no operation" function, associated with a NOP key, the effect of which is to transfer control to the next step. The transfer of control takes a short time and we can use it as a means of killing time. We can vary the number of NOP instructions to regulate the time required for one loop. If we have too few, the calculator is "fast"; too many, and it is "slow". My calculator required 17 successive NOP instructions to keep time.

The flow chart is given below:





● **The calculator used as a digital clock, with display of minutes and seconds.** In this application, the display shows $M_1M_20000S_1S_2$; the digits at M_1, M_2 represent minutes; those at S_1, S_2 represent seconds. (Because the calculator suppresses leading zeros, in the first minute, digits corresponding only to S_1S_2 can be seen.) Register 0 (R0) holds the sum of the minutes. Register 1 (R1) holds the sum of the seconds. Register 2 (R2) holds 1000000. The t-register holds 61. R0 and R1 initially hold zero. The flow chart above should explain the way the programme works.

The effect of this programme is that, towards the end of the first minute, the display is 58, 59, 60, 1000001, 1000002, 1000003 . . . . We have not much scope for regulating the clock, with only two NOP instructions to play with; however, with the programme as given, my calculator loses only two seconds in ten minutes. Those who want a clock with the accuracy of a quartz crystal are not likely to be interested; those who want some fun writing a programme, may be.

Those who have calculators which permit "direct register arithmetic" will find that this facility shortens programmes slightly; I used it in the programmes given above.

T. Palmer,
Acton Technical College,
London, W3

R.F. BREAKTHROUGH IN AMPLIFIERS

C. Streatfield of Dorset, in his "criticism of the criticism" of the advanced pre-amplifier (April letters), comments adversely against the connection of a capacitor directly between base and emitter of the first disc input stage, and asked "why not to earth?"

Being a retailer who handles transmitting equipment as well as high fidelity equipment, I have probably become involved more than most in the suppression of high fidelity amplifiers for radio frequency breakthrough. The reason for putting a capacitor between base and emitter for radio frequency suppression is that "it works". Unfortunately the input transistor of most pre-amplifiers is apt to operate as a crystal diode detector, and by far the most effective cure is putting a capacitor in this position, whereas connecting it between the base and the chassis with some designs seems to affect the high frequency response. What is probably far more important, this is far less effective at suppressing shortwave transmissions and is completely ineffective in preventing pick-up in the v.h.f. range.

It does seem ridiculous that still so many items of audio equipment are completely unprotected from r.f. breakthrough. Quite apart from the absolute chaos which would occur if an a.m. citizens' band were to come into operation, proper r.f. suppression much reduces clicks and plops from refrigerators, and also seems to improve the reliability of high fidelity equipment by removing "spikes" from the circuit.

On recent legislation, retailers who sell equipment which picks up unwanted shortwave transmission have technically "supplied equipment which is not of the quality demanded", and while I have never heard of anyone being prosecuted, they would seem to be in a rather shaky position if someone were to make an official complaint.

Our reaction has been to try and get our suppliers to fit 10p worth of disc ceramics, but we have not always been successful.

Harry Leeming, G3LLL,
Holdings Photo Audio Centre,
Blackburn.

INTERFERENCE FROM AMATEUR STATIONS

I was glad to see Mr Doo's letter in the June issue indicating BREMA recognition of television interference problems. However, in the light of past experience I, and no doubt other radio amateurs, would like to be assured that any filter fitted to tv sets is not yet another "cure all" which works perfectly in the lab between wideband 75-ohm terminations but in the field may only marginally reduce or even enhance both the reception and radiation of interference.

Thanks to the work of RAE Farnborough it is now possible to design filters with a guaranteed minimum loss irrespective of termination. Surprisingly, engineers seem reluctant to exploit this possibility. Further information would be welcome.

B. Priestley,
Langley,
Slough,
Berkshire.

Rhythm unit — 3

Rhythm selection for M253

Switching circuit of Fig. 14 is for selection of the 12 rhythms of the M253AA i.c. Remaining circuitry of a 12-rhythm generator using this i.c. is shown on page 74 of the April issue, also the basis of a 15-rhythm unit using the M252* i.c. A suggested printed board pattern and component layout are available for the M253 i.c. and sound generators shown, and boards made to this SGS-Ates design are available (see April issue).

In the "keyboard" switching circuit, Fig. 14, inset diagram shows connections that are common to all 12 switches, one section serving to connect output three to the snare drum (SD) or claves (CL) circuits in Fig. 12, as determined by the rhythm selection. Output three can also be used to modulate a chord played on an organ.

In organ use, output one allows a "basso alternato" accompaniment using two chosen notes. Each time a beat of the bass drum occurs (output two) a note emerges from the basso alternato; output one serves only to establish which of two notes will be played. In Fig. 15 the tonic appears when output one is absent and output two is present. The other note, a fifth, appears when both outputs one and two are present.

Concluding note

- By resetting the clock generator to zero instead of to one (positive logic), a bar will begin half a clock period later than the release of the reset.
- By leaving the clock generator free and resetting only the M252 or 253, there are two possibilities at the release of reset
  — if the clock is at '0' the rhythm starts immediately from the beginning of the bar
  — if the clock is at '1', the bar begins as soon as the clock switches over, and there is therefore a random delay which varies from about zero to half a clock period.
- With no reset applied, the clock running and no rhythm selected, the down beat signal occurs every 32 elementary times, or every 64 clock pulses (for both i.cs).

* Keyboard/mechanical encoder for the M252 circuit is available on request.

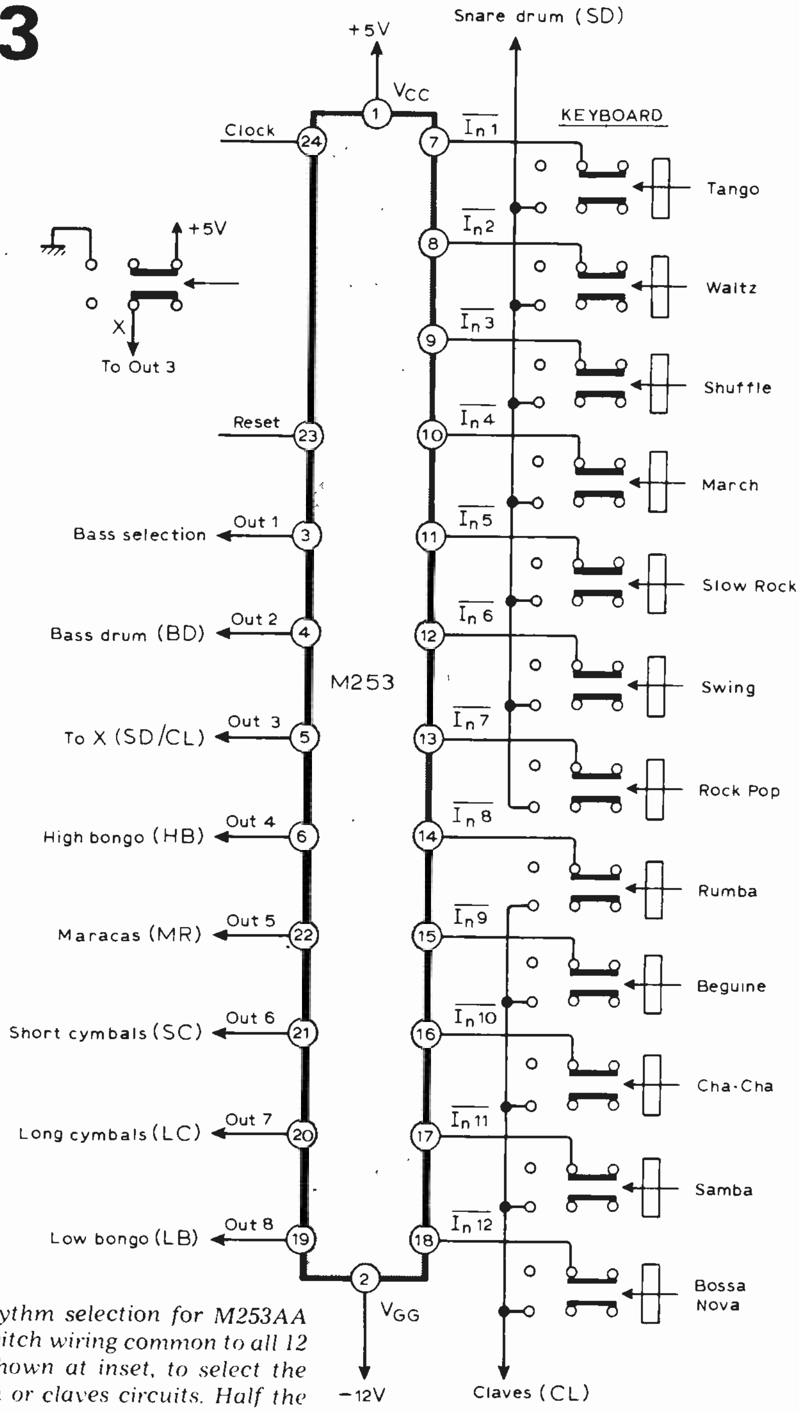


Fig. 14. Rhythm selection for M253AA includes switch wiring common to all 12 rhythms, shown at inset, to select the snare drum or claves circuits. Half the switch contacts can be eliminated if the snare/clave switching is not required.

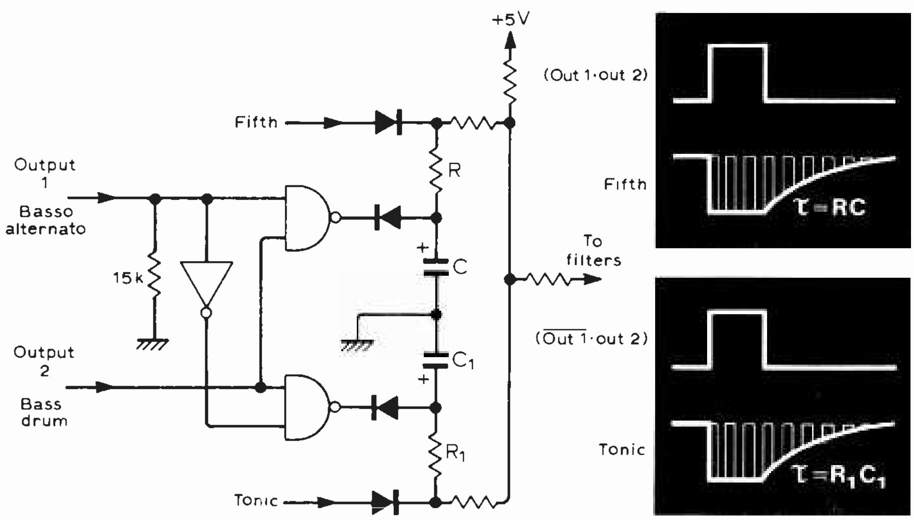


Fig. 15. For organ use, this circuit switches between two chosen notes for an alternating bass effect, and is driven from outputs one and two of M253.

Montreux television symposium

Exhibition impressions of 10th TV symposium

by J. F. Golding

To the Briton visiting the Maison des Congres in June, 1977 the first impression was one of satisfying familiarity. Of the exhibitors from fifteen countries more than a quarter were British firms, outnumbering their nearest rivals, the Americans, by 40% and with more stands than the French and Germans put together. One became accustomed to seeing Benny Hill or Bruce Forsyth on monitor screens since EMI had distributed a PAL signal feed to certain other stands. Such encouraging signs of British marketing overseas seemed appropriate when the BBC were mounting the world's biggest outside broadcast to cover the Queen's Silver Jubilee celebrations.

The most spectacular technical advances in equipment on display were in the electronic news gathering (e.n.g.) and outside broadcast fields, and in the application stemming from the development of microprocessors and associated devices, of digital techniques to signal switching and special-effects applications. New equipment was, however, on show in all areas including telecine, video and sound recording, picture displays and test instrumentation.

Electronic news gathering

The growth of e.n.g. stems from the development of broadcast quality portable colour cameras, which may, in varying degrees, be used instead of 16mm film cameras for television journalism. The approach to television journalism varied considerably with each manufacturer, enabling the broadcaster to choose between high mobility or local studio facilities according to his needs.

Marconi Communications Systems, for instance, were showing a studio quality miniature o.b. vehicle, the Mini Mobile, equipped with two Mk VIIIP portable cameras, a v.t.r. vision and sound mixers, picture and waveform monitors and a microwave-link transmitter, all powered from an on-board generator. This compact unit was driven right into the main exhibition hall at Maison des Congres, illustrating its ability to bring the news studio very close to many locations, and to allow considerable mobility for the portable camera into otherwise inaccessible places.

Similarly EMI were using a number of their latest type 2008 portable colour cameras on their stand and, with their o.b. vehicles, for outside shots both in man-pack form and tripod mounted. This new unit is somewhat smaller and lighter than the Marconi Mk VIIIP, the camera head weighing only 3.63 kg with its 12:1 zoom lens and three-inch viewfinder. It is used with an a.c. powered electronic unit about the size of a small suitcase and weighing 10.4 kg.

Fig. 1. The new colour monitor from Bosch Fernseh. The basic instrument can be expanded by the addition of plug-in boards into a PAL, NTSC, SECAM, or PAL-M monitor; in one form it may display the input test signals as levels.

Fig. 2. Ampex VPR 10 portable video-production recorder complements the VPR 1, and can be used in electronic news gathering.

Philips were showing for the first time a British-built lightweight portable colour camera system identified as the LDK15L. It comprises three mobile units: the camera head, a back pack carried by an assistant and a final processing unit, which feeds the radio or cable link to the base station. Lightweight cable links allow the camera to operate up to 200 metres from the processing unit, which can be powered from the a.c. mains supply or via a converter from a 12/24 volt battery. From the same company's Eindhoven works they were showing an extremely versatile modular camera system known as the Video 80 which can rapidly be converted for studio, electronic field production (e.f.p.) or e.n.g. use as well as a number of specialised applications. In its e.n.g. form the camera becomes a one piece unit, powered from a rechargeable battery belt, capable of delivering a fully encoded colour signal directly to a Philips portable video cassette recorder or to a short-haul radio link transmitter. When used with the cassette recorder this system is the electronic counterpart of the cine film camera, allowing one-man operation complete with sound channel.

A very light portable colour camera system, the Microcam, was also shown by Thomson—CSF. Complete with its belt-carried electronics pack this system weights a mere 5.27 kg plus the weight of its batteries, given as 0.9 kg per conservative hour. This unit can provide direct video drive to a radio link transmitter or to a portable v.t.r. again forming the true electronic counterpart of the film camera for one-man operation.

Other e.n.g. camera systems included the Sony self-contained portable colour camera complete with a sound channel and companion portable 1-inch video recorder, while Ampex took the ambitious step of fitting their lightweight BBC-2 colour camera to the new Wescam stabilized mounting on board a helicopter — which ran into trouble with the local authorities for landing on Lake Léman. This incident was televised by the EMI o.b. team and appeared on a number of monitor screens at the exhibition.

Of course, the camera equipment is only part of the complete e.n.g. system, which shows its advantage over cine film only when the pictures can be relayed back to the broadcasting station for live transmission or direct recording in a news programme. Although several exhibitors were able to supply various link systems, Microwave Associates Limited of Dunstable offered a complete microwave transmission system from camera to studio. They have engineered a three-hop link, (1) from camera to a mobile relay van, (2) from the van to a fixed omnidirectional receiver terminal at 2GHz and (3) from this terminal to the studio via either a cable or microwave link. The second and third links follow largely standard practice, although the high maximum power — exceeding 15W — of the mobile 2GHz transmitter is something of an achievement, giving up to 40 miles range with a good line of sight transmission path. It is the short haul link from the camera to the van that usually presents the difficulty, requiring a highly portable system with acceptable immunity from loss of quality due to multiple reflection.

Microwave Associates seem to have solved the problem with their MA-13CP miniature link operating in the 13GHz band. Specially shaped horn antennas produce a circular-polarized wave, which considerably reduces multipath fading effects because the direction of polarization of the reflected wave is reversed so that it is not accepted by the receiving antenna. The transmitter is extremely compact, weights only 3.2 kg and may be operated from a rechargeable battery pack that can provide power for eight hours continuous operation. The wide beam angle allows rapid setting up, so that the system can be set up by the cameraman and "on air" within a few minutes at city hall, stadium, parade route or other location.

Studio Equipment

If e.n.g. presented the novelty, it was studio equipment that provided the spectacle. The magnificent Bosch Fernseh set-up was more like a miniature television theatre than an exhibition stand; a miniature studio complete with cameras, colour monitors, control equipment and seats for the audience, the scene being dominated by an Eidophor projection system with a screen 3m wide showing brilliant colour picture of superb quality. The show matched the equipment. A female pop trio, making full use of an audio system that seemed to deliver at least a hundred watts, attracted a considerable audience who applauded enthusiastically when the entertainment finished, but melted away when the stand manager took the microphone to comment on the equipment.

The excellence of the products was undeniable but there seemed a lack of technical innovation. A very much smaller EMI display of chroma-keying with scene-sync was more interesting. A foreground camera focused on a dart player throwing at a plain blue board on a plain blue wall while a second camera focused on a fixed background card showing the inside of an English pub.

Fig. 3. Marconi's Mini-mobile. It can be equipped with two Marconi MkVIIIP portable television cameras, a v.t.r, vision mixer, audio mixer, sync generators, colour and monochrome monitors, a waveform monitor, vector display and a microwave transmission link. The generator is on the truck.

The well known chroma-keying technique was employed to give a final picture of the player in the pub throwing at the dart board. The new technique of scene-sync employs a servo link between the foreground camera and the scene-card holder, which moves the card horizontally as the foreground camera pans to follow the actor, thus maintaining the realism.

Studio cameras, dollies, tripods and so on were shown by all the leading manufacturers, together with lighting equipment by Thorn and Rank. An important item of studio equipment that has, however, received little attention until recently is the colour camera test chart and some interest was shown in the Porta-Pattern range of test chart systems shown by Crow of Reading. These include an advanced spherical illuminator for transparencies, which gives completely even illumination over the whole test chart area regardless of camera angle, a portable test chart system for e.n.g. applications, and in Porta-Pattern format the new BBC Test Card 61 which may be used instead of a live model for final matching adjustments on colour cameras.

Monitors and Displays

Without question, the most arresting television picture display at Montreux was the Eidophor projector. The workings of the system were described in *Wireless World* in October, 1976, p68.

Conventional colour and monochrome picture monitors were, of course, seen on many stands, and a high proportion of them came from Crow, whose own stand was backed by an array of colour and monochrome monitors showing off-air pictures and pictures supplied on a PAL signal feed by EMI. Although primarily a television systems engineering company, Crow are also international distributors of Barco colour monitors; and, at the Montreaux exhibition, they launched their Windsor range of broadcast quality monochrome monitors, built to Crow specifications by Cotron Electronics Limited of Coventry.

Both Barco and Cotron monitors from Crow were to be found on several other stands. The Crow Berkshire multi-standard colour receiver/monitor, for instance, does not claim full broadcast standard of picture quality, but provides a very acceptable colour picture on the 26-inch screen of its precision-in-line (p.i.l.) tube. Moreover it can function as a multi-standard monitor, instantly switchable to PAL, SECAM or 4.43 MHz NTSC colour coding, or as a receiver tunable over all European broadcast bands, switchable to system codes G, H and I and delivering a colour coded video output to drive other monitors or equipment. The advantages of this versatility on the exhibition stand, where compatibility with other equipment is needed, are obvious, and even Philips were glad of the British company's loan of three Berkshires.

Most manufacturers are critical of the p.i.l. tube and Trinitron tube as studio picture monitors on the grounds that resolution is generally slightly inferior to that of a broadcast quality shadow mask tube operating in a properly adjusted scanning system. Tektronix, however, take an opposite view, claiming that the shadow mask tube is susceptible to moiré effects due to interference between the scanning line structure and the triad dot structure. Montreux provided an ideal opportunity for comparing the Tektronix Trinitron monitors with shadow mask monitors by other manufacturers and it seems that either tube can provide excellent results provided the associated electronic circuits are tailored to compensate for its shortcomings.

Where resolution is the critical factor, such as camera focusing, most engineers would, in any case, use a monochrome display, although the Barco HIREM colour monitor, using a shadow mask tube with a triad dot spacing about half that of a conventional broadcast monitor, can provide the equivalent of monochrome sharpness from an RGB input signal.

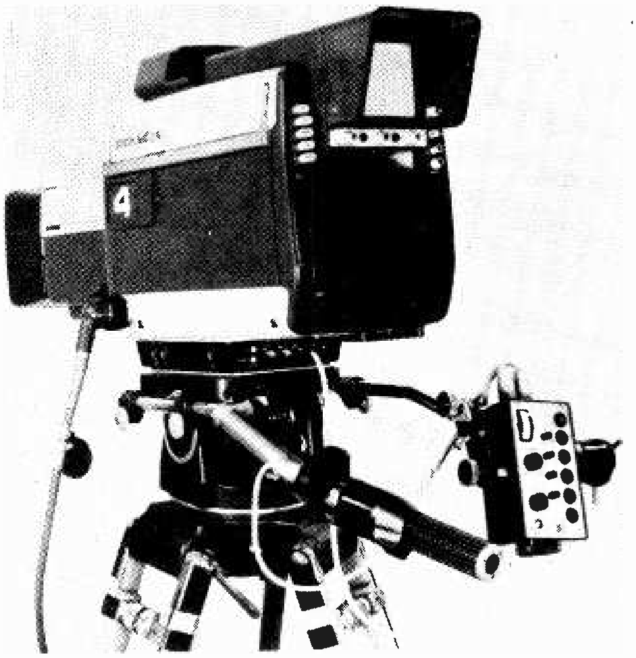


Fig. 4. The Bosch KCK studio camera with automatic line-up and operational technology as used in the Bosch Fernseh studio demonstration at Montreux.

Video Recording

For better or worse an "Ampex" is a video tape recorder in the minds of many, just as a Hoover is a vacuum cleaner. At Montreux the owner of the name demonstrated that an Ampex could also be a high quality camera, a character generator or even a complete system, but the name has crept into our language to mean a v.t.r., and that is likely to stay with us for a long time. The Ampex v.t.r. equipment on show did little to change this view. Both helical and quadruplex recorders were on display. Helical recorders (for colour-encoded and monochrome signals) included examples of the very successful VPR series, and there were special demonstrations of model VPR-10, the new portable 2-inch machine designed for e.n.g. The company were also showing their AVR series of quadruplex recorders (RGB plus luminance), with three AVR-3 recorders, claimed to be the first "intelligent" v.t.r. in the world, having computerized editing features and super high-band pilot capability.

Ampex were not showing their computer-controllable ACR-25 automatic cassette recorder, designed for rapid selection of short items such as commercials or trailers. This was perhaps a pity because Crow were showing their remote control unit for this machine, designed in conjunction with Southern Television to permit simple and flexible programming of the ACR-25 from a television station's presentation control desk. The Crow unit effectively adapts the ACR-25 to the special needs of the British and European commercial television broadcaster, which are rather different from the Americans for whom the machine was originally designed.

Video tape equipment was demonstrated by a number of other manufacturers, including Philips, Thomson-CSF, RCA and Bosch Fernseh. Only Ampex and RCA appeared to be showing both helical and quadruplex machines, but all manufacturers offered machines with built-in or add-on digital editing facilities. These facilities naturally varied from one manufacturer to another, but the basic principle employed is that of storing individual frames in a digital memory. The frames are immediately displayed on the associated monitor, giving a good quality, sustained still picture for editing without risk of wear or damage to the tape.

Bosch Fernseh carry the principle a stage further with provision for storing individual frames on an archive tape, with automatic search and access to any desired frame, which is then held in the digital memory to provide a still picture output signal. Over 100,000 single pictures can be stored on a standard 90-minute tape, and the maximum access time is claimed to be about three minutes.

A much simpler single picture storage system, the Arvin Echo, was demonstrated at Montreux by Crow, who market it in the UK and certain other European countries, and by its manufacturer the Echo Science Corporation. In the Arvin Echo each complete frame is recorded on a separate track of a double-sided interchangeable flexible magnetic disc, which can store up to 200 frames on each side, making a total maximum of 400 pictures per disc. The tracks on a single side are numbered sequentially so that, in the replay mode, any one of up to 200 recorded frames can be called up instantly by simply pressing the appropriate buttons of a standard numeric cluster. Alternatively the machine can be set to replay a sequence of tracks under either manual or automatic control. In the recording mode, the track is selected and a "Record" button pressed. On releasing the button the machine records the next complete frame of an incoming colour or monochrome video signal.

In contrast with the bulky equipment normally associated with still-picture television signals, the Arvin Echo machine is the size of a small suitcase and weighs only 38lb.

Signal Switching and Control

The routing of the large numbers of video and audio signals that go to make up a television programme is now effected by electronic crosspoint switching matrices operated by digital control systems based on computer logic techniques. Switchers were on display by the Grass Valley Group, ELA (a Telefunken subsidiary), Bosch, Sandar and Crow.

The basic job of the switcher is that of routing sound, vision, test and ident signals from a number of sources to the appropriate destinations. Within a broadcast station, sources may range from individual cameras, video recorders, telecines and so on to complete studios or even other stations while final destinations are usually transmitters, other stations or networks. Because of the wide variation in individual requirements modern switchers are invariably of modular construction, normally built up in banks of video crosspoints with associated distribution amplifiers, audio crosspoints, and control logic together with a keyboard for mounting on the control desk.

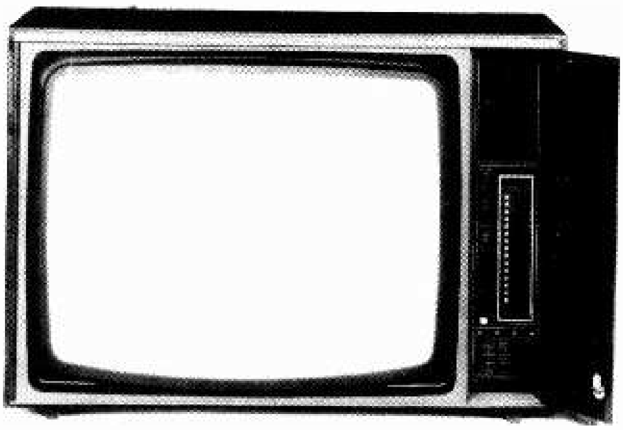


Fig. 5. The Berkshire Colour receiver-monitor can function as a line-fed sound and vision monitor or as a master receiver with video and audio line-feed outputs.

Since the distribution tasks are tending to become increasingly complex the trend in switcher design is to exploit the development of logic devices and techniques to simplify the actual desk panels required to achieve complex switching sequences. In the latest systems it is possible to commit several matrix formats to a storage memory in advance and to call them up individually when required at the touch of a single push button. In the latest systems the logic circuits are clocked by the field sync pulses so that the actual switching action takes place during the vertical interval, giving minimal visual interference with the displayed picture.

Special Effects

Development of high-speed l.s.i. logic devices has opened the door to a wide variety of digital television signal processing techniques, ranging from timebase correctors to versatile standards convertors such as the now famous DICE developed by the IBA.

Perhaps the most fascinating area of application, however, lies in the field of special effects, where a single microcomputer-controlled unit can now produce all the well-known effects previously achieved with optical methods, such as insertion picture compression and positioning, hall-of-mirrors and kaleidoscope effects, and a large number of other effects outside the scope of optical or analogue electronic systems.

Several of the leading television equipment manufacturing companies are using digital techniques in varying degrees.

Quantel Ltd of Caterham, Surrey, who have just introduced a small, low-cost digital standards converter and a timebase corrector, were demonstrating a range of versatile frame-store and synchronizer systems. These permit insertion of a second still or live image of any size into any part of the display. Joystick positioning and continuously variable expansion or compression of the second image display enable the system to be used for any of the effects hitherto achieved by optical methods, controlled by a single operator and without the inevitable loss of picture quality that results from analogue or optical techniques. Indeed, the discriminating viewer at home could probably recognise the use of digital equipment for these effects by the excellent quality of the inserts.

The American Grass Valley Group's equipment ranges from signal routing switchers to comprehensive digital mixers and special effects equipment with built-in chroma-key switching and character generators. In addition to normal mix and fade effects, provision is made for a wide variety of pushbutton-selected geometric wipes with either hard or soft transitions, together with some very spectacular and seemingly impossible effects such as the simulation of a magnifying glass of variable strength and size, which can be positioned anywhere on the screen.

One of the most useful effects available is the shadow key system, which allows natural shadows to be included in a chroma-keyed insert for added realism. And, not surprisingly, provision is also made for digital scene-sync whereby a digitally stored background maintains the correct perspective with a panned foreground insert.

Test Equipment

In as complex a system as colour television transmission, test instruments for accurate setting up equipment and for continuous monitoring of the transmitted signal are essential to preserve good picture quality. Most of the major manufacturers, therefore, also produce associated measuring instruments, which often form part of fixed installations.

Tektronix have become leaders in c.r.t. display equipment with their well-known range of vectorscopes, waveform monitors, and television-orientated oscilloscopes. A representative range of this equipment was on show at Montreux together with the associated test signal generators. A new product from Tektronix was a synchronous demodulator for accurate recovery of the video waveform from the vestigial sideband r.f. signal. This is an essential piece of equipment for overall transmitter equalization tests using sine-squared-pulse and bar test waveforms, since the use of a simple envelope detector introduces a degree of quadrature distortion owing to the loss of high frequency components in one sideband.

In modern transmission systems, where conditions may vary during the programme the picture quality is now monitored continuously by the use of special insertion test signals imposed on certain unoccupied lines of the vertical interval. To maintain a constant vigil on these waveforms using visual waveform monitors is virtually impossible and a degree of automation at the monitoring terminal is essential.

Marconi Instruments Limited of St. Albans showed a convincing demonstration of a fully automatic monitoring system based on their new 24-parameter Insertion Signal Analyser. This was scanned continuously by a data monitor programmed to initiate an alarm when any "out-of-limit" result occurred and to take executive action to switch to a standby transmitter or video feed as appropriate. The automatic system shown also included the company's data selector interface unit to a transmission/recording system — e.g., a line printer or teletype — for remote automatic monitoring.

In addition the Insertion Signal Analyser was shown operating in its semi-automatic mode in which it can be interrogated by operation of the appropriate push button to give the status of any one of the monitored parameters as a digital readout on an LED display, with a printed record on an associated teletype.

This equipment is representative of a new generation of monitoring instrumentation that is becoming essential in order to meet the picture quality required in the widespread national and international networks, and the company claims to have established an international leadership in this field. Philips in the Netherlands and Rohde and Schwarz in Germany have also developed automatic monitoring systems, which were shown at Montreux.

It is encouraging to be able to end this review on a note of British leadership. It has, of course, been possible to mention only a few of the companies who participated, but it is worth noting that, contrary to the situation on the consumer television market, Japan was represented by only one exhibitor, Sony, although it must be admitted that many of the colour c.r.ts and probably all the shadowmasks originated from that country.

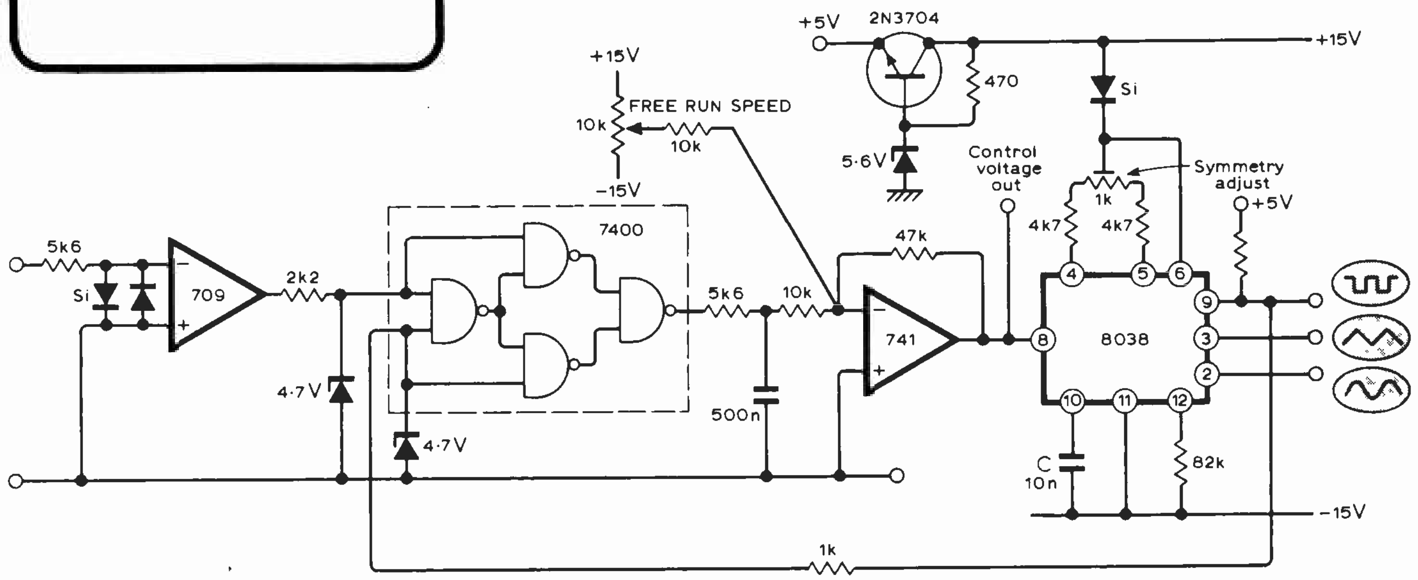
Circuit Ideas

Pitch to voltage converter

This phase locked loop circuit was designed to provide a voltage proportional to the pitch of a signal from an electric guitar or microphone. It also generates sine, square and triangle waveforms, phase locked to the input signal. An uncompensated 709 op-amp is used to amplify and limit the input to a 7400 connected as an exclusive-OR phase comparator. The control voltage is filtered and amplified, and controls the frequency determining circuitry in an 8038 function generator.

In use the free-run frequency is adjusted so that the v.c.o. oscillates above 20kHz. When a signal is applied it jumps into lock and becomes audible. Other possible uses include slow scan tv demodulation, or as the p.l.l. in a chord generator of a synthesizer.

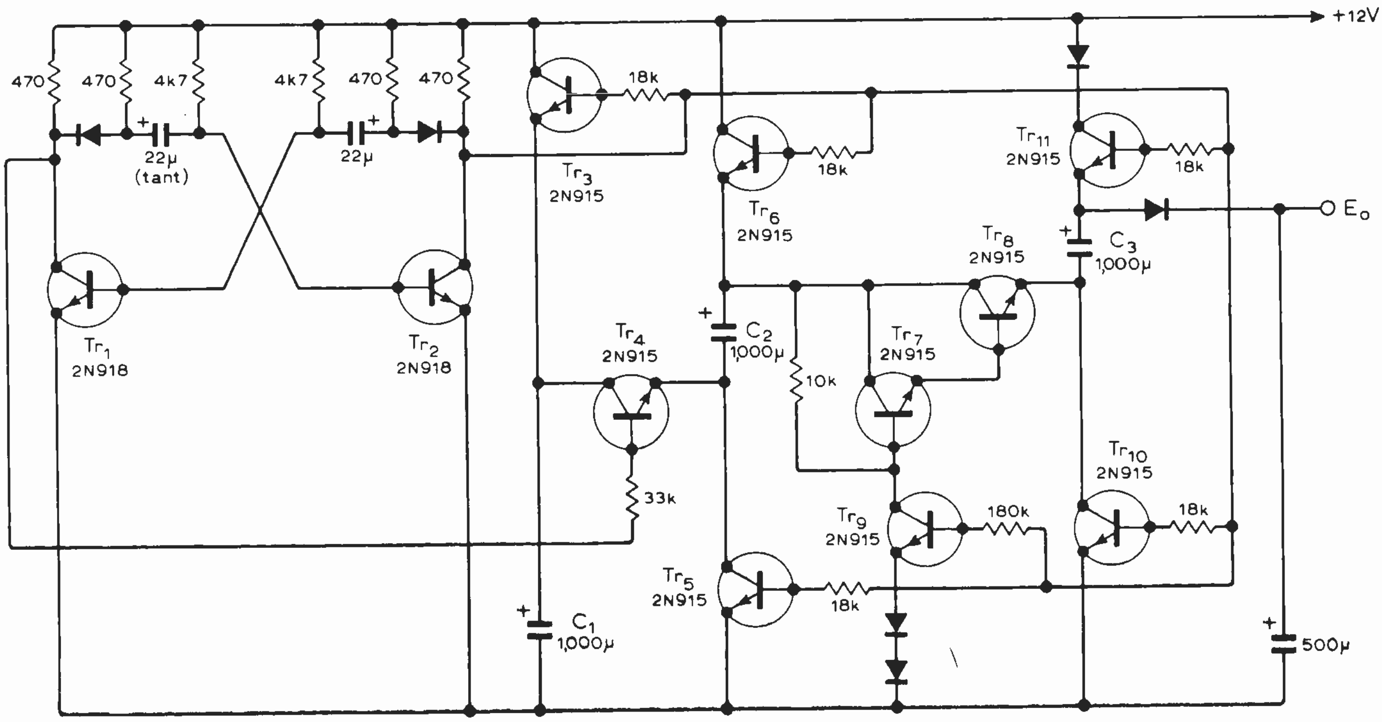
A. G. Falla,
Nottingham.

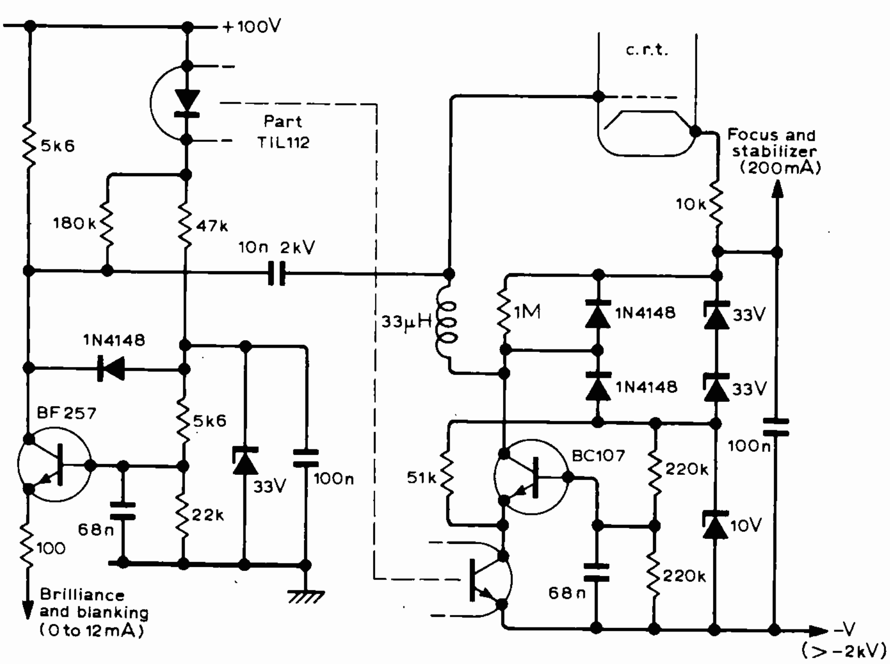


Transformerless d.c. to d.c. converter

This converter operates by charging a bank of capacitors and connecting them in series periodically to give a higher voltage at the output. Transistors Tr_1 and Tr_2 form a multivibrator which produces a square wave. When the output of Tr_2 is positive C_1, C_2 and C_3 are charged through Tr_3, Tr_5, Tr_6, Tr_{10} and Tr_{11}. When the output of Tr_2 is zero, these transistors are cut off and Tr_4, Tr_7, Tr_8 are switched on, which connects the capacitors in series. In the prototype circuit the output voltage was 30V at 1mA although, using high current/voltage switches, an improved performance is possible. This system is also lighter in weight compared to transformer type converters.

H.R.S. Andrew,
Hyderabad,
India.





Optically coupled grid blanking

Grid blanking for c.r.ts can be a problem due to the high direct voltage difference between the blanking amplifier and c.r.t. grid. This often necessitates the use of a second h.t. winding to provide a floating supply. In this circuit an opto isolator is used with unity gain loading to provide d.c. and low frequency control. the 10nF capacitor takes over at higher frequencies. In order to maintain linearity within 5%, the isolator is biased to deliver 130μA and can deliver 60 p.i.v. at the c.r.t. grid. Temperature stability is adequate, and the brilliance control can be mounted in the low voltage section of the circuit. It is advisable to mount the blanking amplifier as close to the tube base as possible in order to maintain bandwidth and immunity to interference.

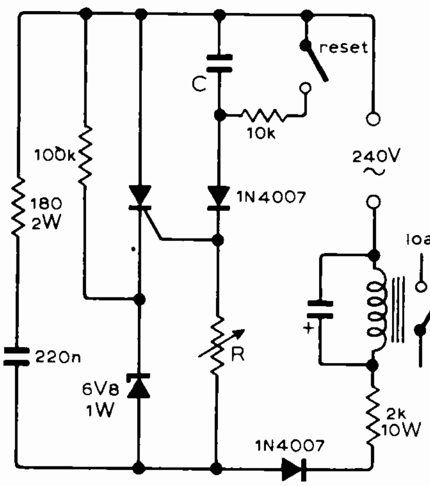
J. M. Rubery,
Rotterdam,
Holland.

Economic timer

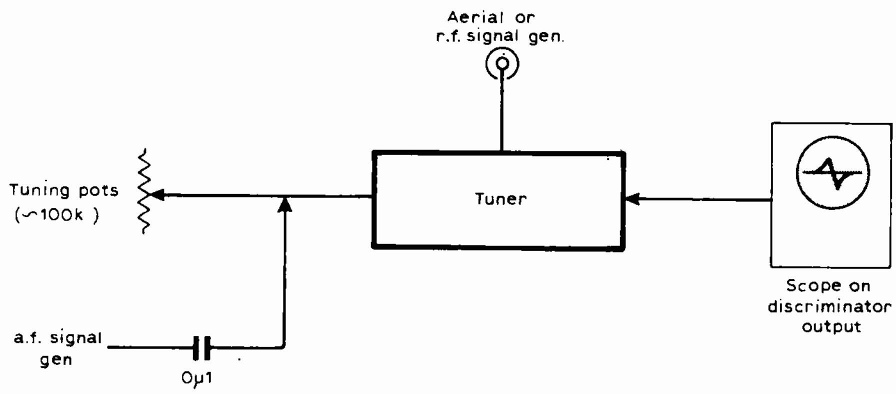
Many electronic timers require excessively high values of capacitance and resistance when used for long delays. If extreme accuracy is not required, this circuit overcomes the problem. When the mains voltage is applied capacitor C is initially discharged. The rising edge of the rectified sine wave causes a voltage across R which supplies a charging current to capacitor C. When the voltage across R reaches the thyristor trigger voltage it turns on and stops the charging of C. The relay is turned on and load current flows. On the next rising edge, triggering occurs at a higher voltage i.e. later in the cycle because there is a residual charge on C. Therefore, each successive mains cycle increases the charge on C. The circuit remains turned off when the voltage on C reaches the peak supply voltage.

The 180Ω resistor and 220nF capacitor supplies the initial current pulse to ensure a fast turn on of the thyristor. Using a low leakage capacitor for C the delay times shown in the table were obtained. Timing is stable to within 10% if the zener diode and thyristor are mounted together on a heat sink, and best results are obtained with low values of R and high values of C. Full wave rectification of the supply may be used to halve the delay times. In certain applications, where retriggering may occur due to voltage surges, a clipping circuit can be used on the supply. Certain thyristors, which have an internal resistor from gate to cathode, are unsuitable in this circuit.

G. J. Thompson,
Codnor,
Derbys.



C(μF)	0·01	0·1	1·0
R(Ω)	time (min-sec)		
10k	—	0-15	2-43
22k	—	0-35	5-51
47k	0-04	1-09	11-47
100k	0-09	2-10	23-25
220k	0-15	3-54	46-50
470k	0-27	7-39	98
1M	0-45	13-51	220



F.m. tuner wobbulator

The discriminator coil in an f.m. tuner should be set up with a wobbulator. If this equipment is not available a varicap f.m. tuner can be used as its own wobbulator in the following way. Tune to an unmodulated station near the top of the band, or to an r.f. signal generator connected to the aerial and tuned to about 97MHz. Connect an oscilloscope to the discriminator output, and an a.f. signal generator, via a capacitor, to the front-end tuning input, as shown in the diagram. Increase the 200Hz a.f. generator sine output until the whole discriminator characteristic is seen. For the LP1186 this corresponds to about 0.3V pk to pk. The oscilloscope should be on the normal time base, and triggered from the audio generator. The 1186 tuning law is $f = (22 \log_{10} V + 81)$ MHz, and a 500kHz sweep is 3.3kHz out at the centre due to the logarithmic characteristic. This error is too small to be visible. Other varicap front ends will probably follow a similar law.

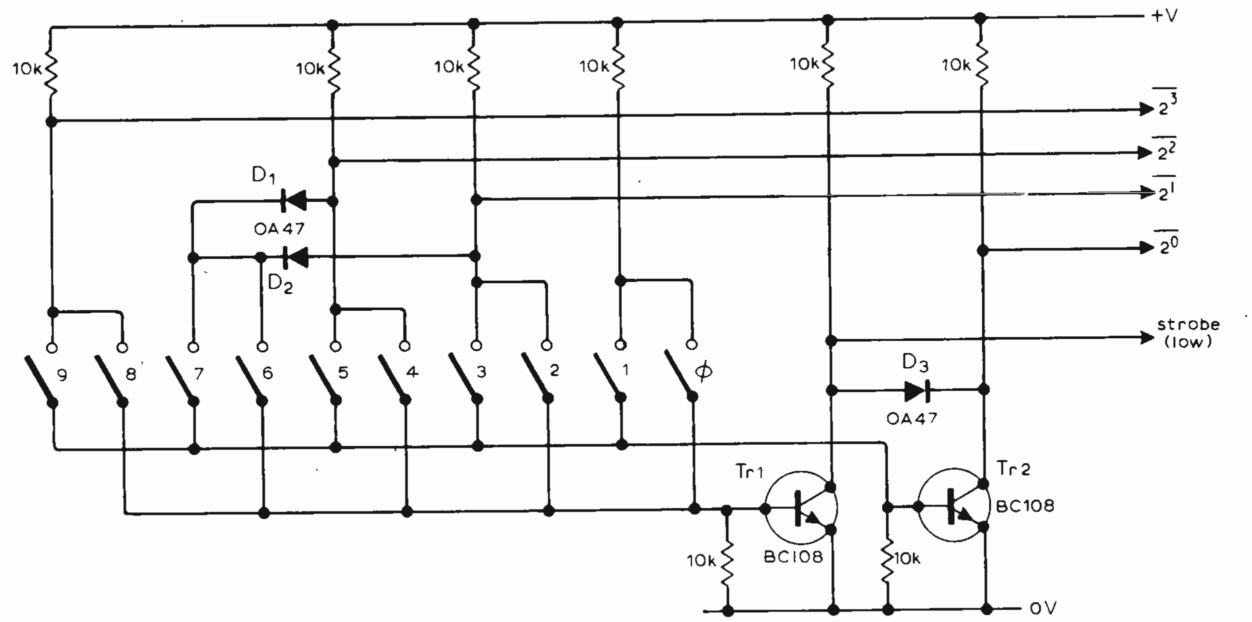
R. D. Hore,
Basingstoke,
Hants.

Keypad encoder

A simple and inexpensive solution to the problem of encoding a push-button numerical keypad can be achieved using the following circuit. Whenever an odd-value key is pressed, transistor Tr_2 saturates and provides the 2^0 output. The other outputs are pulled down as appropriate for the depressed key. When an even-value key is depressed, Tr_1 saturates and drives the strobe line low. Because the strobe line is also pulled low by Tr_2 through D_3, it indicates than any key has been pressed. Outputs 2^1, 2^2 and 2^3 are pulled low as appropriate. Keys 6 and 7 are required to pull down both 2^1 and 2^2 outputs. This is done through D_1 and D_2.

The output swing is between +V and about 1V, and will therefore interface directly with c.m.o.s. logic.

A. F. Cross,
Old Windsor,
Berks.

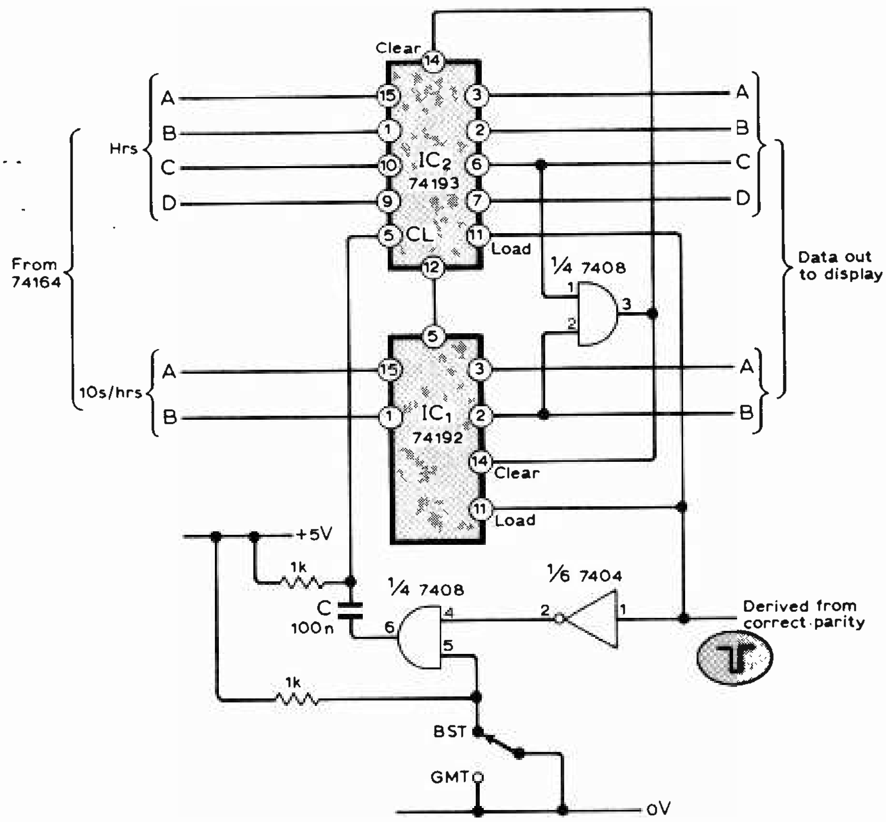


GMT/BST converter

As an alternative to using full adders, a GMT/BST converter for use with MSF clocks can be constructed using a synchronous 4 bit up/down counter and a synchronous b.c.d. up/down counter, together with two AND gates plus an inverter. For GMT, the data presented to the inputs of IC_1 and IC_2 will be transferred to the outputs when a negative pulse from the parity detector is applied to the load input. If the parity is invalid then no pulse will be generated and the previous data will remain displayed.

For BST all that is necessary is a positive going edge, following the load pulse, at the clock input to modify the decimal output by one. Carry out from IC_2 to the clock input of IC_1 must be connected. The 100n capacitor differentiates the inverted load pulse to produce a delayed positive going edge. Gating of IC_1 output B, and IC_2 output C, is required to reset the i.cs at 24.00hrs.

C. G. Armstrong,
London N.W.1.



World of Amateur Radio

Conditions set fair on h.f.

May and early June provided the long-awaited signs that sunspot cycle 21 is really beginning to bite. On 14, 21 and, at times, 28 MHz, it was as though someone up there in the Hams' Happy Hunting Grounds had decided it was time to wipe clean those long-distance windows on the world. West Coast Americans and Canadians, stations in the Far Eastern oblasts of the USSR (including the rare zone 23), Japanese, South Americans, Australians . . . all came roaring through once again, at strength, often with European signals arriving on 21 and 28 MHz by means of Sporadic E openings. Not only were the maximum usable frequencies very high for F layer propagation but the D layer attenuation seemed at times particularly low.

Even those of us who take DX as it comes, without dedicated "chasing," found our logs filling up with stations in all continents in a manner very different from the struggle of recent sunspot minimum years. At such times the various propagation prediction charts tend to get left far behind: unexpected paths open up and stay open for long hours. Suddenly the prospects for a high peak in cycle 21, perhaps as early as 1979-80, seem to have become much brighter. Whereas up to a year or so ago most forecasters were talking in terms of an even lower peak than for cycle 20 in 1968-69, more and more seem prepared to predict that we may be starting towards another exceptionally high peak, such as we experienced in 1958.

It is quite likely that by this autumn we shall be able quite often to eavesdrop on the 27MHz North American citizens' band explosion, where the industry has been trying hard to unload at cut prices stocks of 23-channel models to make way for 40-channel models.

Amateur pioneers

One of the highlights of the RSGB's Alexandra Palace convention and exhibition was the opportunity to listen to that doyen of v.h.f. columnists, Ed Tilton, W1HDQ, review the role of radio amateurs in uncovering and showing how to exploit so many of the odd quirks of v.h.f. radio propagation over the period 1932 to 1977. He also made some pretinent comments on the growth of "repeater" operation although he was able to reassure British amateurs that in North America there are still plenty of other forms of operation, even though there are very few amateurs anywhere in the United States who cannot access at least one repeater station. One of the problems resulting from so much repeater and mobile operation is the question of mixed vertical and horizontal polarisation now used and he clearly felt it a pity that there are not more horizontally-polarised repeater stations.

Ed Tilton is a firm believer in the theory that new propagation modes are first discovered by accident — but that whereas professional research and communications people have to keep their eyes firmly on commercial or orthodox objectives, the amateurs are exceptionally well placed to follow up accidental discoveries.

He quoted the original amateur contacts by Sporadic E on 56MHz in the early 1930s; the work of Ross Hull (an Australian amateur who joined the ARRL staff in the 1930s but who was later electrocuted while working on television equipment) who investigated the early reports of tropospheric propagation; the historic 50MHz F-layer transatlantic contacts that Ed Tilton made with Dennis Heightman, G6DH, in 1947; the discovery by amateurs of transequatorial (t.e.p.) propagation, including the painstaking experiments between Cyprus and Rhodesia.

When first reported, many of these now familiar discoveries had been written off by the experts as "freak propagation."

Scanning the bands

Peter Blair, G3LTF, has now joined the select band of amateurs who have "worked all continents" on u.h.f. through the medium of "moonbounce" (earth-moon-earth paths). The first British amateur to achieve this distinction, his recent 432MHz moonbounce contacts have included those with JA1VDV Japan; ZE5JJ Rhodesia; and FY7AS French Guiana.

Gordon Knight also reports in *Radio Communication* that Paul Widger, G8AGU in South Molton, Devon, is using 400-watts p.e.p. s.s.b. output on the 432MHz band and is able regularly to make contacts up to 250 miles despite local screening even in average conditions. He keep daily schedules with amateurs in Manchester and Southend. With a high-gain multi-element antenna his effective radiated power is of the order of tens of kilowatts.

The A9XC 28MHz beacon on Bahrein has been heard a number of times in the United Kingdom. Several new beacon stations are currently being built for such places as Gough Island (ZD9GI) and Peru (OA4VHF) and the privately-run beacon on Florida is now using the call sign N4RD on 28.2075MHz. All beacons are gradually being moved to the frequency range 28.2 to 28.25 MHz and should prove exceptionally useful as a check on 28MHz openings this autumn, as well as for scientific studies. Altogether 17 of these 28MHz beacons in all continents are either operational, under construction or in the planning stage, states *IARU Region 1 News*.

Project Vesna is a new attempt to span the Atlantic on v.h.f. by means of the Sporadic E mode of propagation. As part of this project a new 50.1MHz beacon (F3THF) has been approved by the French authorities and should by now be operational on the north coast of Brittany, beaming west, with f.s.k. keying (170Hz shift) to provide identification every 50 seconds.

It is easy to work American amateurs on 144MHz if you are prepared to pay a hefty telephone charge. You simply phone an American v.h.f. repeater station via transatlantic cable or Intelsat satellite and then start working the local American amateurs using your own callsign.

In brief

Amateur A licences in the sequence G4GAA are now being issued. Class B licences will soon have exhausted the G8NAA series . . . A. G. Godfrey, ZL1HV and formerly G3DAF, is the current president of the New Zealand Amateur Radio Transmitters Society . . . The 42 national societies who make up the IARU Region 1 division have 94,350 members. From next year the member-societies will be asked to contribute one Swiss franc for every licensed member to help meet the rising costs involved in preparing for the 1979 WARC meetings where all radio frequency allocations come under discussion. The central IARU headquarters in the United States has contributed $10,000 to the Region 1 fund. The Region 1 division is to hold a conference in May 1978 at Miskolc-Tapolca in north-eastern Hungary . . . Dr Dain Evans, G3RPE, is now "microwaves manager" for the RSGB . . . The RSGB National Mobile Rally has been put back into the annual calendar of events this year. Location is Woburn Abbey. Date is August 7 . . . Other August rallies include Derby (Ryknled School) on August 14; Pembroke "Bucket and Spade Party" on August 14 at Regency Hall, Saundersfoot; Preston on August 21 at Walton le Dale County Secondary School, Bamber Bridge; and Torquay on August 28 at Haldon Racecourse near Exeter . . . The Italian national amateur radio society "Associazione Radiotechnica Italiana" celebrates its 50th anniversary this year and a special convention/exhibition is being held in Florence from September 24 to October 3.

PAT HAWKER, G3VA

Rate sensor testing and precision motion systems

Methods of measuring and calibrating angular velocity transducers

by R. G. Bent *Cranfield Unit for Precision Engineering*

Outside the field of avionics very few people have any detailed knowledge of the rate sensor. The purpose of this device is to sense or measure a rate of change of angle. Any form of servo control for stabilization of weapon systems, radar antennae, and space vehicles uses the rate sensor for the measurement of vehicle behaviour. More precisely, the rate sensor measures the rate of change of angular relationship between the vehicle and a fixed earth plane. As with any transducer, performance and specification is of great importance to the system designer. The advent of non-rotating sensors has highlighted the need for standardization of test and calibration procedures, and is emphasizing the design requirements of specialized test equipment.

There are several types of rate sensor and these can be split into three main categories. These are: H rate sensors (H being the symbol denoting angular momentum); angular acceleration rate sensors; and non-rotating rate sensors. Non-rotating sensors use techniques such as the measurement of Coriolis forces induced in vibrating wires, or the deflection of ionized jets of gas between hot wires. A practical application of the theory of relativity is also used as with the ring-laser gyroscope. The most commonly used sensor is the rate gyroscope which has a high angular-velocity spin-rotor of constant angular momentum held in a gimbal arrangement.

When a torque is applied to a gyroscope the spin axis does not move in the direction of the applied torque, but rotates, or precesses, about an axis in quadrature to both spin and torque vector axes as shown in Fig. 1. Directions of vectors are established by the right hand thread rule. The spin vector tries to move into the torque vector, as visualised using the right hand rules — thumb points to spin vector, index finger points to torque vector, and middle finger points to precession vector. The relationship between torque and precession is given by the law of gyroscopics where torque T = inertia I × spin velocity ω_s × precession rate ω_p or, given that angular momentum equals $I \times \omega_s$, then $T = H\omega_p$.

A gyroscope can be considered as a bilateral device because, if a torque is applied then the gyro precesses at an angular rate, but if the gyro is subjected to an angular rate then the result will be an output torque proportional to the input rate. It is this last mentioned feature which is used in the rate sensor gyroscope. The torque resulting from the applied rate is counter-balanced by a restraining torque which is translated into an electrical signal.

An angular accelerometer converts an input angular acceleration into an output voltage proportional to that acceleration, see Fig. 2. The accelerometer is sensitive to angular accelerations about the input axis IA and is rotated at a constant speed ω_s about spin axis SA. If the system is now subjected to an input rate ω_x about axis RA, the instantaneous rate about axis IA will be $\omega_0 = \omega_x \sin \omega_s t$ and the input rate will change to a time-varying angular acceleration. The rotating accelerometer acts as an integrator that provides, for constant spin rate ω_s, an a.c. output voltage whose amplitude is directly proportional to the input rate ω_x at a frequency equal to the spin rotation frequency.

Rate transfer test

Recently, moves toward standardization of test procedures for rate sensor calibration have been made, as suggested by the IEEE gyro and accelerometer panel in America, [1, 2 and 3] and the Inertial Components Assessment Laboratory at the Royal Aircraft Establishment[4]. One of these test procedures, which provides the input-output characteristics of the sensor, is the rate transfer test where the sensor is progressively exposed to different input rates over its operating range. Rates are

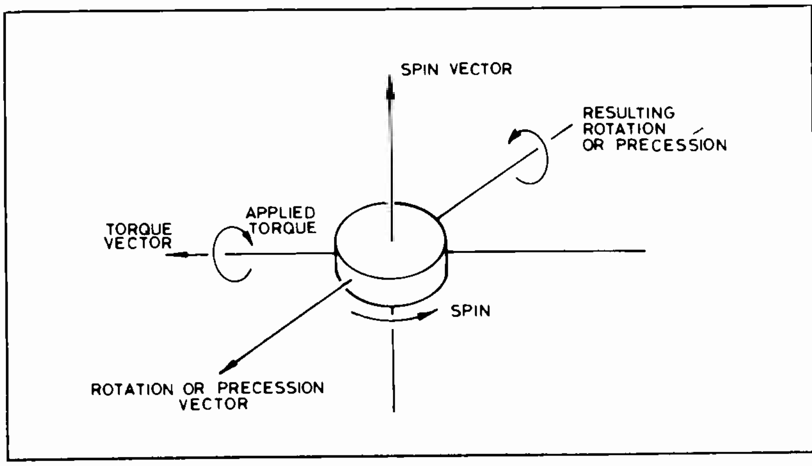


Fig. 1 (left) Torque, spin and resulting rotational axes of gyroscope.

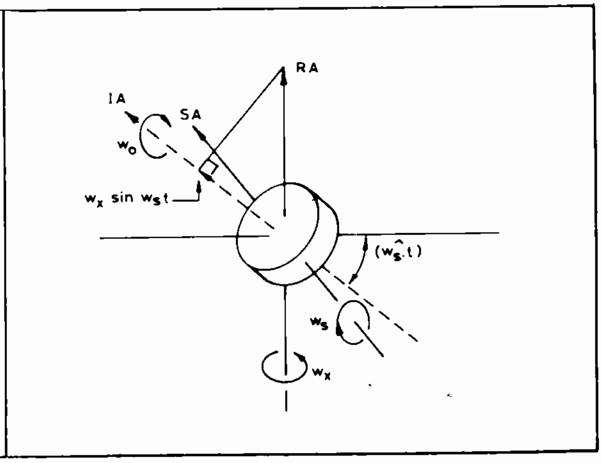


Fig. 2 Input axis IA, spin axis SA, and rate input axis RA of an angular accelerometer.

Table 1: Characteristics obtainable from a rate transfer test

Scale factor-slope of best straight line.
Intercept of the best straight line.
Error at each increment of rate input.
That error expressed as a percentage of its rate input.
Standard deviation of the non-linearities.
Maximum non-linearity-composite error.
Zero offset.
Hysteresis at zero input rate.
Maximum hysteresis and the table rate at which it occurs.
Orthogonality of the two axes in a two axis rate sensor.

applied in the form of a hysteresis loop at set increments starting at zero. After the sensor has seen one increment of negative rate, the input is increased to a maximum positive rate, one increment beyond, reduced back to zero and up to the maximum negative rate, one increment beyond, and eventually back to zero rate. Data from the first negative increment and the two rates in excess of positive and negative maximum are ignored in the subsequent calculations. This information is used to calculate the best straight line through all the data points taken. The slope of this line is the scale factor for the sensor. Using the sensor's output at any particular angular rate, it is possible to calculate its deviation from the best straight line, and this is the residual, or error, at that input rate. With computations for each data point, an error pattern is built up for the entire input range. Table 1 lists the parameters yielded by the transfer test as implemented at RAE, and Fig. 3 illustrates the input-output characteristics in graphical form. In practice the sensor's output appears linear with no apparent hysteresis or non-linearity and this diagram has been grossly distorted in order to illustrate the various parameters.

Constant rate test equipment

Rate gyroscopes and angular rate sensors usually have a voltage output which is proportional to the angular rate applied about the input axis. The basis for any test is therefore a means of measuring the output voltage as a function of a known applied input angular rate. A prime requirement is a rate table capable of rotating in either direction at accurately defined angular rates. The range of the table needs to cater for the maximum rates of the sensor and should also provide very low angular rates, which can be changed in very small increments, to allow threshold and resolution measurements. A typical piece of equipment will provide angular velocities ranging from 1000°/s to 0.0001°/s.

Recent designs use a direct drive d.c. torque motor and a precision d.c. tachogenerator rigidly coupled to a large diameter shaft on which the table platter is mounted. This avoids errors associated with geared systems. Figs. 4 and 5 illustrate the CUPE (Cranfield Unit for Precision Engineering) 2200 series direct drive rate table. The basic control for driving the rate table assembly is a velocity-error servo-system as illustrated in Fig. 6. The tachogenerator output is compared with the required rate derived from the precision voltage reference. The error signal feeds a d.c. amplifier which drives the torque motor and maintains the required rate. Long term performance of the servo loop will be affected by drift in either the preamplifier or the feedback tacho amplifier, so operational amplifiers exhibiting minimal changes in input offset voltage against both time and temperature are used.

A typical system incorporating a 600W d.c. power amplifier, a 0.1% tachogenerator and a 30 Nm torque motor, will provide a performance specification as listed in Table 2. The system uses a precision voltage reference and divider network for the control signal to the servo-system. If this reference is set at zero and an externally generated signal is injected in its place, the rate can be programmed remotely. Also, the rate can be varied continuously through zero and monitored from the tachogenerator. Response of a system is controlled by the power available from the amplifier, characteristics of the torque motor, inertia of the moving parts, and the elimination of electro-mechanical resonance.

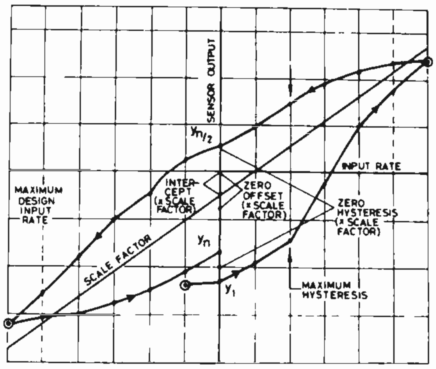


Fig. 3 Rate transfer characteristics.

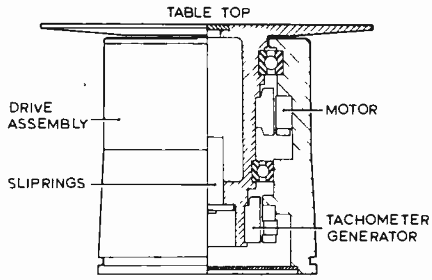


Fig. 4 Cross section of a direct drive rate table.

Table 2. Typical performance specification of a standard rate table.

Speed	Full scale ranges	°/sec	1000
			100
			10
			1
	Resolution on digital speed setting	% of full scale	0.01
	Accuracy at temp. of calibration,	% of set speed	0.1
	Averaged over one revolution	+% of full scale	0.002
		+°/sec	0.0003
	Temperature coefficient	% of set speed/°C	0.02
	Speed variation, wide-band-averaged	% of set speed	0.1
	over 1°	+% of full scale	0.002
		+°/sec	0.0003
Acceleration	Maximum, no load	°/sec²	16,000
		rad/sec²	275
	Time for full reversal, +1000°/sec to 1000°/sec, with no load	sec	0.2
Peak torque	at stall	Nm	30
		lbf. ft.	22
Table top	Diameter	mm	305
		in	12
	Material		Hardened Aluminium
	Flatness	mm T.I.R.	0.03
		in. T.I.R.	0.0012
	Load capacity	kg	160
		lb	350
	Inertia	kgm²	0.107
		lbf. ft. sec²	0.079
External Control	Input required for full scale speed	V	+5
	3dB bandwidth for 10°/sec peak to peak sinewave demanded input	Hz	115
Slip rings	No. power circuits 5A		6
	No. twisted pairs of signal circuits 1A		20
	Noise per ring in bandwidth of 1KHz	m	10
Calibration output	One pulse 0V to +5V per rev		
	Angular accuracy	%	+0.05
	Duration	msec	5
	(10 pulses per rev can be provided as an optional extra)		

Automated testing

Besides providing information on the various parameters, the rate transfer test is used as the fundamental calibration of any rate sensor. It is therefore important that the test conditions are repeatable. Many factors can influence the output of a rate sensor, such as settling time, which is the time allowed after a change to an input rate before the sensors output is recorded, and the dwell time.

The effect of most variables can be minimised by agreed standardisation between different operators, but for exact repeatability of test conditions it is essential that the process is automated. The need for automatic testing of rate sensors has led to the development of rate table programme units which accept paper-tape commands for range setting and rate control, and provide digital monitoring facilities. A precision digital-to-analogue converter is used in place of the voltage reference source and divider networks, with relays to control the setting of range. Such units can be driven by a numerical control and logging station which translates commands from punched paper-tape and issues them upon clock demands as b.c.d. signals to the unit. After a preset delay, data are recorded in punched tape form for subsequent computer analysis.

The parameters established by the rate transfer test are obtained under steady state conditions. In practice, however, the sensor is normally used dynamically within a servo-control system, and knowledge of the dynamic characteristics is required. This is achieved by subjecting the sensor to oscillating rate inputs and measuring the amplitude and phase shift of the corresponding outputs. In this way information on the transfer function order, gain and error constants, and resonant frequencies is obtained. The oscillating rate table is designed specifically for high bandwidth frequency testing of rate sensors. The basis for the oscillating table and control system is a velocity servo-loop similar to that used for standard rate control. Frequency response of the system is usually limited by the resonant frequencies of the mechanical coupling between table platter and motor drive.

The inertia of the moving parts controls the peak rate achievable from the available torque at any specified frequency of rate oscillation. Consequently, oscillating tables tend to be of a smaller and lighter construction than the constant rate types. The performance of a typical system using a 250W d.c. amplifier to power a 9.5 Nm torque motor is shown in Table 3.

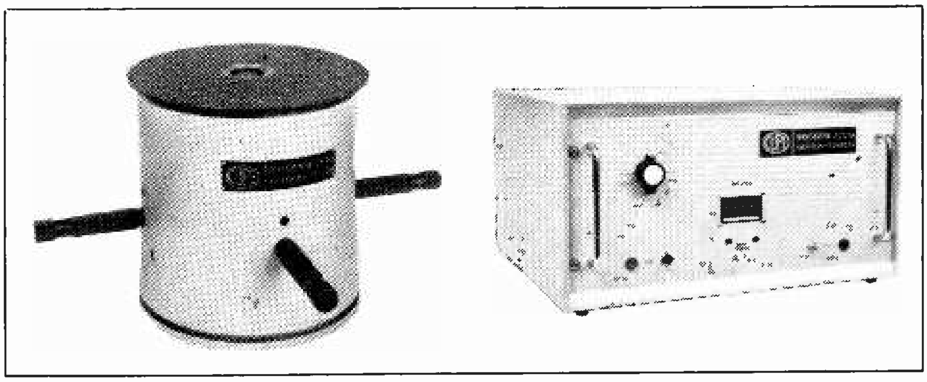


Fig. 5 Rate table and servo-system control unit.

Precision low rate testing

Integrating-rate gyroscopes are restrained from rotating about their output axes by a torque generator. An angular pick-off between gimbal and case provides the input signal to a gyroscope servo-loop which drives the torquer and restores the gimbal angle to a null. Thus the integrating gyro is a low-rate input device in which the time integral of the torquer current represents the total angular movement of the gyro. Any error torque will generate a compensating current through the gyroscope servo and will be integrated into the calculation of angle. Predictable non-random error torques may be quantified at low rates on a rate table and may be subsequently removed by compensation within the avionics. At low testing rates, typically one degree per hour and below, the signal from the tachogenerator of the rate table is liable to drift by as much as 10%. Also, the table rate may be swamped by the earth rate of 15 degrees per hour. Proportions of earth rate, or vector summations of earth rate and table rate, can be achieved by precise orientation of the gyroscope and table axis relative to the earth axis. This is most easily achieved with a precision tilt-stand. A solution to table error at low rates is the use of precision position

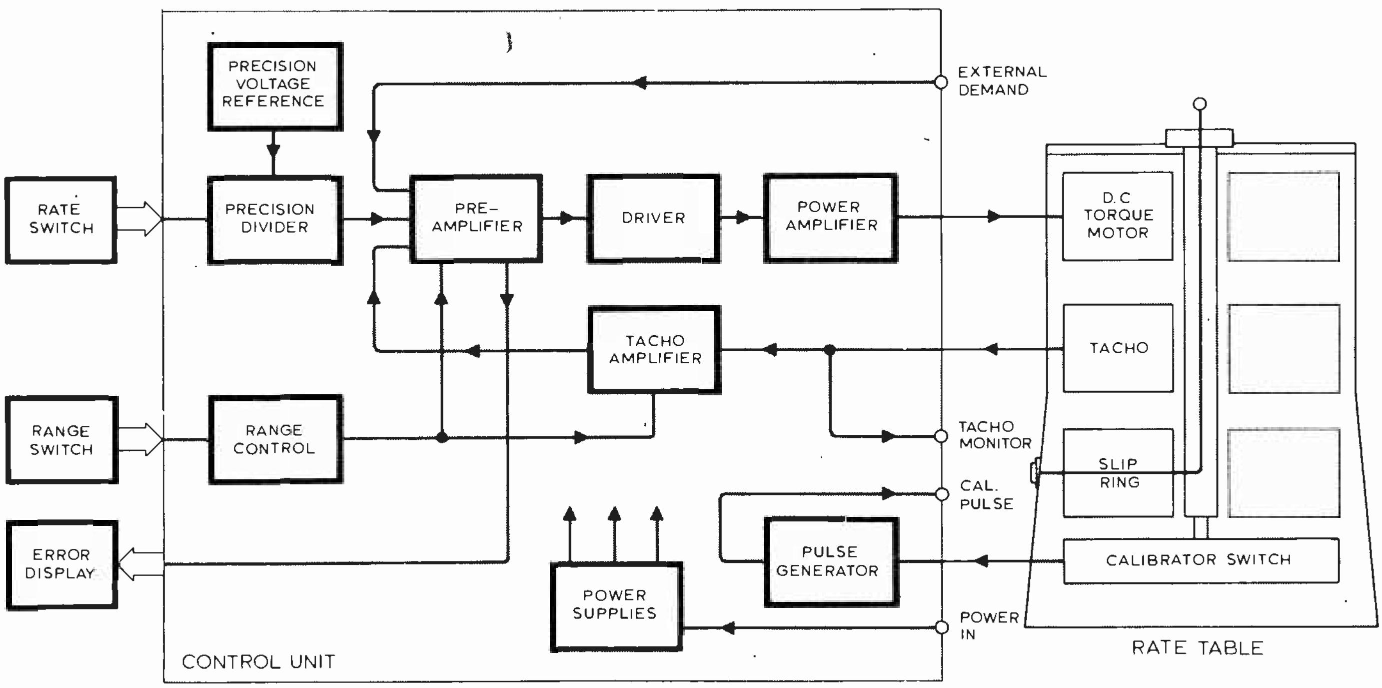


Fig. 6 Block diagram of rate table control system.

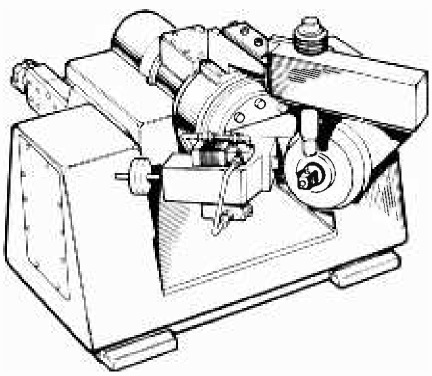


Fig. 7. Multi-axis system. This system allows three-axis component testing from two axes.

markers to monitor the average rate between pulses. Moire fringe techniques will provide absolute positional accuracies to ±0.001°, allowing rate to be monitored to an accuracy dependent on the averaging distance.

Multi-axis systems and motion simulators

In practice rate sensors are rarely used singly but are incorporated within an overall system containing two or three sensors aligned with mutually perpendicular axes. Each sensor is calibrated, both for steady state and dynamic response, for inputs about the rate-sensitive axis and also for inputs about the other two axes, to determine any cross-coupling effect.

By using a multi-axis rotational table, a sequence of rates may be applied along various directions without the need to physically move the system. The testing of all axes ensures that the same conditions apply to each test and also removes the possibility for error in relocating the sensitive axis. The natural extension of using a multi-axis system is to simulate the motion of the vehicle in which the package will be used. A computer is programmed to generate the vehicle response to signals from the package, and the multi-axis system is driven by the computer to simulate the resulting vehicle motion. Thus, the multi-axis system can be used as a development tool to calibrate and test systems and can also provide a useful facility during the design and development of the control system.

Design difficulties for a multi-axis system are the same as those for a rate table, but multiplied by the number of axes and compounded by the physical size and inertia of the axis elements and the need to carry one axis within another. The basic components are the same as previously described for rate tables, a d.c. torque motor drive, tachogenerated signal for rate achieved, d.c. power amplifier, and slip ring assembly, for each of the rotating axes. The reference rate is set either internally by a precision voltage reference or by external analogue signals from the computer. In addition there is usually a mechanical accuracy requirement for orthogonality of the axes and the sphere of axis intersection. It is an unavoidable fact of life that the axes increase in physical size from innermost to outermost, with consequent decrease in speed, acceleration, and frequency response. The inertia of each axis controls the dynamic capability of the system and thus optimum performance is achieved by designing each multi-axis system for the specific application. Fig. 7 shows an optimised design which achieves three-axis component testing from two axes. This can be used when two of the axes are interchangeable. For example, in the case of a missile spinning about the roll axis, the pitch and yaw axes see identical motion waveforms which are 90° apart.

Table 3. Typical performance specification of an oscillating rate table.

Peak rates	Input frequency 2Hz (No load)	°/sec	1000
	Input frequency 200 Hz (No load)	°/sec	60
	Input frequency 200 Hz (load 0.01 lbf. ft. sec^2)	°/sec	17
	Input frequency 200 Hz (load 0.02 lbf. ft. sec^2)	°/sec	11
Acceleration		°/sec^2	100.000
Peak torque	(Nominal at stall)	Nm	9.5
		lbf ft.	7
Table top	Diameter	mm	152
		in	6
	Material		Surface hardened aluminium
	Flatness	mm T.I.R.	0.03
		in. T.I.R.	0.0012
	Inertia (total moving parts)	kgm^2	0.005
		lbf ft. sec^2	0.004
Inertia load capacity	Maximum inertia	kgm^2	0.03
		lbf. ft. sec^2	0.02
Demand	Sensitivity range 1	°/sec/V	1
	2	°/sec/V	10
	3	°/sec/V	100
	Maximum input	V	10
	input impedance	kn	100
	Frequency response		
	+ 1dB, small signal, unloaded	Hz	150
	+ 3dB, small signal, unloaded	Hz	250
Rate monitor output	Output voltage ranges 1 and 2	V/°/sec	0.1
	range 3	V/°/sec	0.01
	Minimum load impedance	kn	500
	Maximum load capacitance	pF	220
	Accuracy	%	1
		+°/sec	0.02
Calibration output	One pulse OV to + 5V per revolution		
	Angular accuracy	%	0.2
	Duration	mS	5

Conclusion

Major advances in the near future will be the universal adoption of standard calibration procedures, the use of test equipment in production areas, and the increasing use of completely automated test facilities. Longer term developments for test equipment are likely to be increased range and accuracy to accommodate new designs of sensor and more demanding applications.

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3. Test procedures for single - degree - of - freedom spring-restrained rate gyros, *IEEE Gyro and Accelerometer Panel*, November 1967.
4. Andrews, *T. R. DGON Symposium on Gyro Technology:* Calibration of the Rate Transfer Characteristics of a Rate Sensor, February 1976.

Correction to advertisement

AVO Limited have asked us to point out that in their advertisement for the AVO Model 73 in the June 1977 issue, p.10, the price stated was incorrect. It should read "UK Trade Price £36.30 plus VAT".

Amateur radio equipment — 1

A survey of modern commercially-built receivers, transmitters and transceivers

by Ray Ashmore, G8KYY

The radio amateur scene has changed quite considerably over the past fifteen years or so. Today the amateur equipment market is dominated almost entirely by the Japanese, instead of the Americans as it was ten years ago.

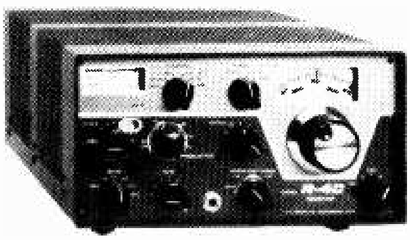
It was in the mid-sixties when the British and American manufacturers, such as Drake, Collins, Eddystone Radio, Hallicrafters, Hammerlund, National, Heathkit, Lafayette, Swan and KW Electronics and some European firms were first confronted with Japanese equipment. In those early days the products from the Far East were very similar, in basic design, to the then current American designs, but they were offered at 'landed' prices sometimes less, it is claimed, than what it was costing UK firms for components and labour for similar equipment.

The main Japanese companies which export amateur equipment to Britain, America and Europe at present are Trio (also known as Kenwood), Yaesu Musen (initially marketing in Europe as Sommerkamp) and Inoue (who manufacture Icom products). Other companies include Seiwa (makers of the Drake SSR-1 receiver) and Fukuyama (who make FDK products).

Another change resulted from the introduction of the Class B licence in 1964, which entitled amateurs who had passed the Radio Amateurs Examination, but not the morse test, to operate only telephony on frequencies of 430MHz and above – and later 144MHz and above. This resulted, initially, in an acceleration in the rate of issue of amateur licences, and later, in the appearance of amateur equipment for v.h.f. and u.h.f.

Before 1970 most of the equipment available was for, what are now, Class A licensees who may operate telephony and morse telegraphy (c.w.) in both the v.h.f./u.h.f. bands and the h.f. bands. At present, about sixty percent of commercial amateur equipment is for the amateur v.h.f. and u.h.f. bands. Another reason for this is that these bands are very narrow compared to the h.f. bands, and this greatly simplifies the manufacture of the equipment – for example, no bandswitching is required. This has resulted in a number of small companies setting themselves up to produce only v.h.f. equipment.

Although there are more amateurs today, fewer of them appear to be building their own main-station equipment. The main reason for this is that, with the increasing cost of one-off or small quantity electronic components, it is very difficult for the amateur to build such compact equipment equal in quality and performance to some of the Japanese equipment now available, for less cost. However, it is good to see that the manufacturers and traders make an effort to educate the amateurs in the workings of their products, through their instruction books, and encourage them to carry out their own repairs or modifications. Unlike the makers of domestic appliances and hi-fi equipment, amateur equipment manufacturers normally allow the amateur to carry out these operations without affecting the warranty – unless, of course, a fault occurs as a result of these operations.



Drake R-4C valve/semiconductor hybrid receiver.

Drake SPR-4 programmable receiver introduced in 1971.

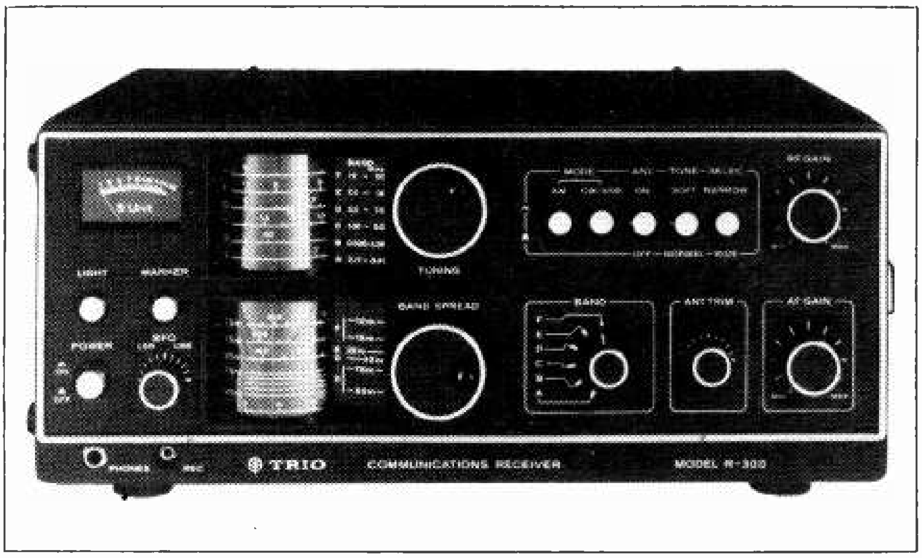
Also, now that the amateur movement is enveloping and taking more seriously other areas such as satellite communications, slow-scan tv, amateur television, r.t.t.y., facsimile, microwaves, etc., and including them within the terms of the normal amateur licence, there is ample for the constructor to build and take an interest in without feeling unadventurous because he is not designing and building his own transmitter and receiver. Aerial design, for example, is one area where amateurs are very active and where they can cheaply make improvements to their stations.

High frequency receivers

In the early sixties the radio amateur or shortwave listener could choose from a very wide selection of h.f. receivers. These included general coverage receivers, ham-bands-only receivers, and communications receivers – the last-mentioned referring to receivers of either of the former types but with send-receive switching to make them suitable for use in two-way communications. The sets came mainly from British and American manufacturers.

In addition there was a large number of older professional and military communications receivers, for example the famous HRO from National and AR88 from RCA, which had become popular among the amateurs and were available on the second-hand or 'surplus' markets. Many of these receivers still appear on the second-hand market today. New professional-type receivers were then, as they are now, normally too expensive for the average amateur.

Today, by comparison, there are only a few manufacturers producing h.f. receivers for the amateur market. One reason for this was undoubtedly the reduced demand for amateur receivers due to the increase in the number of transceivers developed after 1960. When amateurs began to use trans-



Trio's Model R-300 single/double-conversion receiver introduced in 1976.

ceivers for normal fixed station operation there was less need for a communications receiver than there was when one was required to accompany a separate transmitter for two way communications.

However, the main reason for the reduction in the number of receivers is that many of the companies who produced amateur equipment in quantity for Britain and America were hit very hard when faced with the strong competition from the Japanese in the mid-sixties. For example, National, the makers of the HRO single-conversion receiver, ceased production of amateur equipment altogether, and so did Hammerlund. Of the other American and European manufacturers, some disappeared altogether and others either entirely or partly withdrew from the amateur market.

One UK company which was badly affected by the Japanese competition, but still produces amateur equipment today, was KW Electronics. Although this company no longer exists under the name KW Electronics, its KW products continue to be made and marketed by Decca Communications Ltd. These products, however, are all-valve designs which are having to compete with the all-solid-state synthesized designs now being introduced by the Japanese, who are undoubtedly the pacesetters in amateur equipment design.

Another UK company which, before the sixties, was very active in the amateur scene, was Eddystone Radio. This company, now part of the GEC group, ceased production of amateur equipment in 1969 and now produce receivers intended mainly for professional military and marine communications. The Eddystone 1001 receiver has been included in the abridged-specifications table so that the amateur receivers listed can be compared with a professional set having a similar frequency range.

Professional receivers are generally more expensive than amateur ones for a number of reasons. A professional receiver, more often than not, is required to continuously cover a larger frequency range than an amateur set. Also the selection of an i.f. can be greatly simplified in amateur h.f. receivers because the frequency can be chosen to lie between one of the amateur bands. This cannot be done in the professional receiver, which also, more frequently, has to use band-switching capable of altering the number of frequency conversions to optimise the receiver characteristics throughout the frequency ranges.

In addition, professional receivers normally have to comply with strict type approvals – especially if they are for military or marine applications. For example, the parts in a marine receiver may require special treatment for humidity protection and the design itself may have to take into account the presence of transmitter aerials in close proximity to the receiver aerial. Other factors, such as high stability, long testing procedures and the fact that production quantities are normally small, all increase the cost of manufacturing professional receivers. However, unlike amateurs the professional users can live with these high prices, and this is one reason why UK receiver manufacturers prefer to stay in the professional market.

Design aspects

Owing to increased use of s.s.b., which occupies only a narrow band, the crowding of the amateur bands, and the difference between strong and weak signals, which may differ by up to 500,000 times, there have been stringent demands made on the designers of modern amateur receivers.

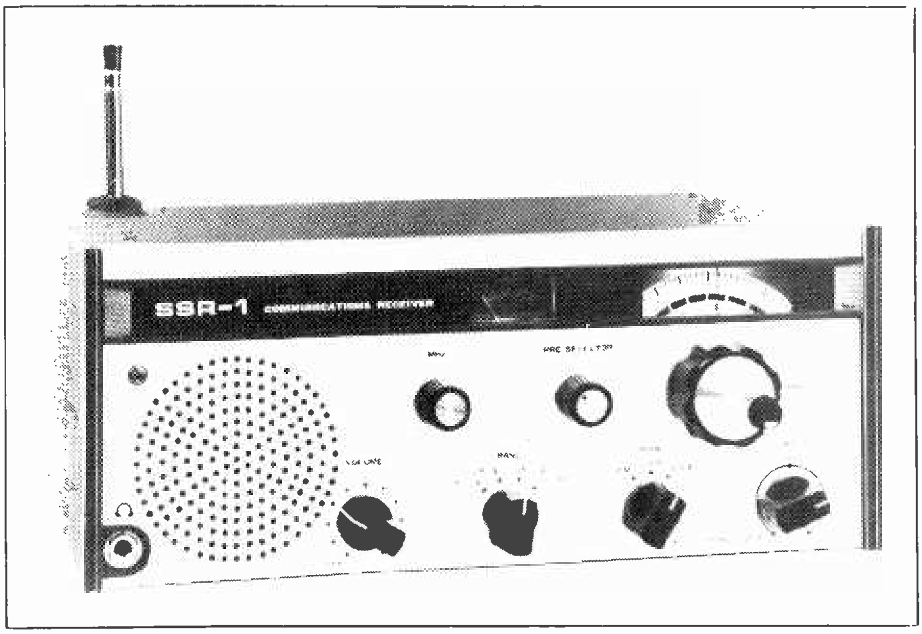
The four main considerations in communications receiver design are selectivity, sensitivity, stability and spurious signals.

Selectivity

For amateur telephony, selectivity should be about 3kHz on each side of the nominal frequency (at the −6dB point), and for c.w. this should be about 100 to 200Hz. This compares with a bandwidth of about 9kHz for a good quality broadcast receiver.

Most of the modern receivers available today, many of them multimode sets, have bandwidths of typically 2.4kHz at the −6dB point, and typically 7kHz at the −60dB point, on the s.s.b. mode. Some sets, such as the Drake DSR-2 communications receiver, have variable selectivity. This particular receiver has four bandwidths ranging from 6 to 0.3kHz at the 6dB point. Other receivers have separate selectivities for

Drake SSR-1 synthesized receiver manufactured by Seiwa.



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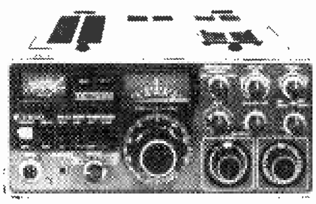

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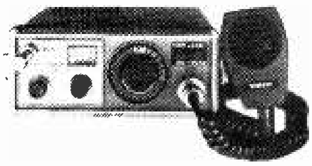

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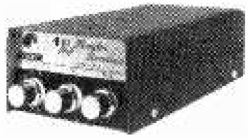

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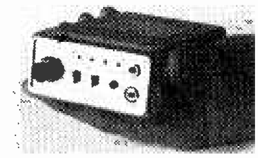

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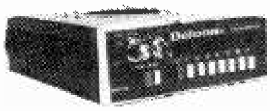

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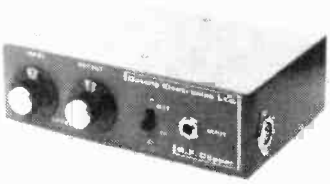

Processes speech as a SSB signal at 60kHz to increase its ratio of average to peak levels without adding harmonic distortion. Improves talk power of SSB, FM, and AM transmitters without increasing the peak transmitted power. Connects between microphone and transmitter (See articles by Dr D. A. Tong, Wireless World Oct 1976, 77-81 and Feb 1975, 79-82).

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Today we present:

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allband, HF, 300watts transceiver, 160 / 80 / 40 / 20 / 15 / 11 / 10A / 10B / 10C / 10D / WWV, modes FSK, USB, LSB, CW, AM, with separate 8 pole X-tal lattice filters for each mode fitted.
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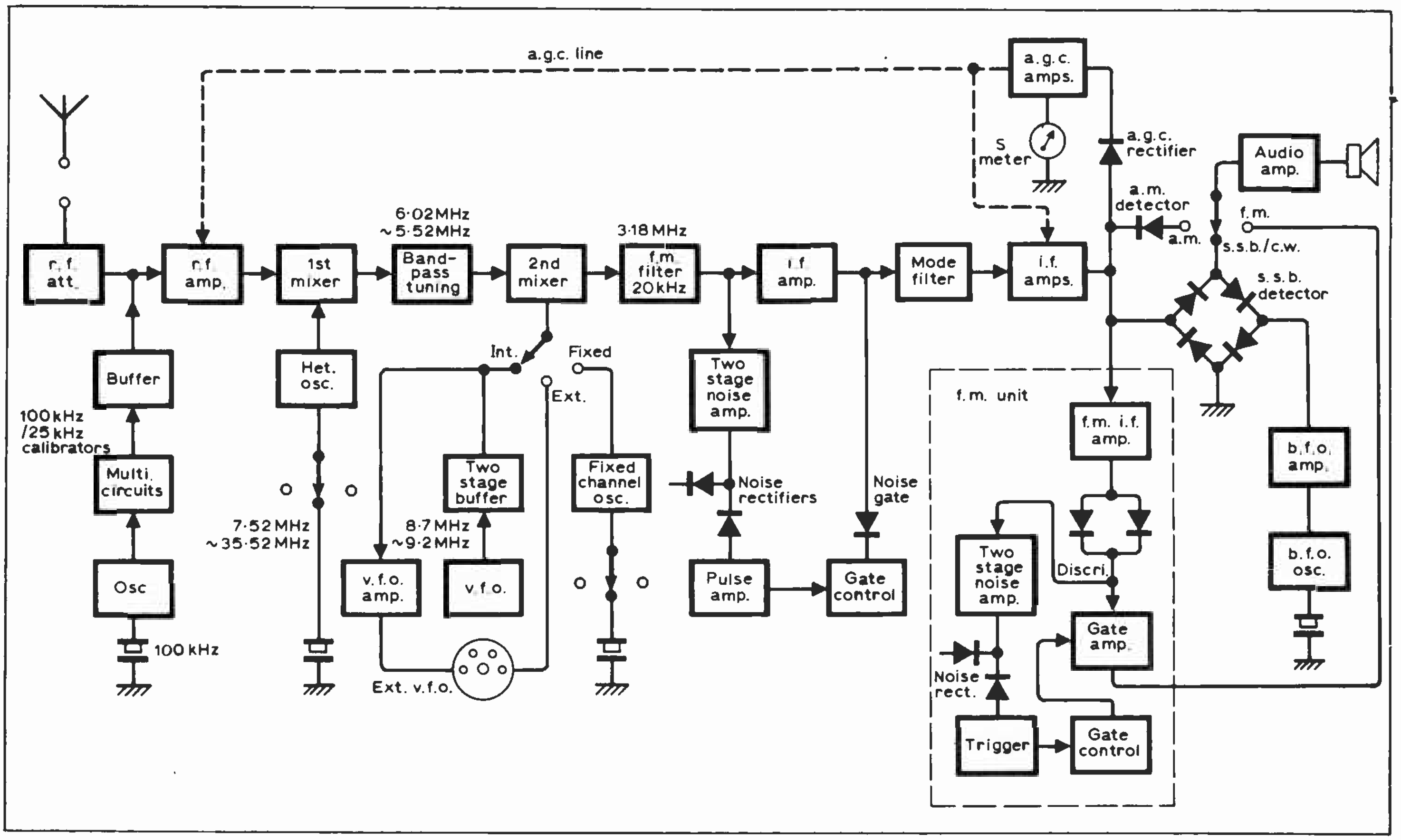


Fig. 1. Block diagram for the Yaesu Musen FR-101 amateur communications receiver. This is a typical modern double-conversion superhet having built-in mode filters for c.w. (0.6kHz), a.m. (6kHz) and s.s.b. (2.4kHz), and an optional filter for f.m. The f.m. unit and filter shown are also optional. It has three b.f.o. oscillators for u.s.b., l.s.b. and r.t.t.y., with crystals for the s.s.b. modes only. Other options include 6m and 2m converters which can be switched in between the aerial and the r.f. attenuator.

each mode of operation. The Trio R-599, for example, at the one end , has a bandwidth of 20kHz for its f.m. mode, and at the other end a bandwidth of 0.5kHz for its c.w. mode. The Drake SSR-1, Drake R-4C, FDK TM56B and Trio R-300 each have only two selectivities, one narrow and one wide, either for s.s.b. and a.m. reception or for narrow- and wide-band f.m. reception.

Having bought a receiver, the amateur is not necessarily restricted to the bandwidths specified for the set. Some receivers, such as the Yaesu FR101, the Drake R-4C and the Trio R-599 offer mode filters as optional extras. Fig. 1 shows a block diagram of a typical modern amateur communications receiver.

Smaller, simpler receivers, such as pocket portables or scanning monitor receivers, do not, in general, have such narrow bandwidths. They are mainly v.h.f. f.m. receivers, having selectivities of about 12kHz at 6dB down and 24kHz at 50dB down, used either by shortwave listeners interested in the v.h.f. bands or by amateurs monitoring their favourite frequencies. Since these sets are not used for two-way communications, broadcast quality is normally adequate.

Decca's all-valve receiver, the KW202, has a 6dB selectivity bandwidth of about 3kHz but it uses a Q-multiplier to increase its selectivity to isolate a c.w. signal, for example, or to provide a deep notch to eliminate an interference signal. The Drake SPR-4 also uses a notch filter.

Sensitivity

In communication receivers the sensitivity is not how much the set will amplify a signal, but how well the set will receive a small signal above the noise level. A high-quality amateur receiver should have a signal-to-noise ratio of about 10dB for an input of between 1 and 3μV. However, even an input of 5μV for this noise figure is very good for amateur purposes or shortwave listening.

Commercial receivers now available have sensitivities very much better than this. Typical input levels for a 10dB noise figure at 14MHz are from 0.25 to 0.5μV for s.s.b. and 0.5 to 1.5μV for 30% modulated a.m.

Yaesu Musen FRG-7 receiver with Wadley-loop drift cancelling system.

Stability

Without stability, sensitivity and selectivity is useless in a receiver. In most well designed receivers drift should be small and should settle down within 15 minutes of switching on from cold.

For s.s.b. speech, the resolution requires that a receiver should be capable of remaining within about 30Hz of the nominal frequency. Unlike the professional receiver, which normally requires long term stability, the amateur receiver is adequate if it has a good short-term stability.

Typical stability figures for modern amateur receivers are less than 100Hz drift during any 30 minutes after warm-up and less than 100Hz drift for a 10% change in line voltage. In comparison the specification for the Eddystone 1001, designed for professional use, quotes one part in 10 per dec.C.

The Yaesu Musen FRG-7 and Drake SSR-1 receivers both use synthesized drift-cancelling systems which are variations of the Wadley-loop system, probably first used in the Racal RA217. Both of these receivers are relatively low cost sets with reasonably good performance characteristics.

Phase-locked synthesizer systems using digital techniques are also being used more in amateur equipment, especially in the latest Japanese transceiver designs. This will be discussed in more detail in the next part of this survey.

Since some components do not return to exactly the same values after a few temperature cycles, all good modern amateur-bands or general-coverage receivers include built-in calibrators.

Mechanical shock was often responsible for frequency drift in the older valve receivers, and consequently they had to be very rugged. Today, most sets are all solid-state and the semiconductors used are of fairly rugged construction. However, because of the miniaturization and portability of modern receivers, they are more frequently moved from place to place and used for mobile communications. Consequently the sets still have to be ruggedly constructed, and it is a credit to most of the manufacturers that their equipment is extremely hardy. The number of after-sales repairs required occur on only about 1% of all receivers sold, the most common fault being semiconductor failure.

Spurious signals

One of the main enemies in receiver design is the spurious signal. Many amateur-built and commercially-built receivers, and this includes some designed for professional use, have had extremely good specifications, and have been very popular among the users, but, when used in the field, they have rapidly developed a bad name for spuriae.

An example of a 'rig' which suffered in this way was the once very popular Liner-2 Transceiver. Happily to say, this set is still used extensively by amateurs, normally as a mobile station.

The most common spurious signal is image response. Others include internally-generated signals (birdies) and i.f. breakthrough. To reduce the possibilities of birdies, attention must be given at the design stage to the number of mixer stages used and the choice of frequencies. Because each mixer produces many different frequencies at its output, the greater the number of stages used, the more probable is the occurrence of spurious signals.

The Yaesu Musen FRG-7, which has three mixer stages, uses two dual f.e.ts and one balanced mixer together with eight tuned circuits and a four stage low-pass filter to minimize spurious responses. Careful screening is also used, and ceramic filters are employed for the rejection of unwanted signals and interference.

Typical specifications for modern amateur receivers are: image rejection, greater than 50dB down; i.f. rejection, greater than 50dB down; and internal spurious signals, below 1μV (equivalent to the aerial input).

The trend in modern receivers is now towards the use of a higher first i.f. (for better image rejection) and one less conversion stage to reduce these spurious responses.

One method of obtaining audio image rejection is that of using phasing techniques similar to those used in s.s.b. generation. With careful design, the use of, for example, 90 degree phase-shifting networks in an "outphasing" system (see the Radio Communication Handbook, fifth edition) can result in the reduction of one sideband by about 30 to 40dB. Another system, the "third method" (sometimes called the Weaver or Barber system), uses additional balanced mixers working at a.f., to eliminate the need for accurate 90 degree a.f. networks. This system has yet to be developed for commercial amateur designs.

V.h.f. receivers

There are very few v.h.f.-only receivers on the amateur market. Those that do exist are normally f.m. monitor receivers. Fig. 2 shows a block diagram of typical v.h.f. receiver, the MS-2 from Seiwa. This set has four crystal channels which are digitally scanned.

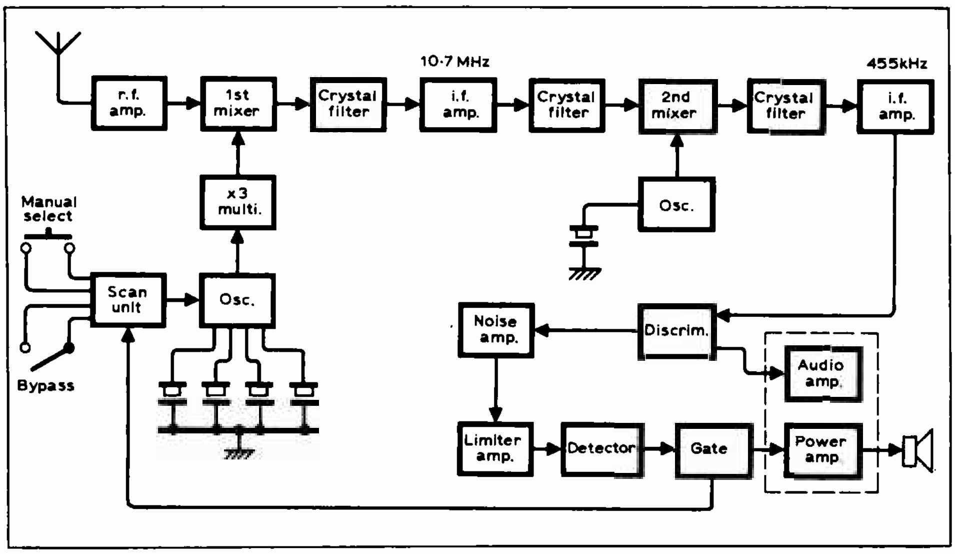
Scanning systems are common only to v.h.f. or u.h.f. f.m. receivers because of the regular channel spacings; they are unsuitable for s.s.b. v.h.f. or h.f. receivers where channels are narrower and normally harder to define. On digitally synthesized receivers channel scanning is simplified because it can be done by selecting the frequencies digitally, rather than by switching crystals.

Amateurs or shortwave listeners who wish to monitor v.h.f. or u.h.f. bands normally use home-built or commercially-built converters with h.f. communications receivers or h.f. transceivers. There is now a wide selection of commercial add-on modules available for the amateur. These include pre-amplifiers, filters, transverters and converters for frequencies up to at least 1296MHz. Fig. 3 is a block diagram of a typical commercial converter for 144MHz.

Two firms which produce modules in quantity are Modular Electronics and Microwave Modules.

One rather unusual converter now available from another company, Da-

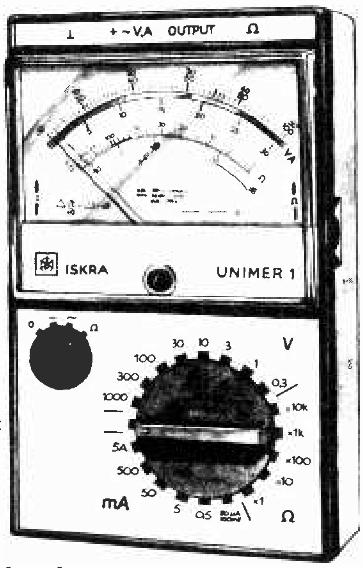
Fig. 2. Block diagram of the MS-2 v.h.f. f.m. receiver – a pocket-sized channel-scanning superhet made by Seiwa. This is a crystal-controlled double-conversion design suitable for frequencies from 140 to 170MHz. Crystals are sequentially switched into the first mixer oscillator by a digital circuit until a signal appears on one of the channels. The receiver remains on this channel for about 7s only, unless switched to manual.



Iskra Multimeters a choice of units for every application

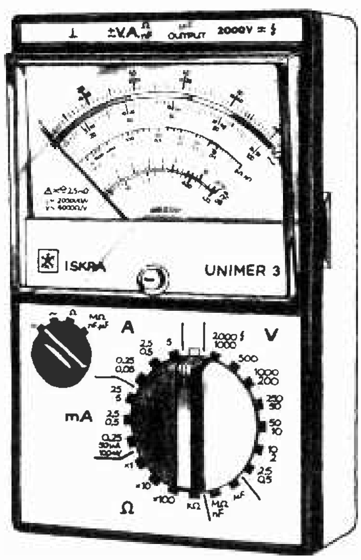
All the multimeters shown here are made by the international Iskra organisation. Three of these superbly styled units are known as Unimer 1, Unimer 3, and Unimer 4—while the fourth is called the Minimer, a miniature version of the Unimer range.

Each model is designed for a specific application, and is available from any one of a nationwide network of officially appointed Iskra distributors.



Unimer 1
Electronic multimeter.
50 ranges.
Sensitivity 200kΩ/V.
100mV to 1000V
and 5μA to 5A,
on both a.c. and d.c.
Shunt available for
currents up to 30A,
and a probe for
up to 30kV d.c.
Accuracy of volt and current ranges ±2.5% FSD.

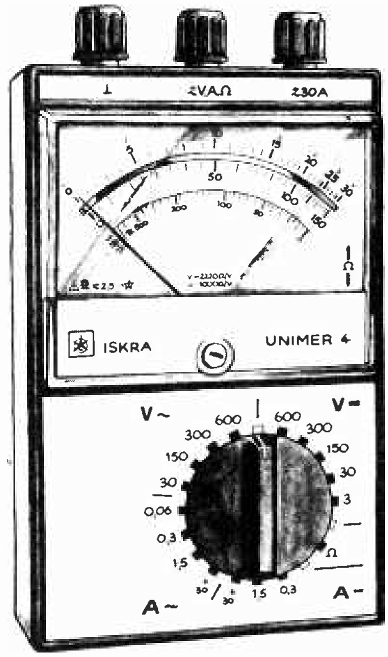
Unimer 1 is a high sensitivity electronic instrument for laboratory use.



Unimer 3
42 ranges including 2
for capacitance.
Sensitivity 20kΩ/V (d.c.).
100mV to 2000V and
50μA to 5A d.c.;
2.5V to 1000V and
250μA to 2.5A a.c.
Accuracy of volt and current ranges ±2.5% FSD.

If you're looking for a general purpose multimeter, you need the Unimer 3 which is intended for educational and industrial applications.

When it comes to on-site electrical work, choose the robust Unimer 4.



Unimer 4
19 ranges.
Sensitivity 2.2kΩ/V (d.c.).
Voltage to 600V and
current to 30A, on both
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And for servicing household appliances, the Minimer is ideal.

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Abridged specifications for most of the commercially-built amateur receivers available today.

Model	**Trio R-300** about £184	**Trio R-599D** about £396	**Yaesu Musen FRG-7** about £145	**Yaesu Musen FR101** £299 to £480	**Decca KW-202** about £236	**Drake SSR-1** about £150	**Drake R-4C** about £450	**Drake SPR-4** programmable receiver, about £472	**Heathkit HR-1680** about £198 Easy assemble kit	**Eddystone 1001** less than £600
Frequency coverage	170KHz to 30MHz in 6 ranges with bandspreads for s.w. or ham bands	3.5 to 29.7MHz in 10 ranges	0.5 to 29.9MHz	1.8 to 30MHz in 21 amateur and s.w. bands	1.8 to 30MHz in 9 ranges	0.5 to 30MHz in 30 ranges	Five ranges from 3.5 to 29MHz with crystal sockets for 15 extra 500kHz ranges	Can be programmed for 23 ranges from 0.15 to 30MHz	3.5 to 29MHz in 6 ranges	0.55 to 30MHz in 5 ranges
Receiving modes	u.s.b. l.s.b. a.m. c.w.	u.s.b. l.s.b. c.w. a.m. f.m.	u.s.b. l.s.b. a.m. c.w.	u.s.b., l.s.b. a.m., c.w. Provision for f.m. and r.t.t.y.	u.s.b. l.s.b. a.m. c.w.	u.s.b. l.s.b. a.m. c.w.	s.s.b. c.w. a.m. r.t.t.y., s.s.tv	u.s.b., l.s.b. a.m. c.w.	u.s.b. l.s.b. c.w.	u.s.b., l.s.b. a.m. c.w., m.c.w.
Type of circuit	Single - conversion superhet with double conversion on 18 to 30MHz range	Double-conversion superhet	Wadley loop synthesiser with triple - conversion superhet	Double-conversion superhet	Double-conversion superhet with mechanical filter Attenuator Preselector	Triple-conversion superhet with synthesized drift-cancelling system	Triple-conversion superhet	Double-conversion superhet	Double-conversion superhet	Single-conversion superhet with cascode r.f. amplifier.
Sensitivity for 10dB S+N/N ratio	Better than 1.5μV (a.m.) and 0.5μV (s.s.b./c.w.) on all bands	0.5μV (s.s.b./c.w.), 3μV (a.m.) for 10dB 3μV (f.m.) for 20dB	s.s.b./c.w. 0.7μV at 30% mod	0.3μV for s.s.b./c.w. 1μV for a.m. at 14MHz	0.5μV	0.3μV on s.s.b. 1μV on a.m. at 30% mod. from 2 to 30MHz	Less than 0.25μV on ham bands	s.s.b./c.w. 0.25μV, a.m. 0.5μV with 30% mod.	Less than 0.5μV on s.s.b.	5μV on 4 ranges 15μV on low freq. range for S+N/N of 15dB
Selectivity	Two selectivities. narrow, more than 2.5kHz at 6dB and less than 12dB at 60dB	2.2kHz (s.s.b.), 0.5kHz (c.w.), 5kHz (a.m.), 20kHz (f.m.) at 6dB	3kHz at 6kB 7kHz at 50dB	2.4kHz at 6dB 4kHz at 60dB on s.s.b./c.w. and r.t.t.y.	3kHz at 6dB 6kHz at 60dB	3kHz ±25% on s.s.b. 5.5kHz ±25% on a.m. at 6dB	2.4kHz (s.s.b.) and 8kHz (a.m.) at 6dB Filters available for c.w.	4.8kHz (a.m.), 2.4kHz (s.s.b.), 0.4kHz (c.w.) at 6dB	2.1kHz min. at 6dB 7kHz max. at 60dB	4kHz at 6dB 12kHz at 40dB for narrow selection
Devices	4 f.e.ts 21 transistors	2 i.cs 10 f.e.ts 34 transistors	2 i.cs 9 f.e.ts 12 transistors	4 i.cs 12 f.e.ts 20 transistors	Valves	All solid state	Hybrid	All solid state	All solid state	I.f. and audio i.cs. F.e.t. mixer
Country of origin	Japan	Japan	Japan	Japan	U.K.	Japan	USA	USA	USA	UK
Additional information	Introduced about Oct 76 500kHz calibration marker as standard Tone selector	Introduced about April 75. 25kHz calibration	Introduced about Aug 76 Includes r.f. attenuator, pre-selector and tone selector	Introduced about Feb 75. Four types including a digital readout model	Introduced in 1971 Built-in Q-multiplier with notch or peak facility (200Hz at 10dB) 100kHz calibration	Introduced about Sept. 75. Preselector.	Introduced about March 73. Permeably tuned v.f.o. Notch filter. 25kHz calibration.	Introduced in 1971. Includes a notch filter 100kHz calibration	Introduced in summer 76. Includes preselector 100kHz calibration.	Introduced in summer 72. Flywheel-loaded reduction drive tuning

tong Electronics Ltd, is the Up-converter Model UC/1, described in the November '76 issue of Wireless World.

Trends in receiver design

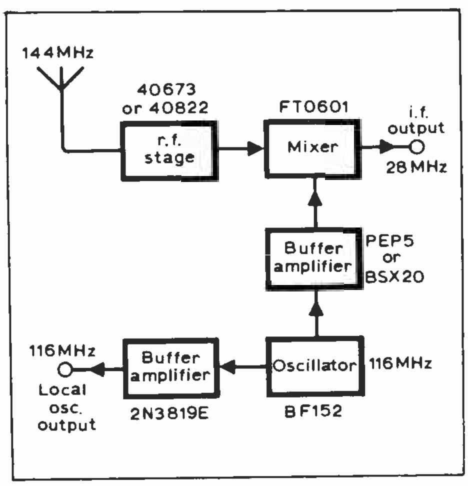
During recent years the trend towards the use of h.f. semiconductors instead of valves has brought the most significant change in h.f. receiver design. More recently, integrated circuits have also been used, especially in phase-lock-loop systems and portable receivers and transceivers. These solid state devices have led the way to amateur receivers which are compact, highly stable and more reliable than valve sets.

An obvious advantage of semiconductor receivers is that they may be operated from low voltage supplies, making them very suitable for mobile and portable operation. In addition the semiconductors used today can have better noise characteristics, even up to ultra high frequencies. They have also enabled compact converters to be constructed easily and quickly.

One disadvantage with semiconductor designs is that, because they are more susceptible to cross-modulation and intermodulation, and damage due to strong local transmitters and static build-up on the aerial, the dynamic range of the receiver is limited. This has brought about a change in design emphasis. A few years ago the main criterion in amateur receiver design was sensitivity. With the now crowded bands, and the increase in s.s.b., the principal criterion is signal handling – the ability to listen to weak signals in the presence of strong signals. This is a function of the r.f. and mixer stages at the front end of the receiver.

Amateur receiver designers are now following the example of the professionals by keeping low gain in these early stages, even in cheap sets, to increase the dynamic range, leaving just enough gain to drive the following stages. Some manufacturers foresee a trend towards removing the first r.f. amplifier altogether in addition to the use of very low noise double-balanced mixers.

Fig. 3. Block diagram of a 144MHz m.o.s.f.e.t. converter, as manufactured by Microwave Modules Ltd, suitable for use with a h.f. receiver tuned to the 28 to 30MHz band. The module also provides a 116MHz local oscillator signal suitable for use with transverter.



Hand-portable v.h.f. receiver. This is typical of the 12-channel crystal-controlled sets produced by Seiwa.

Other problems normally associated with semiconductor designs, for example increased circuit loading due to the lower input impedances, feedback capacitances and characteristic changes with temperature, have largely been overcome by the use of single- and dual-gate field effect transistors.

Some manufacturers, however, still prefer to use valves. The KW202, for example, is an all-valve receiver which is still popular among many valve-orientated amateurs. However, a spokesman from Decca Communications Ltd, who manufacture the set, said that any new design from them would be a solid-state one, mainly because of the future availability of valves rather than a lack of confidence in them. The company has been assured a supply of valves for another 10 years.

The Japanese company Trio, although producing all solid-state receivers, prefers to use valves in the driver and final p.a. stages of their transmitters and transceivers.

In the mid-thirties the tuned-radio-frequency receiver, in which the received signal is converted directly into audio by means of a demodulator working at the signal frequency, because of its poor performance and lack of selectivity on a.m. telephony, was beginning to be replaced by superhet communications receivers.

These early superhet designs were mainly single conversion sets which used an i.f. from about 455kHz to 470kHz and two or three i.f. stages. At least one r.f. amplifier stage was needed to raise the signal level so that the minimum of amplifier gain would be needed after the relatively noisy mixer stage.

Because of the conflicting desire to have a low i.f. for good selectivity and a high i.f. for good image rejection, a later trend was towards double or even triple conversion receivers. The double-conversion sets normally had a first i.f. of 1.6MHz or above and a second i.f. at about 470kHz. In the triple-conversion receivers the third i.f. was usually about 50kHz, which gave good single-signal selectivity without using a crystal filter.

Later still there was a trend towards the variable i.f. type of receiver which provided a higher stability than was possible with a band-switched h.f. oscillator. These designs were usually single- or double-conversion superhet receivers having a series of crystal-controlled converters at the front end, each covering a narrow frequency range of about 500kHz.

The present trend is to go back to fixed i.f. receivers of the single-conversion or sometimes double-conversion type – the minimum number of conversions being preferred because of the difficulties involved in minimising spurious responses in receivers having a number of mixers. In the double-conversion case, an extra filter is necessary in the first i.f. to reduce the number of strong signals passing down the i.f. chain. Image rejection is maintained by using a much higher i.f. of about 9MHz. This is now possible due to the availability of suitable s.s.b. and c.w. crystal filters.

To obtain the maximum possible dynamic range, double-balanced mixers using Schottky diodes or f.e.ts are preferred.

Finally, there is a trend, especially in the latest Japanese transceivers, to use Nixie-type or l.e.d. displays for frequency readout. The Yaesu Musen FR-101 Digital receiver is one example of this. However, this facility can add as much as £100 to the cost of a receiver.

The next part of this survey will discuss transmitters, transceivers and Japanese importing and exporting.

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* Published by the Radio Society of Great Britain.

Surround sound decoders — 7

Multi-system ambisonic decoder

2 — Main decoder circuits

by Michael Gerzon, M.A., *Mathematical Institute, Oxford*

This series of articles describes a decoder capable of decoding all major existing and proposed two-channel surround-sound systems, including the Ambisonic System 45J, SQ, Regular Matrix, BMX and BBC Matrix H. For systems other than SQ, the decoder gives full psychoacoustically optimized results using NRDC Ambisonic decoding technology. In addition, Ambisonic playback of mono, stereo and three-channel studio-format signals is provided. The decoder is suitable for three-amplifier/four speaker, four amplifier/four-speaker, and four amplifier/six speaker reproduction.

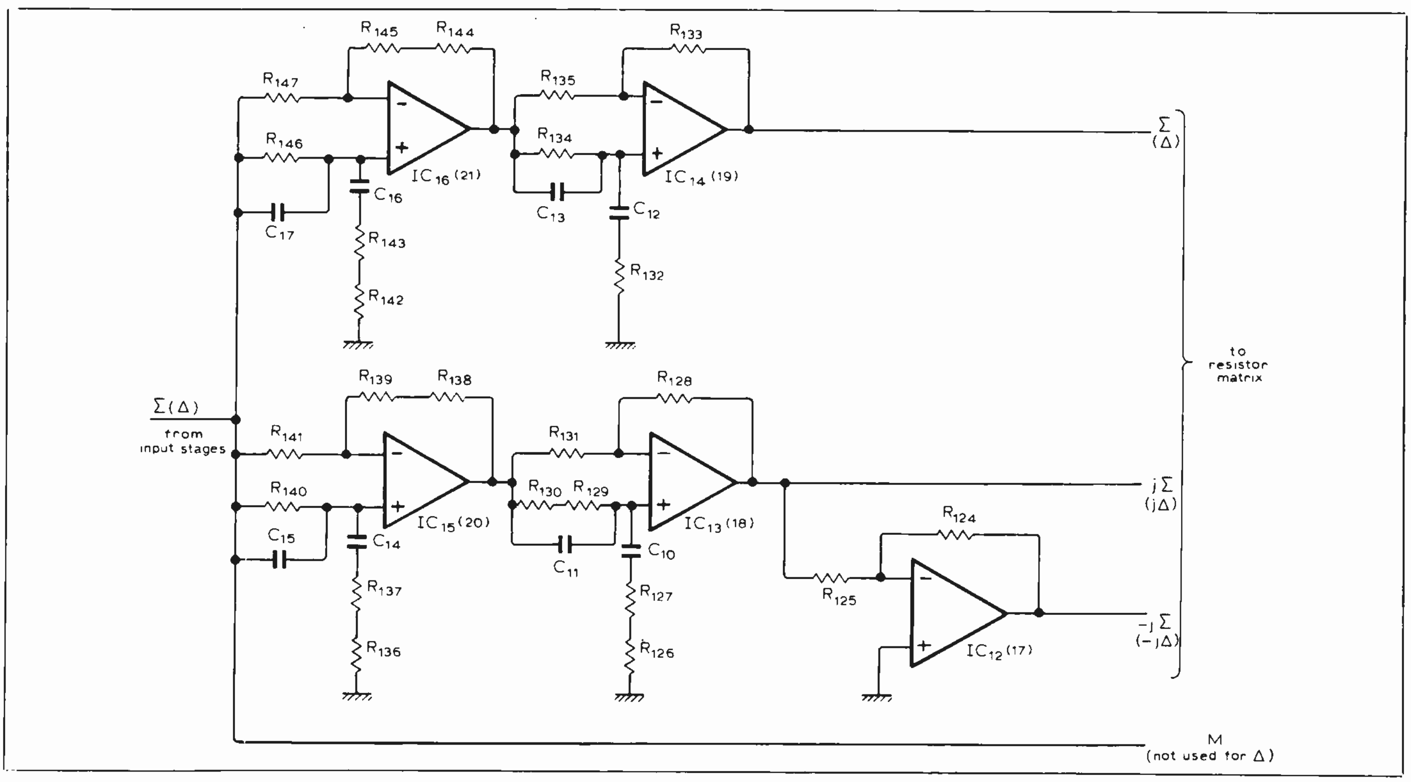
The ten systems of decoding provided in this decoder are listed in Table 1. The mono and stereo decoding modes provided are not conventional two-speaker reproduction, which in any case is not a sensible means of reproduction with the first hexagon speaker layout of Fig. 5 last month. Instead they provide a full ambisonic multispeaker reproduction of conventional mono and stereo records or broadcasts, providing a subtle enhancement of first-rate material, but no gimmickry or "pseudo-quadraphonic" effect. The enhancement is not obvious except during extended listening, and a more obvious but still gimmick-free effect over a wider stage is provided by the "superstereo" mode.

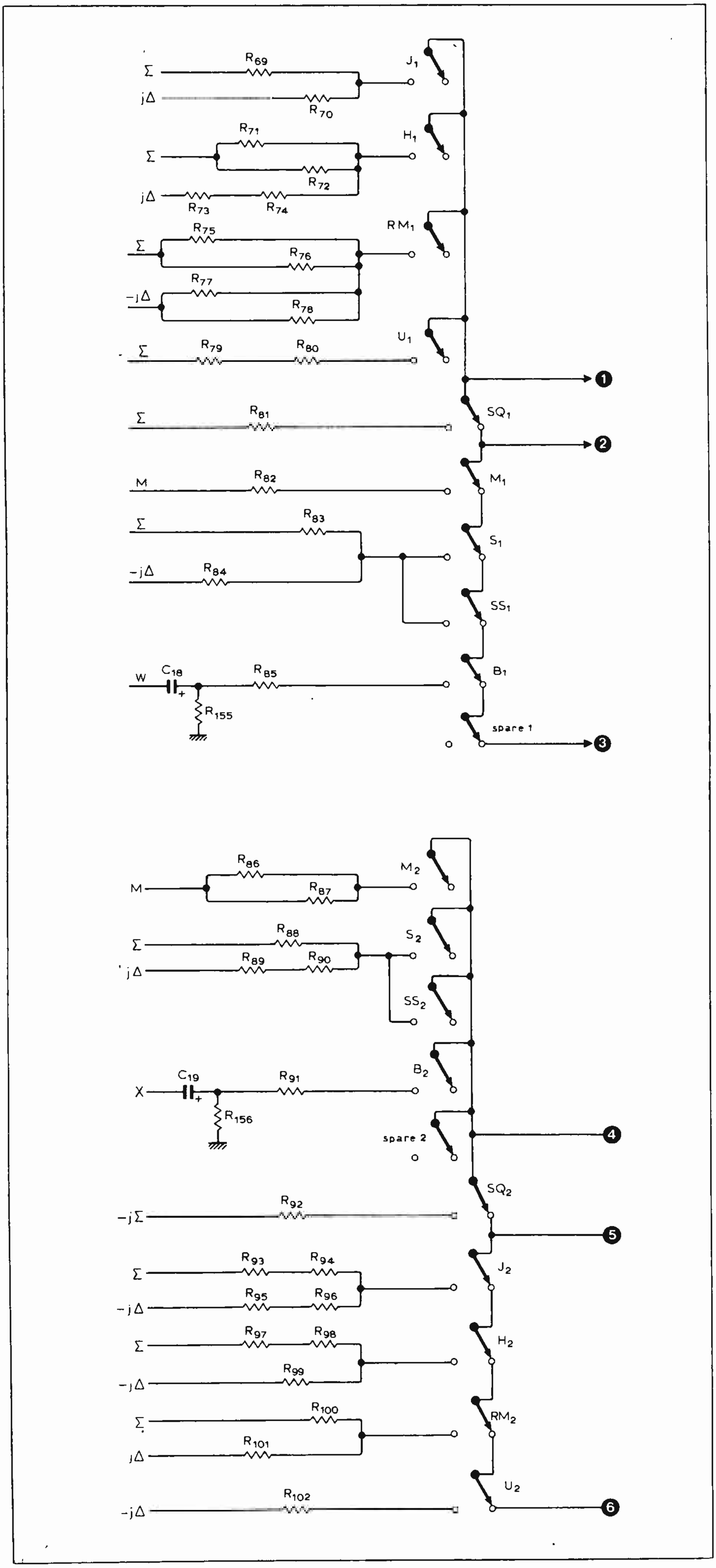
Superstereo also gives excellent reproduction of many Regular Matrix and QS records with a full 360° stage, although the RM decoding mode is in some ways better optimized for surround reproduction of records in that system. The five decoding modes for recordings made in the System 45J, Matrix H, Regular Matrix, BMX (such as Nippon Columbia UD-4 issues) and SQ systems have an obvious purpose, and the B-format mode is intended for studio three-channel recordings in ambisonic B-format. The spare mode, presently unused, is provided to allow for the possibility of the decoder being updated when three-channel discs or broadcasts in System 45J become available, although it can be used by experimenters to test further decoding ideas.

The switching is done by ten interdependent push-button switches; only one switch remains depressed at a time. In the circuit diagrams following, the switches are illustrated in their out position, and the poles of each switch are lettered as listed in Table 1.

Five other push buttons also provide the facilities listed in Table 2. Forward preference, which is operative only in the 45J, Matrix H, RM/QS and BMX system decoding modes, enables the

Fig. 1. Two of these phase shift circuits are used, one to handle the sum signal Σ, and the other to handle the difference signal Δ. Input and output signals in the Δ case are given in brackets; the M output path is used only in the Σ circuit and is omitted from the Δ case. The i.c. numbers in brackets are the numbers for the Δ case.





Figs. 2-5. Resistor matrix and switching circuits fed from phase shifter circuits of Fig. 1 and feeding corresponding numbered inputs to Fig. 6. Inputs marked W, X and Y in these circuits are the B-format inputs to the decoder. The spare switches are for future developments. Switch poles with the same letters belong to the same switch, and all switches are shown in the out position.

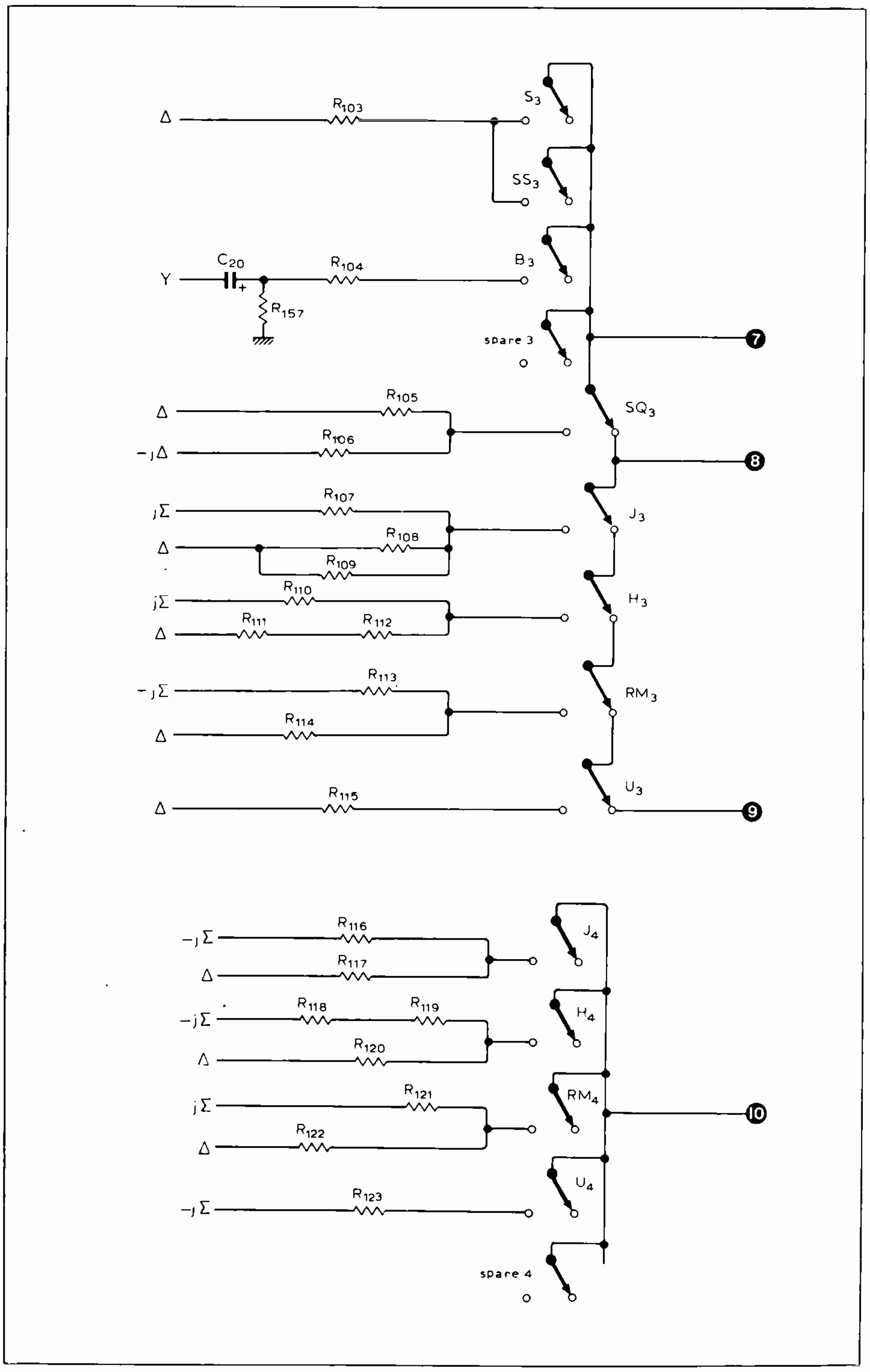
Table 1. List of systems for which decoding is provided. Switch code is the letters by which poles of the switch are indicated in circuit diagrams. Number of switch poles used in each case is listed, although the switches in the available kit have 4 poles each except for the spare position which has 6. The fourth pole of the SS switch is in a part of the circuit to be given in part 3.

Decoding for system	*Switch code*	*Number of poles*
Mono	M	2
Stereo	S	3
Superstereo	SS	4
B-format	B	3
System 45J	J	4
BBC Matrix H	H	4
Regular Matrix/QS	RM	4
BMX (UMX/UD-4)	U	4
SQ	SQ	3
Spare	SPARE	(6)

Table 2. Other pushbutton operated facilities. The three switches L, X, Y are interdependent, only one remaining depressed at a time.

Facility	*Switch code*	*Number of poles*
Forward preference	F	1
Distance compensation	D	2
Rectangle layout	L	2
Hexagon 2 (part 1)	X	3
Hexagon 1 (part 1)	Y	3

user to choose the decoding mode most suited to his requirements. The in position gives low phasiness for predominantly front-stage material e.g. most classical music and much pop, and the out position gives higher front-stage phasiness but better rear-stage sound quality, e.g. for drama and "easy listening" music. Distance compensation compensates for the effect of the distance of the loudspeakers from the centre of the listening area. The in position is for a nominal speaker distance of 2.4m, corresponding to an 11ft × 11ft square layout, and is suitable for distances of ⩽3m. The out position is for speaker distances greater than 3m, being nominally exact for a 4m speaker distance. Finally, three interdependent pushbuttons select whether



the decoder is to be used for a rectangular-shaped four-speaker layout, or for the two alternative hexagon layouts, which are wired up as shown in Fig. 5 last month. In the rectangular mode, the shape of the rectangle is compensated for by the layout control potentiometer.

To minimize the possibility of constructional errors and to keep the already rather complicated circuit as simple as possible, the circuit has been based on integrated circuit operational amplifiers. Such a construction requires special precautions in terms of signal levels and input bandwidth to minimize the risk of transient intermodulation distortion. The input stages that include these precautions are described in part 3, along with details of the recommended op-amp types and their connections. The input stages include low-noise input stages, Bessel filters to prevent t.i.d. and slew-rate distortions, preset gain adjustments to cope with a variety of input levels, a sum and difference matrix to produce the sum signal $\Sigma = L + R$ and difference signal $\Delta = L - R$, and a ganged volume control affecting the sum and difference signals rather than left and right, to minimize the subjective effects of small tracking errors between the potentiometers.

The rest of the circuit performs the signal decoding and is shown in Figures 1-6. Resistors are ±2% tolerance unless otherwise indicated, when a lower ±5% tolerance is adequate. Similarly all capacitors are ±2% or 2½% tolerance unless otherwise indicated. These relatively high tolerances are necessary for good subjective results, as one is producing a 360° sound stage from the two-channel inputs in place of the 60° wide stage of stereo. Such a magnification of the size of the sound stage means that errors are also magnified to a degree that the ears can hear faults that would be negligible in stereo. In addition, there are sufficiently many processing stages that small errors can accumulate. If the decoder were designed for a lower quality of directional reproduction, for example in a music-centre application, tolerances could be relaxed.

To minimize possibility of constructional error, resistors or capacitors of the same value have the same tolerance, although a few resistors — some of those used in series or parallel combinations to make up non-preferred values — could be of lower tolerance than stated. For studio and laboratory applications, the 2% tolerances may be replaced by 1% tolerances, because no precision resistor or capacitor values in the circuits given deviate from their ideal values by more than 1%, and most by considerably less.

The sum and difference signals are each fed into a separate phase-shifter stage as in Fig. 1. Because it is impossible to produce an absolute 90° phase shift in physically realisable circuits, these shifters consist of two all-pass networks one of whose outputs phase-leads the other by 90°. The design shown is a high-quality unity-gain eight-pole design giving 90° relative phase shift over the frequency range 30Hz to 16kHz, ideally with an error of ±1⅓°, but with an error of ±3° approximately using 2% tolerance components. A phase inverter at the output of the 90°-lead circuit produces a 90° lagging signal. The phase shifters used for the Σ and Δ signals are identical circuits, except that for the Σ signal only, a path bypassing the phase shifter is also provided (marked M in Fig. 1). Because of the duplication of circuits, two each are needed of the resistors R_{124} to R_{147} and of the capacitors C_{10} to C_{17}. Seven outputs are provided from the phase shifters, namely M, Σ, $j\Sigma$, $-j\Sigma$, Δ, $j\Delta$ and $-j\Delta$ where j indicates a relative 90° phase shift.

These outputs feed an elaborate switched resistor matrix, shown in Figs 2-5. The elaboration is, of course, a consequence of providing ten different options for decoding. For mono decoding, the signal M is taken from before the phase shifters, to minimize phase distortion. Although by present day standards, the type of low-Q phase distortion produced by the phase shifters is not very audible, it does have some audible effect, and so should be avoided where possible. It is not possible to avoid phase distortion in two-channel surround-sound systems with currently available technology, and the justification for allowing such phase distortion is that the beneficial effects of

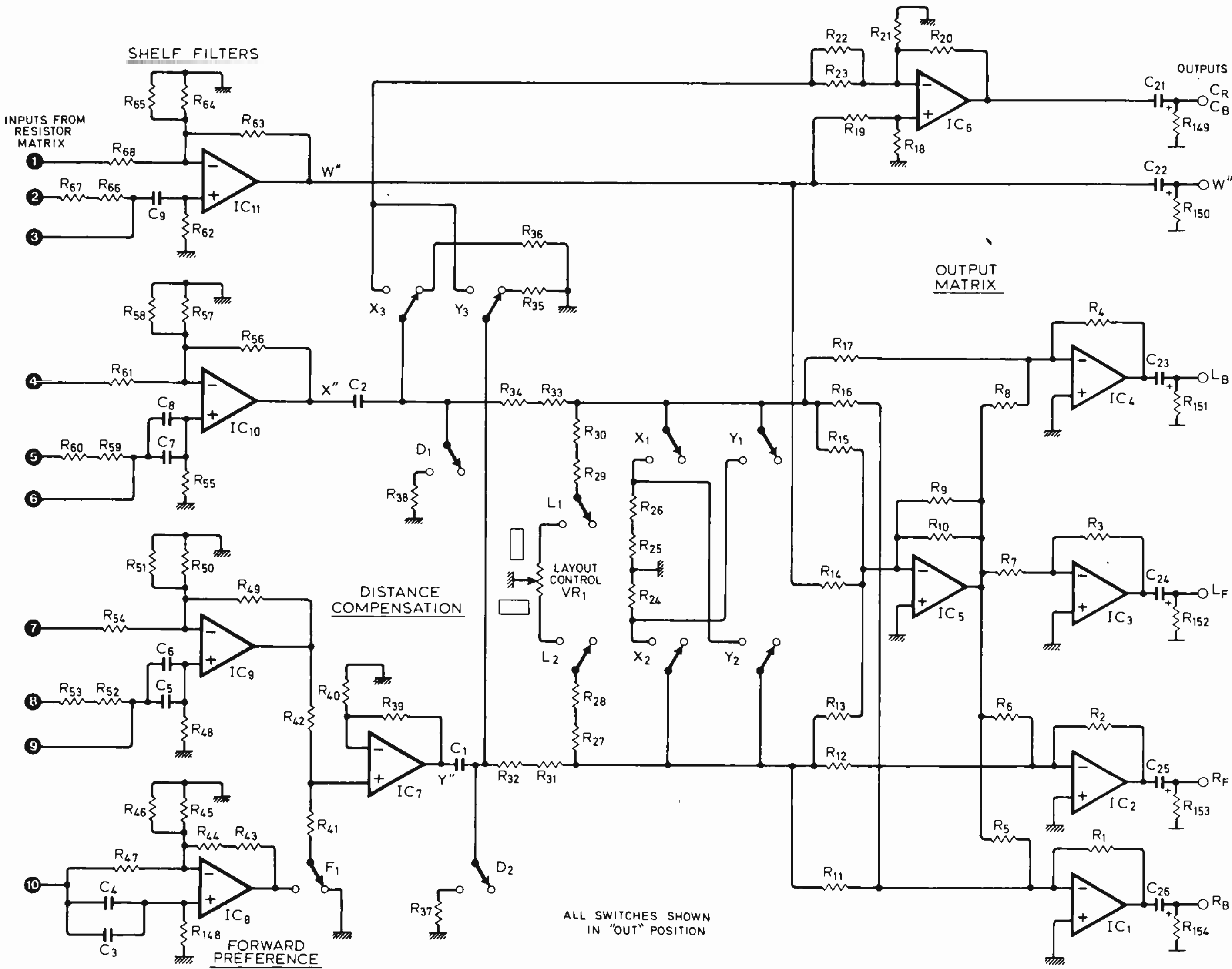


Fig. 6. Shelf filters, distance compensation and output matrices, including forward preference switch, distance compensation switch, rectangle and hexagon selector switches and layout control. Switch poles with the same letter (as in Table 2) correspond to the same pushbutton, and all are shown in out position. See text for selection of resistors R_{28} and R_{29} associated with the linear 5kΩ nominal layout control potentiometer VR_1. Circuit fed from Figs 2-5, and outputs L_B, L_F, R_F, R_B, W″ and C_B or C_R feed power amplifiers or "quadraphonic" preamp. Switch X selects C_B output and switch Y selects C_R output.

surround sound can easily outweigh any small quality losses thus caused.

The switching shown in Figs 2-5 selects the required matrix resistors and modifies the action of the shelf filter circuitry following to obtain the shelf filter characteristics required for each system. The poles of each push-button switch are marked with the same letter (eg J) as indicated in Table 1, but with a number running from 1 to 4 indicating the pole used. All switches are shown in their out position. For example, switch pole RM4 is the 4th pole of the regular Matrix/QS push button. Pole SS4 (not shown) us used in the input stages to be described in the next article.

Apart from the seven signals M, Σ, jΣ etc already discussed, another three inputs marked W, X, Y also feed the resistor matrix, and are taken from a separate input socket. These three inputs are for studio B-format signals, previously discussed in ref. 1. The ten output connections of Figs. 2-5 are fed to the corresponding numbered points at the input of Fig. 6, which includes the rest of the decoder.

The circuits surrounding the operational amplifiers $IC_{8\text{-}11}$ are the shelf filters, which have a resistive input impedance of 22kΩ to terminate the resistor matrix, and which except in the SQ mode give a phase at their output 90° in advance of their inputs at a frequency of 400Hz, thereby ensuring virtually identical phase responses. The amplitude gains (ignoring phase) of these filters at frequencies much less than 400Hz and at frequencies much more than 400Hz are shown in Table 3.

Including the effect of these filters and the effect of the summing circuit at IC_7, a pressure signal W″ and two velocity signals X″ and Y″ are produced at the outputs respectively of IC_{11}, IC_{10} and IC_7 in Fig. 6, that at frequencies well above 400Hz satisfy the following

Table 3. Amplitude gains of shelf filters at low (≪400Hz) and high (≫400Hz) frequencies for the decoding systems in Table 1, for the signal paths handling pressure signal W′, velocity signals X′ and Y′ and phasiness compensation signal P (through IC_8). The P signal for spare mode is as for J, H, RM and U systems.

Signal path	J, H, RM, U l.f.	J, H, RM, U h.f	M, S, SS, B, SPARE l.f	M, S, SS, B, SPARE h.f	SQ both
W′	3.73	5.65	3.73	4.56	3.73
X′ and Y′	3.73	2.91	3.73	3.23	3.73
P	1.38	3.73			

matrix equations for the various decoding modes. For systems J, H, RM, U, the expression for Y″ is the sum of two bracketed terms, the second of which is deleted for the forward preference switch in the out position.

Mode M (mono)
$W''=0.707M$, $X''=0.707M$

Mode S (stereo) and SS (superstereo)
$W''=0.717\Sigma-0.291j\Delta$
$X''=0.717\Sigma+0.291j\Delta$
$Y''=0.583\Delta$

For superstereo, the signal gain is modified in the input stages as well.

Mode B (B format)
$W''=1.288W$
$X''=0.911X$

Resistors
Tolerance ±2%, except when marked with asterisk when ±5% is adequate.

R_{1-4}	200k
R_{5-10}	68k
R_{11-13}	33k
R_{14}	200k
R_{15-17}	33k
R_{18}	27k
R_{19}	100k
R_{20}	150k
R_{21}	110k
$R_{22\star}$	1M
R_{23}	270k
R_{24}	6.8k
$R_{25\star}$	39Ω
R_{26}	2.7k
$R_{27,30}$	1.6k
$R_{28,29}$	see text
$R_{31,33}$	6.8k
$R_{32,34}$	10k
$R_{35,36}$	120k
$R_{37,38}$	27k
R_{39-42}	47k
R_{148}	22k
$R_{43\star}$	3.3k
R_{44}	27k
R_{45}	12k
R_{46}	150k
$R_{47,48}$	22k
$R_{49,56}$	82k
$R_{50,57}$	39k
$R_{51,58\star}$	680k
$R_{52,59\star}$	56Ω
$R_{53,60\star}$	1k
$R_{54,61}$	22k
$R_{55,62}$	22k
R_{63}	82k
R_{64}	18k
$R_{65\star}$	820k
$R_{66\star}$	1.1k
$R_{67\star}$	1.8k
R_{68}	22k
R_{69}	100k
$R_{70\star}$	910k
R_{71}	100k
$R_{72\star}$	2.2k
R_{73}	430k
$R_{74\star}$	8.2k
R_{75-78}	270k
R_{79}	100k
$R_{80\star}$	5.6k
R_{81}	91k
R_{82}	120k
R_{83}	110k
R_{84}	270k
R_{85}	56k
$R_{86\star}$	360k
R_{87}	100k
R_{88}	68k
R_{89}	160k
$R_{90\star}$	8.2k
R_{91}	56k

R_{92}	91k
R_{93}	100k
$R_{94\star}$	3.9k
R_{95}	47k
$R_{96\star}$	3.3k
R_{97}	150k
$R_{98\star}$	8.2k
R_{99}	33k
$R_{100,101}$	82k
R_{102}	68k
R_{103}	100k
R_{104}	56k
$R_{105,106}$	68k
R_{107}	330k
R_{108}	56k
$R_{109\star}$	2.2M
$R_{110\star}$	1M
R_{111}	56k
$R_{112\star}$	4.7k
$R_{113,114}$	82k
R_{115}	68k
$R_{116\star}$	240k
$R_{117\star}$	2.2M
$R_{118\star}$	390k
R_{119}	22k
$R_{120\star}$	1.8M
$R_{121,122}$	220k
R_{123}	180k
$R_{149-156}$	390k
$R_{157\star}$	390k

Two off of the following

$R_{124,125}$	47k
$R_{126\star}$	1.8k
$R_{127,132}$	22k
$R_{128,133}$	47k
$R_{129\star}$	3.9k
$R_{130,134}$	47k
$R_{131,135}$	12k
$R_{136\star}$	2.0k
R_{137}	33k
$R_{138,144\star}$	5.6k
$R_{139,145}$	100k
R_{140}	39k
$R_{141,147}$	22k
$R_{152\star}$	3.3k
R_{143}	47k
R_{146}	56k
R_{148}	22k

Capacitors
Tolerance ±2 or 2½%, except when marked with asterisk when ±10% is adequate.

$C_{1,2\star}$	680n	
C_3	1n	
$C_{4,8}$	10n	
C_9	15n	
C_{18-26}	47μ	10V low tolerance

Two off of the following

$C_{10,11}$	470p
$C_{12,13}$	100n
$C_{14,15}$	27n
$C_{16,17}$	1n

$$Y''=0.911Y$$

Mode J (two-channel system 45J)

$$W''=0.998\Sigma+0.107j\Delta$$
$$X''=0.374\Sigma-0.772j\Delta$$
$$Y''=(0.132j\Sigma+0.798\Delta)+(-0.295j\Sigma+0.032\Delta)$$

Mode H (BBC Matrix H)

$$W''=\Sigma+0.219j\Delta$$
$$X''=0.215\Sigma-1.037j\Delta$$
$$Y''=(0.044j\Sigma+0.736\Delta)+(-0.186j\Sigma+0.041\Delta)$$

Mode RM (Regular Matrix/QS)

$$W''=0.728\Sigma-0.728j\Delta$$
$$X''=0.515\Sigma+0.515j\Delta$$
$$Y''=(-0.515j\Sigma+0.515\Delta)+(0.310j\Sigma+0.310\Delta)$$

Mode U (BMX)

$$W''=1.018\Sigma,\ X''=-0.720j\Delta,$$
$$Y''=(0.720\Delta)+(-0.406j\Sigma)$$

Mode SQ (for SQ recordings)

$$W''=0.73\Sigma$$
$$X''=-0.73j\Sigma$$
$$Y''=0.73\Delta-0.73j\Delta$$

These decoding equations include some allowance for maximizing the number of preferred resistor values, and are arranged so as to give substantially the same loudness in all decoding modes.

The shelf filters in the X″ and Y″ paths are followed by a passive RC high-pass filter for distance compensation, with switched resistors R_{35-38} arranged so that switch D changes its time constant and the hexagonal-mode switching does not alter the relative time constants in the X″ and Y″ paths. The hexagonal-mode switching activiates a summing circuit to derive the signals C_B or C_R described in part 1, and which alter the matrixing coefficients for the L_B, L_F, R_F, R_B outputs. Switches are shown in their out position, and as before the numbering indicates the pole number of the switch lettered as in Table 2.

In the rectangular decoding mode, a linear-law potentiometer VR_1 is switched into circuit to enable the output matrix to be varied continuously so as to compensate for layout shape. This potentiometer should ideally have a total track resistance equal to 5kΩ within 2%, but this would be extremely expensive and not very practical. Thus two padding resistors R_{28} and R_{29} are provided so that the total track resistance be brought up to the desired exact value. They should be chosen to have identical values R such that $2R+VR_1$ has a total resistance of 6.2kΩ. If precision measurement of resistors is not available (and if the circuit is not being built from a kit with R_{28} and R_{29} provided to match VR_1), then choose R_{28} and R_{29} to have values identical to within 5% such that the total measured resistance of R_{30}, R_{29}, VR_1, R_{28} and R_{27} in series is the same as that of two 4.7k 2% tolerance resistors in series.

The layout control is connected so that a long and narrow loudspeaker layout involves a setting with the wiper near the X″ end of the potentiometer, and conversely for a short and wide layout. This arrangement may be found confusing because many people feel (incorrectly) that it should be the other way round. The central setting of the potentiometer corresponds to a square loudspeaker layout, and the end settings correspond to a rectangle whose long side is twice its short side. Calibrations for the layout control are provided in kit versions, and calibration instructions for do-it-yourselfers will be provided later. The equations describing the action of the output matrix and layout control were given in part 1.

Details of the input stages and of recommended op amps are given in part 3.

Reference

1. Gerzon, M. A. Ambisonics, Part two. Studio techniques, *Studio Sound*, vol. 17, Aug. 1975, pp. 24-6, 28, 30. Correction *ibid* vol. 17, Oct. 1975, p. 60.

Literature Received

Publications produced by the ITU (conference documents, lists, statistics, etc.) are classified in the List of Publications Nos. 1 and 2 (1977). Listings cover those publications devoted to telegraphy and telephony, radio, those common to both fields. Administrative Council documents and miscellaneous publications. International Telecommunication Union, General Secretariat, Sales Service, Place des Nations, CH-1211 Geneva 20, Switzerland. WW401

A brochure and number of leaflets describe a Rugby time-code clock, an off-air standard frequency receiver, a crystal chronometer, c.c.d. television cameras and a frequency tracking receiver with print-out. The products are from European Electronic Systems Ltd, Unit 3, West Station Industrial Estate, Maldon, Essex. WW402

General electronic components, audio accessories, semiconductors and integrated circuits are listed in a catalogue recently received from Bi-pak, The Maltings, 63a High Street, Ware, Herts. WW403

A short-form catalogue, describing a range of temperature controllers, timers and motor speed controllers is obtainable from Solid State Controls Ltd, Brunel Road, Acton, London W.3. WW404

Cassette mechanisms and electronics for digital applications are discussed and the Phi-deck described in a catalogue, sent to us by Triple I, 4605 N. Stiles, P.O. Box 25308, Oklahoma City, OK 73125, U.S.A. WW405

A catalogue from Bear Microcomputer Systems describes a series of designs for microcomputers using both microprocessors and t.t.l. i.cs, design notes on accessories and stationery. The catalogue is obtainable from Bear at 24 College Road, Maidenhead, Berks SL6 6BN. WW406

New Products

Digital test meter

A digital meter, designated PM-10, is capable of measuring signal levels from −50 to +10dBm in the frequency range 200Hz to 4kHz. The PM-10 also incorporates an internal generator which will send a 820Hz signal at fixed levels of —10 and —27dB. A liquid crystal display offers a resolution of 0.1dB and an internal battery provides 100 hours of continuous operation. To minimise current drain, the meter switches off automatically after 5 minutes use. Input impedance is switchable between 600Ω and 100kΩ. Overall dimensions of the instruments are approximately 90 × 160 × 40mm and the weight is about 500g. Wandel & Goltermann (UK) Ltd, 40-48 High Street, Acton, London W.3.

WW 301

Processing voltmeters

Two new digital meters from Solartron, the 7055 and 7065, are current, voltage and resistance meters with 5½ and 6½-digit displays respectively. Both use the pulse-width a.-to-d. conversion method with calibration balance, a technique which Solartron claim to enable cheaper input circuits to be used. Settling time is 2.7ms, input resistance 10GΩ and c.m.r.r. is 144bB. Sensitivity, resolution and linearity are all that one would expect in an instrument of this standard. In addition, however, a microprocessor option, 70556, is available and provided for in the design, and enables the basic instrument to process the 'raw' readings in various ways and to display the processed data instead of the original measurement. Nine programmes can be selected to multiply the measurement by a constant, provide percentage deviation from a chosen nominal value, subtract a constant, compare with a chosen reference in a linear or logarithmic manner to give dB or squared to give power, to present maxima or minima of series of readings, to show measurements which exceed chosen limits, to present a series of statistical data (standard deviation, up-dated r.m.s. etc.) and to linearize and zero-suppress the characteristic of thermocouples. All these programmes can be governed by a built-in clock. Further information on these instruments can be obtained from Solartron Electronic Group Ltd, Farnborough, Hants GU14 7PW.

WW 302.

WW 301

Wide-range sweep/function generator

Two swept function generators are used in the Exact 757, which covers the range 0.0001Hz to 50MHz. The ramp and step generator, which runs between 0.001Hz and 1MHz, triggered or astably, triggers the main generator, which produces sine, square and triangular waveforms. A large variety of duty cycles, repetition frequencies, amplitude and polarities are available and there is ±15V of variable offset, unaffected by the attenuator. The main generator can be voltage-controlled directly from the front panel or by the ramp generator, in either a linear or logarithmic mode. Start and stop frequencies of the internally-generated sweep are independently adjustable by means of front-panel dials. The instrument is obtainable at £1125 from Dana Electronics Ltd, Collingdon Street, Luton, Beds.

WW 303

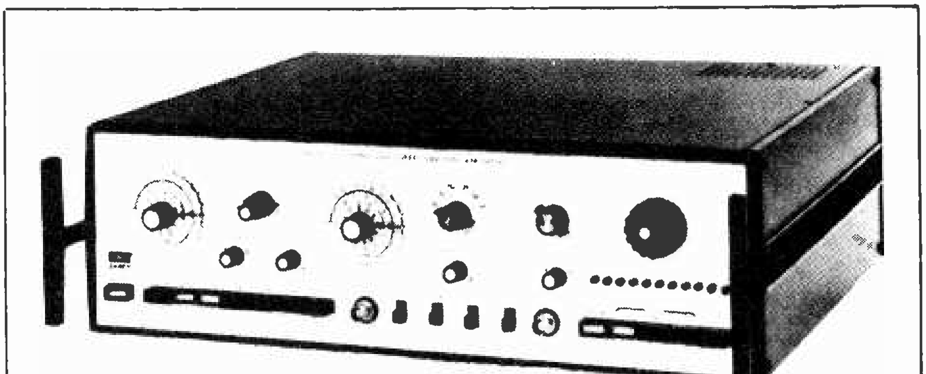
Portable digital meter

The 8020A is a very small, battery-powered digital multimeter which provides for the measurement of direct and alternating volts and current, resistance and a conductance reading of high resistances. The battery life of up to 200 hours is assisted by the use of a liquid-crystal display and a mains unit is an accessory. The instrument is a 3½-digit unit, reading 1.999mV to 1000V d.c. (750V a.c.), 1.999mA to 1999mA a.c. and d.c., 199.9Ω to 19.99MΩ and 1.999mS to 199.9nS on the conductance range, which is equivalent to 500Ω – 10GΩ. Input resistance is 10MΩ on all voltage ranges, while voltage drop on the current ranges is 250mV up to 200mA and 700mV at 2A. A diode test facility is able to turn on silicon junctions, but the low-power ranges are used for in-circuit resistance measurements, ignoring semiconductor junctions. Errors in measurement vary from ±0.25% reading + 1 digit on direct voltage to ±2% of reading plus 10 digits on the 200 nanosiemens range. A group of optional accessories permit the determination of temperature from −50°C to 150°C, high voltage to 40kV d.c. (28kV r.m.s.), and r.f. voltages at frequencies from 100kHz to 100MHz, and there is a clamp-on current transformer for alternating-current measurements up to 600A. The instrument is available at £99 from Fluke International Corporation, Garnett Close, Watford WD2 4TT.

WW 304

Trimmer capacitors

The 101120 series of air trimmer capacitors are manufactured using a single milling operation. This process is claimed to reduce the cost and offer



WW 303

high mechanical and electrical stability. Capacitance values range from 1.2 – 4.0pF to 2.3 – 21pF and the temperature coefficient is $+45 \times 10^{-6}/°C$ with a loss factor of 2×10^{-4} at 1MHz. All of the devices mount on 10mm centres. Steatite Insulations Ltd, Hagley House, Hagley Road, Birmingham B16 8QW.
WW 305

Alphanumeric keyboard

A keyboard comprising a 55 key-switch matrix controlling a 2376 bit r.o.m. will produce a 7-bit ASCII output with upper and lower case codes. The manufacturers claim that a new switch construction, which uses a spring to connect two coding wires, reduces the cost of the keyboard and gives more than two million operations. The layout complies with ISO standards and the unit features a full range of non-printing functions within the CCITT No. 5 alphabet. Input requirements are −17V ± 1V at 20mA, or −12V ±0.75V, 0V, and +5V ±0.25V. Elliott Relays, Associated Automation Ltd, 70 Dudden Hill Lane, London NW10 1DJ.
WW306

Silicon photocell arrays

A family of photocell arrays, available with up to nine matched silicon cells mounted at 0.1in spacing on a one-piece metal base, has been introduced by National Semiconductors. Designed for readout from punched cards, tape, code wheels etc., the NSL-701 range has a response rate of typically 8μs. The spectral response range of 0.4 to 1.1μm extends across the whole visible spectrum into the near infrared, and matches with the output from gallium arsenide light emitting diodes. Cell leakage current is 10μA maximum when reverse biased by 1.5 volts. The output is claimed to remain constant "over long periods of time." Each cell has a sensitive area of 0.080in × 0.160in and the family of arrays will operate over a temperature range of −65°C to +150°C. National Semiconductors Ltd, Stamford House, Stamford New Road, Altrincham, Cheshire WA141 DR.
WW 307

Low-bounce switch

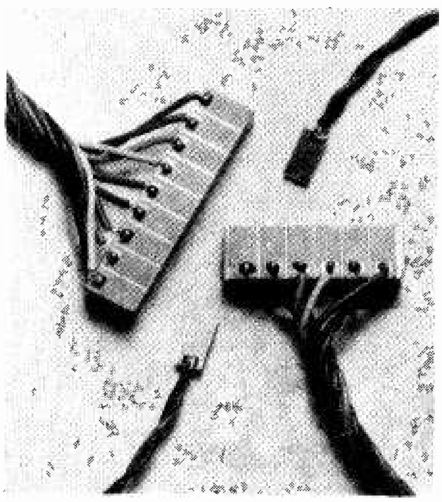
Push-button switches from Highland, Series 31LL, are claimed to reduce the amount of contact bounce by means of multi-section contacts. Each pole is provided with four self-cleaning contact sections and it is arranged that each section has a different natural vibration period. The maximum time of bounce has, it is said, been kept to 100μs. Two poles, arranged as 2 n.o., 2 n.c., or 1 n.o. + 1 n.c., shorted or non-shorted, are available and are rated at 100mA, 60V a.c. or d.c. The switches are illuminated and are equipped for either printed-board or socket mounting. Highland Electronics Ltd, Highland House, 8 Old Steine, Brighton BN1 1EJ.
WW 308

Capacitor microphones

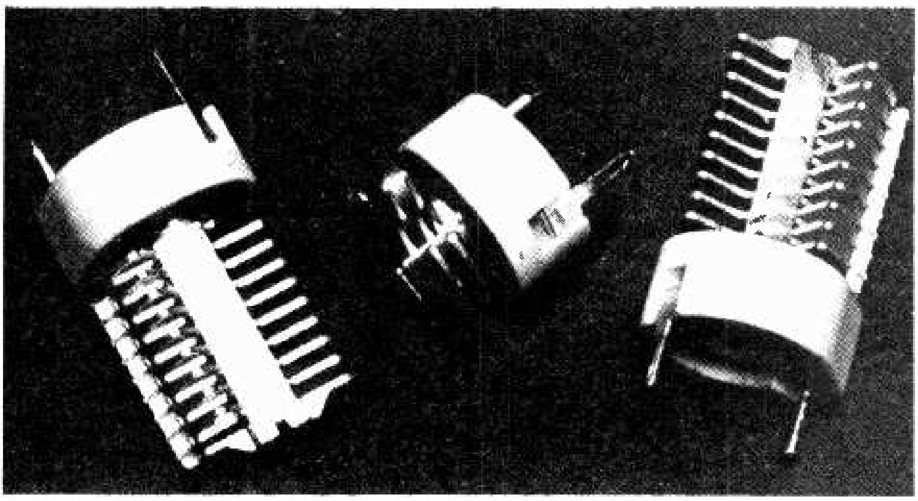
Four capacitor microphones for studio use have been introduced by Beyer. Constructed on the modular principle, each head unit (or transducer capsule) fits on to a common compatible amplifier module, which is available with male DIN connector or 3-pin Switchcraft, Cannon XLR or equivalent connector. The four microphone units are: the MC711, a pressure transducer with omnidirectional characteristics; the MC712, similar to the MC711 but with elastic suspension of the capsule system and an integral windscreen to reduce wind and pop effects; the MC713, a pressure gradient transducer with cardioid pick-up pattern; and the MC714, similar to the MC713 but with elastic suspension of the capsule system and an integral windscreen. The amplifier module incorporates switchable 10dB attenuation, and also has a switch for bass attenuation (10dB at 50Hz ref. 1kHz) to compensate for the bass boost which occurs when the microphone is used in a close talking position. The system requires power from a 48V +6/−8V phantom circuit to DIN 45 596, and has a current consumption of 400μA. The frequency range of all capsules is 40Hz to 20kHz. Pick-up pattern is claimed to be virtually frequency independent. Input impedance is 200Ω and the rated load impedance not less than 1,000Ω. Equivalent noise level (DIN 45 405) is 3.6μV p-p and the signal-to-noise ratio ref. 1 Pa is 69dB. Maximum s.p.l. for 0.5% t.h.d. is 132dB s.p.l. and the A weighted equivalent sound pressure level is approximately 18dBA. Beyer Dynamic (GB) Ltd, 1 Clair Road, Haywards Heath, Sussex RH16 3DP.
WW 309

Motor with tacho

A small d.c. motor with an integral tachogenerator, the Escap 16 GIC 204/104, is intended for use in miniature drive or servo systems in electromechanical instrumentation. The built-in tachogenerator enables the motor speed to be controlled without a separate tacho unit. The tacho coil is wound directly on to the ironless rotor motor coil, thereby eliminating mechanical resonance, and the motor and tacho coils are arranged in such a way that the voltage induced by the motor current is reduced by half. The motor measures 16mm diameter by 18mm long, has a moment of inertia of 0.26gcm, and can be mounted on any of the maker's E16 series of reduction gearboxes. The motor part has a nominal voltage of 6V, a mechanical time constant of 90ms, a no-load speed of 10,500 r.p.m., and a stall torque of 3.3×10^{-4}Nm. The tacho section has a voltage output of 0.28V per 1000 r.p.m., with a peak-to-peak ripple of 10%. Portescap (U.K.) Ltd, 204 Elgar Road, Reading RG2 0DD.
WW 310



WW 307



WW305

Sidebands by mixer

Hoc opus, hic labor est

In the Toranomon-Tachikawa Building, in Tokyo, there is probably a bigger pile of various countries' Standards publications than in any of the standards organizations themselves. The reason I mention this is because the *Wireless World* library has recently been presented with an enormous tome, entitled "World Standards Mutual Speedy Finder" on Electrical and Electronics. According to the foreword, about 18000 standards were obtained, examined and re-classified in a way that makes sense – and in English. I haven't counted the entries, but the foreword says "about . . . items", which seems to indicate that someone else ran out of patience and didn't finish counting either. Lack of patience, though, is not something these Japanese compilers appear to have trouble with. To sort through the publications of the USA, UK, France, West Germany, Japan and the IEC, coping with language, problems, different ways of classifying standards and any amount of hassle in actually getting hold of the things is a job I'm glad someone else had to do.

Eggs with chips

There are very probably some exceedingly puzzled birds at the Slimbridge Wildfowl Trust. There they sit, brooding away for all they are worth, and all the eggs do is lie smugly in the bottom of the nest, humming nonchalantly. The reason for this unnatural lethargy is that the eggs are made of glass fibre and, furthermore, have electronic yolks.

It seems that the Wildfowl Trust, in cooperation with the University of Bath, are trying to improve their breeding programme. Incubators, says Paul Howey of the university, who runs the study, are not in the same league as a mother bird when it comes to hatching eggs, and the glass eggs are containers for instruments to measure the conditions underneath broody birds with a view to duplicating them artificially. The eggs, which can be as small as a pigeon's egg, contain thermistors, CdS cells, and six mercury switches with a resistive matrix to measure temperature, humidity, light and egg attitude. The data is sampled and used to modulate a crystal-controlled carrier in the 29MHz region, which is transmitted, by way of a transponder, to a remote data-logger. The whole inside of the egg, including seven c.m.o.s. chips and power, can be kept down to a weight of 40g.

Crossed lines

Only one thing is preventing me taking an active part in amateur radio. Well, two, actually, but I'll pass over the fact that I stand about as much chance of being able to afford it as does Joe Bugner of being chosen to play Tinkerbell. No, the problem I have is that I can't understand a word anybody says.

'I've listened for some time now to my colleagues chattering away and offering seemingly intelligent replies to what I an only describe as the gruntings of Cro-Magnon Man spoken through a mouthful of cornflakes. Several times, when writing the log, I have been on the point of writing Munster for Plumstead and Belgrade instead of Belgravia, only being stopped by the realization that the majority of Jugoslavs don't adopt a Mayfair accent.

The sideband chopping, random noise and the ludicrous s.s.b. chipmunk effect do nothing to help comprehension and I am very worried that, if I were doing the operating, G8LWW would gain a reputation for being either deaf or thick. And it all makes me wonder a bit about military radio. I can now easily understand the reason for the message "Send reinforcements — we are going to advance" being received as "Send three-and-fourpence — we are going to a dance"; the possibilities for disaster are endless.

Headquarters to "A" Company: "Retreat!"

"A" Coy. to H.Q.: "That's alright, sir latrines were set up by the advance party."

H.Q. to "A" Coy: "No, don't advance, you fool, retreat!"

"A" Coy to H.Q.: "We can't advance now, sir, the enemy is in front of us. Sorry about your feet, sir."

H.Q. to "A" Coy: "Listen, I'm coming over."

"A" Coy to H.Q.: "Oh, that *is* good news, sir. If it's over, I'll just pop across to their lines with a few chaps and take their weapons away. Thank you, sir."

H.Q. to "A" Coy: "No, you idiot, don't . . . . . hallo?"

All dressed up . . .

In the early days of the laser, it became a cliché to say that it was a solution looking for a problem. Any exhibition of electronic equipment worthy of its name had its regulation laser spitting away at perfectly good razor blades and it always seemed rather a misdirection of effort. Later, of course, the potential measuring and cutting power of the laser was put to work with good effect.

We seem now to be in a similar position with the current 'in' device, the microprocessor (we really can't go on using a word like that — two people standing face-to-face would quickly become saturated). At a conference on d.i.y. computing, held at the IEE in May, it was revealed that a lot of amateur users have equipped themselves with several hundred pounds worth of micro and peripheral equipment and find themselves with, as it were, nowhere to go.

Maybe this kind of pressure to spend money on shiny new devices simply because they can now be made rather than because we need them will be the standard way of doing things in the future. There must now, for instance, be several thousand people in Britain who, while otherwise innocent of any mathematical knowledge or desire for such knowledge, are able to tell you without a flicker of expression that arcsin 0.46 is equal to 27.3871075°. They can do this because they have bought (or, more likely, been presented with) a beautifully-made pocket calculator, the lack of which had made them neurotic and not nice to know. Many of us can now tell anyone who expresses an interest the time to the nearest nanosecond and can locate beer cans quite a long way down in the earth.

Let us hope that it doesn't soon become possible to visit Alpha Centauri by building a d.i.y. matter transference machine — I don't want to go because I don't know anyone there and I'm quite sure the weather will be absolutely dreadful.

CQ Two — after you!

I had my first taste of amateur radio in earnest this last weekend and was very impressed by the extreme courtesy and orderliness in which the operators conduct themselves. I was only listening — no call-sign yet — but my colleague is an experienced operator and our station, G8LWW/P, was pulling them in on two metres s.s.b. from Europe and the far North of England with no trouble at all, perched as we were on Headley Hill, near Dorking. The procedure in these contests is to exchange call-signs, signal reports and locations as rapidly as possible and to press on with the next contact. But, in spite of the need for speed, everyone seemed to find time to exchange good wishes for the contest and to express the hope that we would "meet" again further down the log. Operators are very careful not to butt in on a contact and it all seems very civilised. Then, I expect, they all climb into their cars and turn into wild-eyed, road-hogging monsters.

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SURROUND SOUND DECODER

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The unit is designed to decode not only 45J but virtually all other 'quadrophonic' systems (Not CD4), including the new BBC Matrix H 10 input selections.
The decoder is linear throughout and does not rely on listener fatiguing logic enhancement techniques. Both 2 or 3 input signals and 4 or 6 output signals are provided in this most versatile unit.

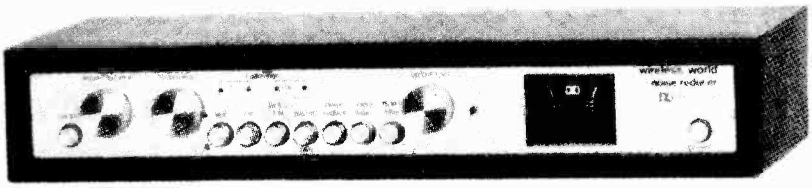
Complete kit, including licence fee £45.00 + VAT

INTRUDER 1 RADAR ALARM

With Home Office Type approval.
As in this issue of "Wireless World", designed by Mike Hosking, 240V ac mains operated and disguised as a hardbacked book. Detection range up to 30 feet. Complete kit. Exclusive designer approved kit £46.00 + VAT.

Wireless World Dolby(TM) noise reducer

Trademark of Dolby Laboratories Inc.



Typical performance
Noise reduction better than 9dB weighted.
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Harmonic distortion 0.1% at Dolby level typically 0.05% over most of band, rising to a maximum of 0.12%

Signal-to-noise ratio: 75dB (20Hz to 20kHz, signal at Dolby level) at Monitor output

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Featuring
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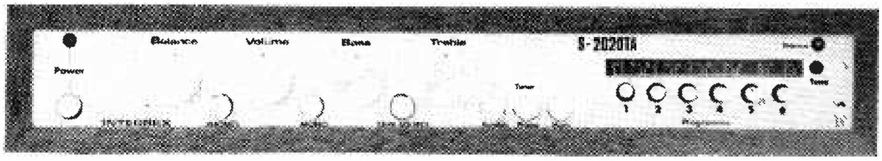


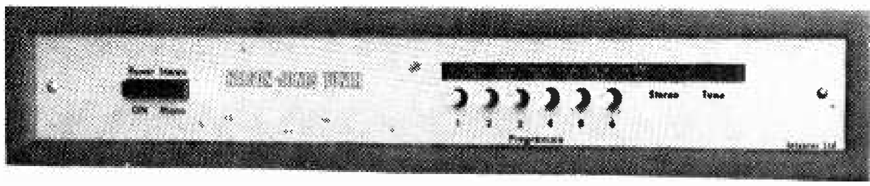
A high-quality push-button FM Varicap Stereo Tuner combined with a 24W r.m.s. per channel Stereo Amplifier.

Brief Spec. Amplifier Low field Toroidal transformer, Mag. input, Tape In/Out facility (for noise reduction unit, etc.), THD less than 0.1% at 20W into 8 ohms. Power on/off FET transient protection. All sockets, fuses, etc., are PC mounted for ease of assembly. Tuner section uses 3302 FET module requiring no RF alignment, ceramic IF, INTERSTATION MUTE, and phase-locked IC stereo decoder. LED tuning and stereo indicators. Tuning range 88—104MHz. 30dB mono S/N @ 1.2μV. THD 0.3%. Pre-decoder 'birdy' filter.

PRICE: £58.95+VAT

NELSON-JONES STEREO FM TUNER KIT

A very high performance tuner with dual gate MOSFET RF and Mixer front end, triple gang varicap tuning, and dual ceramic filter/dual IC IF amp.



Brief Spec. Tuning range 88—104MHz. 20dB mono quieting @ 0.75μV. Image rejection — 70dB. IF rejection — 85dB. THD typically 0.4%.
IC stabilized PSU and LED tuning indicators. Push-button tuning and AFC unit. Choice of either mono or stereo with a choice of stereo decoders.

Compare this spec. with tuners costing twice the price.

Mono £32.40+VAT
With ICPL Decoder £36.67+VAT
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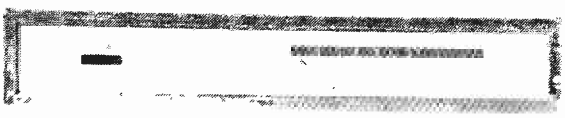
STEREO MODULE TUNER KIT



Sens. 30dB S/N mono @ 1.2μV
THD typically 0.3%
Tuning range 88—104MHz
LED sig. strength and stereo indicator

A low-cost Stereo Tuner based on the 3302 FET RF module requiring no alignment. The IF comprises a ceramic filter and high-performance IC Variable INTERSTATION MUTE. PLL stereo decoder IC. Pre-decoder 'birdy' filter Push-button tuning

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Printed in Great Britain by QB Ltd, Sheepen Place, Colchester and Published by the Proprietors IPC ELECTRICAL-ELECTRONIC PRESS LTD., Dorset House, Stamford St., London, SE1 9LU, telephone 01-261 8000. *Wireless World* can be obtained abroad from the following: AUSTRALIA and NEW ZEALAND: Gordon & Gotch Ltd. INDIA: A. H. Wheeler & Co. CANADA: The Wm. Dawson Subscription Service Ltd, Gordon & Gotch Ltd. SOUTH AFRICA: Central News Agency Ltd: William Dawson & Sons (S.A.) Ltd. UNITED STATES: Eastern News Distributors Inc., 14th Floor, 111 Eighth Avenue, New York, N.Y. 10011.

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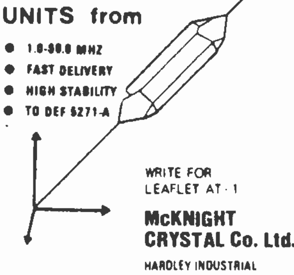

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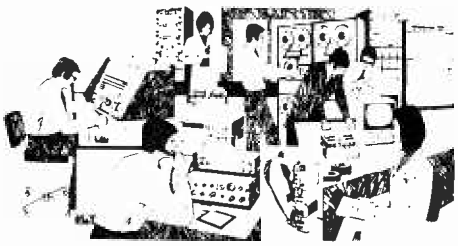
Appointments

Radio Communications Systems Planning Engineers



Racal Communications Systems Limited, pleasantly situated in Bracknell, Berkshire, is a member of the highly successful Racal Electronics Group and a world leader in H.F./S.S.B. telecommunications techniques.

Racal design a wide range of systems from small networks to major radio communications projects, which include Point-to-Point, Ground-to-Air and Shore/Ship complexes. With the continued growth in demand for Racal communications systems there has resulted a need for Engineers, at all levels, to undertake the planning of radio systems in many parts of the world.

The Engineers selected will be capable of accepting responsibility for the systems from inception to final implementation, and have experience, both operationally and technically, in H.F. radio systems and associated ancilliary equipments. They will be required to liaise on a technical basis with customers, at all levels, throughout the world, and this will necessitate overseas travel of limited duration from time to time.

For these positions Racal offers competitive salaries, over 4 weeks annual holiday, and a first class pension and free life assurance scheme.

Communicate with Racal

If you are interested in, and wish to be considered for, these positions please write, stating age, experience and present salary, for an application form to:

The Personnel Manager,
RACAL COMMUNICATIONS SYSTEMS LTD,
Western Road,
Bracknell, Berks.

(7342)

RACAL
The Electronics Group

BE A SUCCESSFUL TV ENGINEER. Join our full-time Two-Year College Diploma Course, specially designed to cover the examinations of the City and Guild Radio, Television and Electronics Technician's Certificate. Full theoretical and practical instruction on all types of modern receivers including the latest colour sets. Enrolments are now under way for September 1977. Minimum entrance requirements are Senior Cambridge or 'O' Level or equivalent in Mathematics and English. September includes a specialised Colour TV and FM Stereo servicing course plus a 2nd year Technicians' Course. Contact us for free prospectus — THE PEMBRIDGE COLLEGE OF ELECTRONICS, Dept. WW, 34a Hereford Rd., London W2 5AJ. Tel 01-229 9117 (7353)

CUCKFIELD HOSPITAL. SENIOR ELECTRONICS TECHNICIAN. For servicing, maintenance, repair and testing of electro medical and electronic equipment. Applicants must possess A.N.C (electronics) or equivalent or preferably H.N.C (electronic) and not less than seven years relevant experience. The salary is in the scale £2.931 to £3,824 p.a. plus supplementary payments of £312 and 5 per cent p.a. for 40 hours per week. The successful candidate will be required to be on call outside normal working hours. — Application forms from District Works Office, St. Francis Hospital, Haywards Heath, Sussex. Telephone: Haywards Heath 57411/2. Closing date 30th July, 1977 (7401

eastern electricity

Telecommunications Engineer

A vacancy exists at our Norwich Depot for an engineer to assist with the installation, maintenance, repair and future development of Eastern Electricity's extensive radio and carrier network. Previous experience with microwave and multiplex carrier systems is desirable, and practical experience in the repair and maintenance of VHF/UHF equipment essential.

Applicants, male or female, should possess technical qualifications to HNC standard or equivalent in the telecommunications field.

Salary: £3110-£4860 per annum plus £120 responsibility allowance £312 per annum as a salary supplement and a further supplement of 5% of taxable pay with a maximum payment of £208.56 per annum.

Applicants should apply in writing to The Group Manager, Eastern Electricity, Finborough Hall, Stowmarket, IP14 3DN, by 25 July, 1977.

7351

BINATONE

RESEARCH & DEVELOPMENT ENGINEER IN ELECTRONICS

J Parkar & Co (London) Ltd, sole importers/distributors of the BINATONE range of consumer electronics, are seeking an electronics engineer to take sole charge of their Technical Research and Development Unit. The applicant must have the ability to design and construct prototype equipment as well as making design improvements to existing products and samples to BSS requirements for complete range of mains operated equipment. He or she will also be responsible for quality control testing and devising technical manuals. A minimum of three years experience in consumer electronics is essential and applications are invited from those who possess an appropriate degree or equivalent professional qualifications.

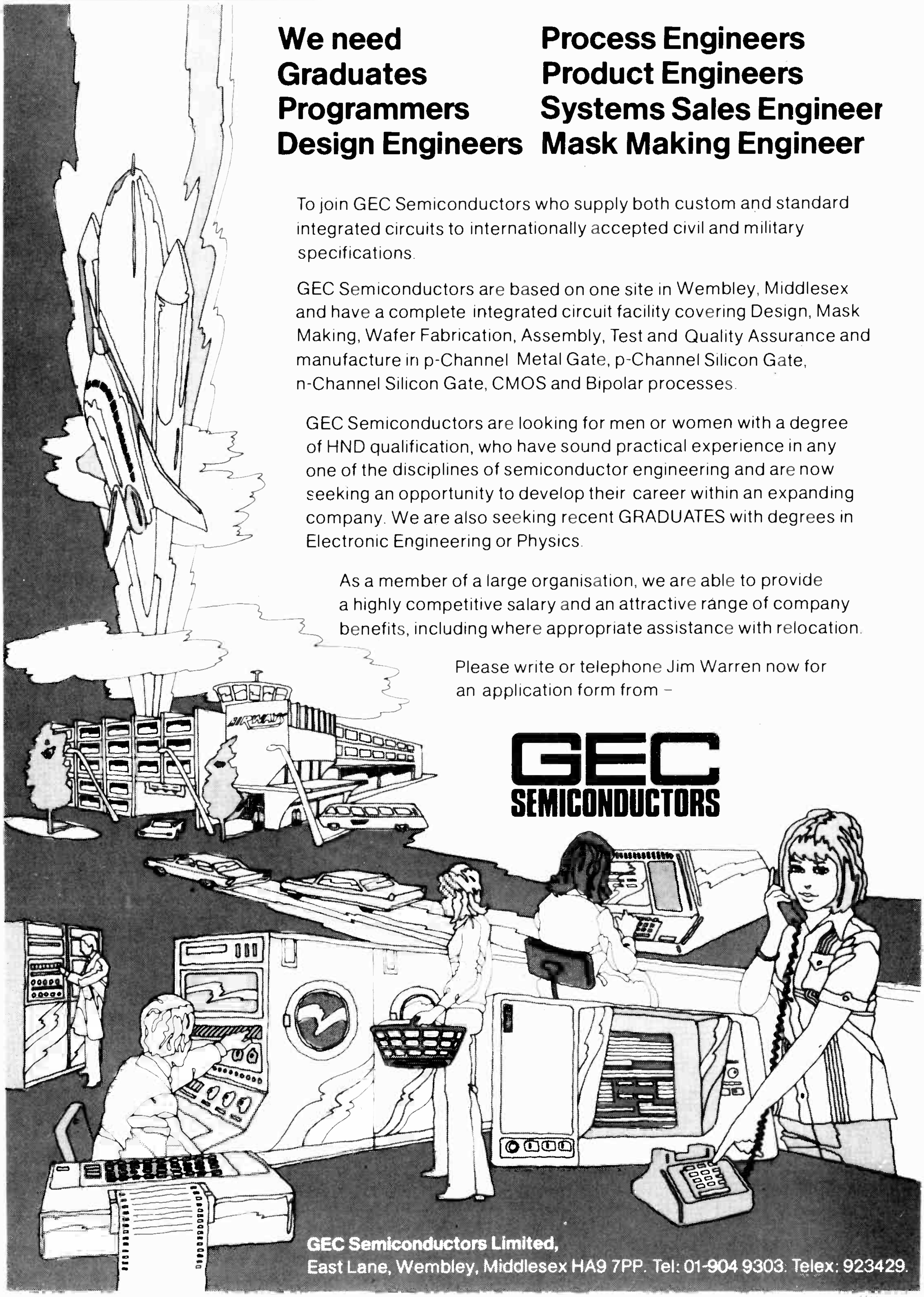
Please apply to

PERSONNEL DEPT.
J. Parkar & Co. (London) Ltd.
1 Beresford Avenue
Wembley, Middx.
01-903 5211

7396

TECHNICAL AUTHOR required for Herts contract. HNC/C&G min — Technical Services (Luton) Ltd., 111 Cutenhoe Road, Luton, Beds. Luton 29673/27601. (7407

NEW VIDEO DEPARTMENT of top London audio dealer urgently require highly experienced Video Engineer to deal with domestic Video, U-matic and contract video installations in the London area. Must be familiar with latest developments. Contact 01-837 2461 Ext. 26. Salary will match experience. (7118



We need Graduates Programmers Design Engineers Process Engineers Product Engineers Systems Sales Engineer Mask Making Engineer

To join GEC Semiconductors who supply both custom and standard integrated circuits to internationally accepted civil and military specifications.

GEC Semiconductors are based on one site in Wembley, Middlesex and have a complete integrated circuit facility covering Design, Mask Making, Wafer Fabrication, Assembly, Test and Quality Assurance and manufacture in p-Channel Metal Gate, p-Channel Silicon Gate, n-Channel Silicon Gate, CMOS and Bipolar processes.

GEC Semiconductors are looking for men or women with a degree of HND qualification, who have sound practical experience in any one of the disciplines of semiconductor engineering and are now seeking an opportunity to develop their career within an expanding company. We are also seeking recent GRADUATES with degrees in Electronic Engineering or Physics.

As a member of a large organisation, we are able to provide a highly competitive salary and an attractive range of company benefits, including where appropriate assistance with relocation.

Please write or telephone Jim Warren now for an application form from –

GEC SEMICONDUCTORS

GEC Semiconductors Limited,
East Lane, Wembley, Middlesex HA9 7PP. Tel: 01-904 9303. Telex: 923429.

URGENTLY REQUIRED

TRANSMITTER ENGINEERS

SHORT WAVE
MEDIUM WAVE
LOW & HIGH POWER

We have immediate vacancies on overseas projects — AFRICA AND MIDDLE AND FAR EAST

You are invited to phone TONY OWERS for more information and we are especially anxious to acquire staff on a permanent basis operating from the United Kingdom.

Would previous applicants please re-confirm their interest.

P & E LTD

PERSONNEL & ELECTRONICS LTD.

Triumph House, 1096 Uxbridge Road
HAYES, Middlesex UB4 8QH
Tel. 01-573 8333 Telex: 934271

7343

SENIOR ELECTRONIC ENGINEERS INTERMEDIATE ELECTRONIC ENGINEERS

The company has vacancies for the above positions in their Repair and Servicing Department.

Applicants for the senior positions should be qualified to at least ONC, ET5 or equivalent level and must have several years proven experience in the field of mini digital computers and a wide range of peripheral devices e.g. lineprinters, paper tape equipment, magnetic disc/tape storage, power supply units, video display units, etc.

Applicants for the intermediate positions would be expected to work on similar equipment to that as above and have a good technical background in electronics. Where necessary appropriate training will be given.

It is important that all applicants should be self motivated and work with minimal supervision.

The department is expanding and there are excellent career prospects for people really interested in fault finding, repair and servicing complex equipment.

Those interested should apply by telephone or in writing to Mr. D. F. Watts, Personnel Department, GEC Computers Limited, Elstree Way, Borehamwood, Herts, WD6 1RX. Tel: 01-953 2030. Ext. 3697.

GEC Computers Limited GEC

(7372)

International Broadcast Sales Engineers

RCA Broadcast Systems has openings for Sales Engineers to assume responsibility for the marketing and sale of our range of professional television and radio studio and transmitter equipment in areas of Europe, Africa and the Middle East.

The positions will be based in Sunbury on Thames, Middlesex, and each salesman/woman will have direct responsibility for the aggressive promotion and sale of our products in an assigned area.

As a considerable amount of time has to be spent in the countries concerned, applications are invited only from persons willing to spend up to 50% of their time in their sales territory.

Ideally, we seek persons with past experience of selling broadcast or associated products, preferably internationally. However, we will also consider for training, candidates with experience in the operation and maintenance of broadcast equipment who are interested and keen to enter commercial and selling activity.

We are looking for persons who are interested in overseas travel and who have the initiative, dedication and personality to operate effectively in the challenging environment of international sales. A knowledge of French and/or German would be an asset for some posts.

Salaries are negotiable but will certainly be in keeping with the responsibilities and demands of these posts. Competitive Company fringe benefits, etc., exist.

Applications outlining past experience, age, etc., should be sent as early as possible to:

Pam Torma
RCA International Ltd.
50 Curzon Street
London, W1
England.

RCA

(7386)

INTERNATIONAL FIELD SERVICE ENGINEER

Required for our International Mass Spectrometer Service Division based in the U K. A sound knowledge of modern electronics is essential and a working knowledge of high vacuum system would be an advantage, although training will be given. Applicants should possess City and Guild or equivalent qualifications. Due to the extensive travel involved the position is probably more suitable for a single person aged between 20 and 30 years.

The Company is internationally renowned for the quality of its products and offers excellent working conditions including company car pension scheme superannuation and profit sharing bonus scheme.

Write or telephone for an application form

LKB

Service Manager
G Division
LKB Instruments Limited
232 Addington Road
Selsdon, South Croydon
Surrey CR2 8YD
01-657 8822

THE OPEN UNIVERSITY
Faculty of Technology

Electronics Technician

An Electronics Technician (Calibration) is required to join the general electronic facilities team of the Open University.

The main duties of the post are

- To provide a 95% in house calibration and maintenance service for all measuring equipment using mainly electronic techniques.
- To assist all O U staff (academic, research technicians and maintenance) with electronic problems and the use of their equipment.
- To set up and maintain the necessary record system to operate such a service.

Experience: Ten years in electronics, five years of which should be relevant to the above duties.

Qualifications: HNC or City and Guilds in an appropriate subject.

Salary: Technician Grade 5 £2889 to £3367 per annum.

Holidays: 20 working days plus 6 university closed days plus 7 national days.

The post is within the New City of Milton Keynes and there is a University Officer to assist with housing. The applicant, male or female, may be eligible for development housing and assistance with removal expenses from the Open University.

Application forms and further particulars are available by postcard request please from The Personnel Manager (ET2), The Open University, P O Box 75, Walton Hall, Milton Keynes MK7 6AL or by telephone from Milton Keynes 63868. Closing date for applications 10th August 1977. 7388

GARNETT COLLEGE

Downshire House
Roehampton Lane
London SW15 4HR
(01-789 6533)

TECHNICIAN GRADE 4 ELECTRICAL ENGINEERING/ RESOURCE CENTRE

Technician with an electrical engineering/electronics background and an interest in the use of closed circuit television and audio equipment required to join the college's technician team. Opportunity to be involved in development work in both Electrical Engineering and the Resource Centre. Training in the operational aspects of closed circuit television will be given. Applicants should possess ONC, Ordinary City and Guilds or equivalent qualifications and a minimum of seven years' experience. Salary scale £2,599-£2,940 plus £276 per annum London Weighting plus earnings related supplement.

Details and application form, returnable within ten days, available from the Chief Technician at the college. (7346)

Test Engineers

The reliable name in radio communications

Pye Telecommunications are a well established company, involved in the field of radio communications, both at home and overseas. The Pye trademark is synonymous with systems that are highly reliable. To ensure that reliability, we need test engineers to check our VHF/UHF systems to very exacting specifications prior to delivery.

We are looking for skilled men and women with experience of fault diagnosis, alignment and testing of electronic equipment, preferably communications equipment. Formal qualifications are desirable, but less important than sound practical ability. Armed Forces experience would be particularly acceptable.

We can offer you job security and long term employment prospects.

We have openings at Haverhill in Suffolk (where there is the possibility of local authority housing) and at Cambridge, both being attractive places in which to live. Relocation expenses are available.

Write or phone (reversing charges if necessary) to:

Catherine Dawe, Pye Telecommunications Ltd, Colne Valley Road, Haverhill, Suffolk CB9 8DU
Tel: Haverhill 4422
or Clare Barton, Pye Telecommunications Ltd, Elizabeth Way, Cambridge.
Tel: Cambridge 58985

PYE

Pye Telecommunications Ltd

A member of the Pye of Cambridge Group

DESIGN/DEVELOPMENT ENGINEERS

Ferranti wins Army contract.

Ferranti land space order.

1200 MORE JOBS FR
FERRANTI EXPANS

MoD order goes to Ferranti.

Come and make headlines with us.

Headlines like these are only possible when you're acknowledged internationally as one of the world's leaders in avionics. To keep us at the forefront we need highly motivated design/development engineers keen to make their mark. And at Ferranti there's plenty of opportunity to do just that. On projects like the Tornado, Sea Harrier, Jaguar and Lynx.

And headlines like these also mean expansion. Which explains why we're looking for more graduate mechanical and electronic engineers to join our airborne radar and inertial navigation teams. They must have the design/development experience to spearhead the progress of equipment from drawing board through to production.

We are particularly interested in talking to engineers with backgrounds in the design of:-

Digital/analogue circuitry.
Microwave and laser techniques.
Small digital computers.
Advanced instruments.
Optics.
Airborne structures and light mechanisms.

So if you're keen to make your mark on avionics, you'll find you're very much on our wavelength.

Think about it. Then ask the family how they'd like living in Edinburgh, freely acknowledged as one of Europe's finest cities.

Salaries are negotiable and, of course, we operate a contributory pension and life assurance scheme and pay realistic relocation expenses.

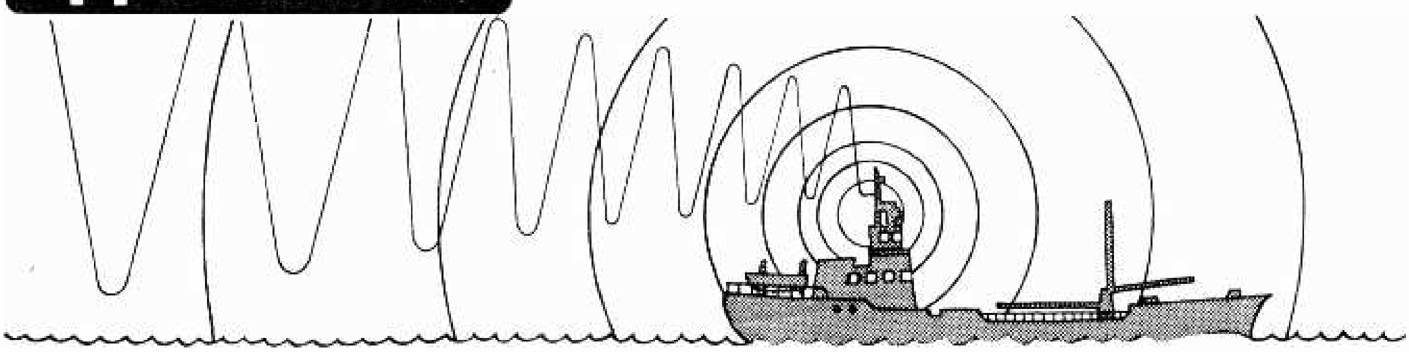
For an application form, write to John McPhee at the address below:

Ferranti Limited
Ferry Road
EDINBURGH EH5 2XS
Tel: 031-332 2411.

These posts are open to both male and female candidates.

(7000)

FERRANTI



Radio Officers–now you can enjoy the comforts of home.

Working for the Post Office Maritime Services really makes sense. You still do the work that interests you, but with all the advantages of a shore-based job: more time to enjoy home life, job security and good money. To qualify, you need a United Kingdom Maritime Radiocommunication Operator's General Certificate or First Class Certificate of competence in Radiotelegraphy, or an equivalent certificate issued by a Commonwealth Administration or the Irish Republic.

Starting salaries, at 25 or over, are £2905 rising to £3704 after three years service. Between 19 and 24, the starting salary varies from £2234 to £2627 according to age. In addition, a supplement of £312 p.a. is payable. You'll also receive an allowance for shift duties which at the maximum of the scale averages £900 a year and there are opportunities to earn overtime. There's a good pension scheme, sick pay benefits and prospects of promotion to senior management.

Right now we have a few vacancies at some of our coastal radio stations, so if you're 19 or over, preferably with sea-going experience, write to:
ETE Maritime Radio Services Division (L690),
ET 17.1.1.2., Room 643, Union House,
St. Martins-le-Grand, London EC1A 1AR.

Post Office Telecommunications

Brunei

Jefri Bolkiah School of Engineering

SENIOR TECHNICAL INSTRUCTOR

Telecommunications

To teach C & G Telecomms Technician Courses 270/271 with Telephony/Telegraphy as specialist subjects, advise on course development and procurement of equipment.

F T.C. in Telecomms Technician with Telephony and Telegraphy and/or HNC. Good practical experience preferably including exchange wiring, cables and termination, including to M D F S Teaching certificate and/or Tech College teaching desirable

SALARY in range up to £7980 p a TAX FREE Plus 25% terminal gratuity

Appointments on contract to Government of Brunei for 3 years beginning as soon as possible Free passages, education allowances and holiday visit passages for children, subsidised accommodation, generous leave outfit allowance

Application form and further details from Recruitment Unit, TETOC (Technical Education and Training Organisation for Overseas Countries), 35-37 Grosvenor Gardens, London SW1W 0BS

Quoting ref BRU/WW

7390

RADIO TECHNICIANS

Government Communications Headquarters has vacancies for Radio Technicians. Applicants should be 19 or over.

Standards required call for a sound knowledge of the principles of electricity and radio, together with 2 years experience of using and maintaining radio and electronic test gear

Duties cover highly skilled Telecommunications/electronic work, indluding the construction, installation, maintenance and testing of radio and radar telecommunications equipment and advanced computer an analytic machinery

Qualifications: Candidates must hold either the City and Guilds Telecommunications Part I (Intermediate) Certificate or equivalent HM Forces qualification.

Salary scale from £2,230 at 19 to £2,905 at 25 (highest pay on entry), rising to £3,385 with opportunity for advancement to higher grades up to £3,780 with a few posts carrying still higher salaries. Pay supplement of £313.20 per annum

Annual Leave allowance is 4 weeks rising to 6 weeks after 27 years' service

Opportunities for service overseas

Candidates must be UK residents.

Further particulars and Application forms available from

Recruitment Officer
Government Communications Headquarters
Oakley, Priors Road
CHELTENHAM, Glos GL52 5AJ
Tel. Cheltenham 21491 Ext. 2270
(STD 0242-21401)

(7219)

KING ALFRED'S COLLEGE
WINCHESTER SO22 4NR

CCTV STUDIO TECHNICIAN

Duties will include the setting-up of television equipment, first-line maintenance and participation in production and training.

Applicants should have some qualification in electronics or experience in the use and maintenance of CCTV equipment.

Salary scale £2841-£3165.

Further details and application from the Bursar. Tel 0962 62281

Closing date for applications, 29th July.

7369

APPOINTMENTS IN ELECTRONICS

Take your pick of the permanent posts in:

MISSILES – MEDICAL
COMPUTERS – COMMS
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For expert advice and immediate action on career improvement, 'phone, or write to, Mike Gernat BSc

Technomark
Engineering and Technical Recruitment

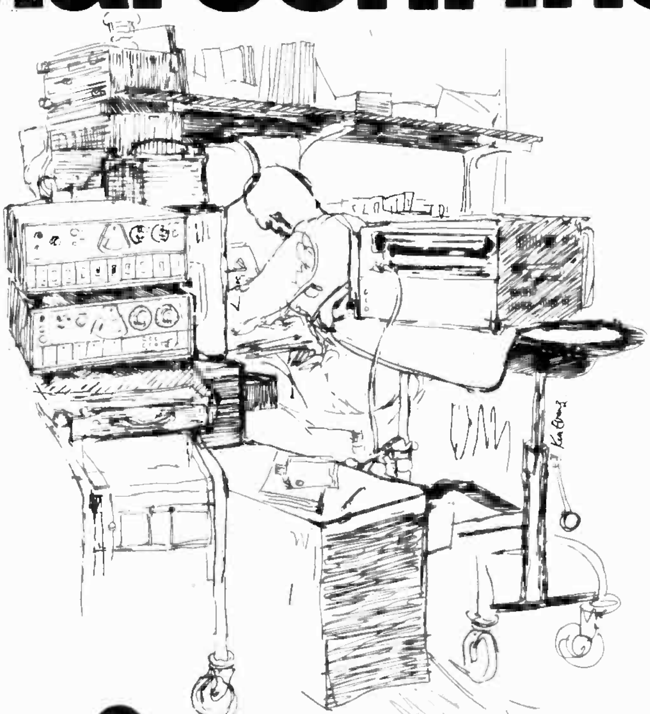
11 Westbourne Grove
London W2 01-229 9239.

Appointments

Advertisements accepted up to 12 noon Monday, August 1, for the September issue, subject to space being available.

DISPLAYED APPOINTMENTS VACANT: £7.50 per single col. centimetre (min. 3cm).
LINE advertisements (run on): £1.10 per line, minimum three lines.
BOX NUMBERS: 50p extra. (Replies should be addressed to the Box Number in the advertisement, c/o Wireless World, Dorset House, Stamford Street, London SE1 9LU.)
PHONE: Eddie Farrell on 01-261 8508
Classified Advertisement Rates are currently zero rated for the purpose of V.A.T.

Marconi Instruments



ELECTRONIC TECHNICIANS

Opportunities for the experienced and sometimes inexperienced in St. Albans and Luton.
Work situations range from fault finding on PCB's and components, to batch product testing of equipment that utilise very advanced techniques including microprocessors and the repair/calibration of all manner and types of test instruments.
Attractive salaries and, where appropriate, relocation are offered for the right candidates.
Further information may be obtained in confidence from John Prodger
Marconi Instruments Limited,
Longacres, St. Albans, Herts. tel: St. Albans, 59292

A GEC-MARCONI ELECTRONICS COMPANY

(7344)

mi

DESIGN TEST FIELD SERVICE

Immediate vacancies exist in most areas for engineers qualified to BSc/HNC/C&G with analogue, digital or R.F. experience.
Phone or write

APEX PERSONNEL
800 FULHAM ROAD
LONDON S.W.6
01-731 4353.

(7155)

ELECTRONIC RESEARCH AND DEVELOPMENT TECHNICIAN

required with an automotive bias to join a small friendly team. London, S.E.1.
Applicant should be qualified to at least HND level and have some knowledge of or interest in the automobile application.
Salary by negotiation. Four weeks' annual leave and non-contributory pension scheme by qualification.
Contact Mr. D. Bland, on 01-407 7311 for appointment. (7354)

AVIONICS TECHNICIAN

Douglas Airways Pty. Ltd., Papua, New Guinea, invite applications for the position of Avionics Technician in their overhaul shop at Jacksons Airport, Port Moresby. This workshop is one of the most comprehensively equipped in the Southern Hemisphere.

Successful applicant will have at least ten years' experience of which a proportion will be bench work on VHF and HF radios. He will also have a good understanding of navaids and hold appropriate licences.

Specialists on one system only need not apply.

Salary negotiable according to experience and qualifications. Free accommodation in Port Moresby.

All applications in writing giving full details of experience and qualifications to

DOUGLAS AIRWAYS PTY. LTD.
C/O NORMAN BUTCHER AND JONES LIMITED
120/122 Southwark Street
London, SE1 0SW

CAPITAL APPTS.

FREE LISTS
101 Design/Development and Test Jobs.
Permanent and Contract
To £6,000

34, Percy St. London, W.1.

7377

637 5551 day: 550 0836 eve.

INSTRUCTOR IN MARINE RADIO

is required by

College of I.M.R. Communications
160-176 Chorlton Road
Brooks' Bar
Manchester M16 7WT

Suitable applicants for the above position will have served in the Merchant Navy and will have an up-to-date knowledge of electrical fundamentals.
Salary scale £2,900-£4,500
Write to the Principal, giving details of qualifications and experience. (7349)

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For Semiconductors Capacitors Resistors I/C Sockets L.E.D.'s and Hi-Fi Accessories

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†BC548A	13
†BC548B	13
†BC549	14
†BC549B	15
†BC557	11
†BC558	12
†BC559	12
BCY30	90
BCY31	98
BCY32	1 20
BCY33	80
BCY34	90
BCY38	1 00
BCY39	3 40
BCY40	1.25
BCY42	.28
BCY43	25

BCY58	22
BCY70	17
BCY71	18
BCY72	14
BD115	60
BD121	.90
BD123	.90
BD124	86
BD131	42
BD132	42
BD133	65
†BD135	37
†BD136	39
†BD137	44
†BD138	47
†BD139	.54
†BD140	58
BD144	2 00
†BD155	.75
†BD165	.43
†BD232	1.00
†BDX32	2.25
BDY20	.80
BF115	22
†BF152	.20
†BF153	.24
†BF154	.20
BF156	.25
BF157	.26
†BF158	.20
†BF159	.26
†BF160	.20
BF166	.38
BF167	.21
BF173	.20
BF177	.24
BF178	.24
BF179	.25
BF180	.30
BF181	.30
BF182	.34
BF183	.34
BF184	.25
BF185	.28
†BF194	10
†BF195	10
†BF196	12
†BF197	12
BF200	.38
†BF244	.32
†BF244A	.37
†BF244B	.37
†BF244C	.37
†BF245	.42
†BF245A	40
†BF245B	.40
†BF245C	

BF257	.30
BF258	.40
BF259	42
BF271	40
†BF273	.30
†BF274	.34
BF336	.32
BF337	.33
BF338	.34
†BFR39	.26
†BFR40	.30
†BFR41	.32
†BFR79	.26
†BFR80	.32
†BFR81	.26
BFW10	68
BFW11	.68
BFX12	.24
BFX13	.25
BFX19	.55
BFX29	.26
BFX30	.25
BFX38	.25
BFX39	.25
BFX40	.28
BFX48	.36
BFX51	.25
BFX84	.22
BFX85	28
BFX86	.21
BFX87	.24
BFX88	.22
BFY50	.28
BFY51	.28
BFY52	.58
BFY53	.20
BFY56	.28
BFY64	.27
BFY72	.27
BFY75	.17
BFY76	.17
BSW66	.65
BSW67	.70
BSW68	.85
BSX19	.23
BSX20	.23
BSX21	.26
BSX27	.27
BSX29	.23
BSX66	.23
BSX67	.30
BSY95	.24
BSY95A	.24
†BU105	2.00
†BU105–02	2.25
†BU108	2.50

†BU133	1.95
†BU205	2 00
†BU206	2.30
†BU208	2 45
BY126	.16
BY127	.16
BY133	.20
BY164	.40
BYX10	.14
MJE2955	1 40
MJE3055	.90
OA5	.71
OA10	.62
OA47	.14
OA70	.30
OA73	.30
OA79	.30
OA81	.30
OA85	.30
OA90	.08
OA91	.08
OA95	.08
OA200	.09
OA202	.09
OC20	2 20
OC25	.98
OC28	1 10
OC29	1 10
OC35	.96
OC36	.96
OC41	.80
OC42	.90
OC43	2 30
OC44	.62
OC45	.60
OC71	.56
OC72	.60
OC73	1 00
OC74	.62
OC75	.67
OC76	.56
OC77	1.20
OC81	.70
OC82	.67
OC83	.67
OC84	.74
OC170	.62
OC171	.64
OCP70	1 68
OCP71	1 75
ORP12	.80
†TIP29	.42
†TIP29A	.47
†TIP29B	.53
†TIP29C	.57
†TIP30	.50
†TIP30A	.56
†TIP30B	.63
†TIP30C	.78
TIP31	.51

TIP31A	.57
TIP31B	.64
TIP31C	.79
TIP32	.60
TIP32A	.67
TIP32B	.76
TIP32C	.94
TIP33	.84
TIP33A	.94
TIP33B	1 05
TIP33C	1.31
TIP34	1 00
TIP34A	1 13
TIP34B	1 26
TIP34C	1 59
TIP35	2.37
TIP35A	2 61
TIP35B	2.80
TIP35C	3 20
TIP36	3 02
TIP36A	3.31
TIP36B	3 63
TIP36C	4 10
TIP41	.60
TIP41A	.67
TIP41B	.75
TIP41C	.94
TIP42	.72
TIP42A	.80
TIP42B	.90
TIP42C	1 10
TIP2955	.97
TIP3054	.50
TIP3055	.48
UC734	.60
†ZTX107	.14
†ZTX108	.12
†ZTX109	.14
†ZTX300	.15
†ZTX301	.16
†ZTX302	.18
†ZTX303	.20
†ZTX304	.23
†ZTX310	.14
†ZTX311	.15
†ZTX312	.17
†ZTX313	.19
†ZTX314	.24
†ZTX320	.19
†ZTX321	.18
†ZTX330	.21
†ZTX331	.22
†ZTX337	.17
†ZTX338	.15
†ZTX341	.20
†ZTX342	.22
†ZTX500	.17
†ZTX501	.18
†ZTX502	.20
†ZTX503	.21

†ZTX504	25
†ZTX510	16
†ZTX530	23
†ZTX531	23
†ZTX537	20
†ZTX538	18
†ZTX541	20
†ZTX542	25
†ZTX550	20
†ZTX551	21
IN914	06
IN916	07
IN4001	07
IN4002	07
IN4003	07
IN4004	08
IN4005	09
IN4006	10
IN4007	11
IN4009	06
IN4148	06
IN4149	08
IN5400	13
IN5401	14
IN5402	16
IN5403	18
IN5404	20
IN5405	24
IN5406	28
IN5407	35
IN5408	40
IS44	06
IS920	07
IS921	08
IS922	09
IS923	10
2N404	1 10
2N456	80
2N456A	90
2N457	1 20
2N457A	1 30
2N458	1 30
2N458A	1 40
2N525	1 10
2N696	30
2N697	30
2N706	20
2N706A	22
2N708	22
2N711	75
2N711A	77
2N718	22
2N718A	27
2N743	20
2N744	20
2N753	22
2N910	72
2N914	24
2N916	28
2N918	33
2N929	22
2N930	22
2N1131	30
2N1132	30
2N1302	36
2N1303	36
2N1304	50
2N1305	45
2N1306	54
2N1307	54
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2N1309	60
2N1613	30

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2N1671A	1 60
2N1671B	1 80
2N1711	30
2N1889	34
2N1890	34
2N1893	28
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2N2193A	40
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2N2194A	40
2N 2218	30
2N2218A	33
2N2219	30
3N2219A	33
2N2220	20
2N2221	20
2N2221A	21
2N2222	20
2N222A	.21
2N2368	20
2N2369	25
2N2369A	26
2N2646	50
2N2647	85
2N2904	30
2N2904A	33
2N2905	25
2N2905A	28
2N2906	25
2N2906A	27
2N2907	23
2N2907A	26
†2N2923	22
†2N2924	23
†2N2925	24
†2N2926 Brn	11
†2N2926 Red	12
†2N2926 Org	13
†2N2926 Yel	14
†2N2926 Grn	15
2N3053	30
2N3054	60
2N3055	80
2N3440	55
2N3441	96
2N3442	1 35
2N3525	90
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2N3576	20
2N3611	1 30
2N3612	1 40
2N3613	1 50
2N3614	1.60
2N3615	1 70
2N3616	1 80
2N3617	1.90
2N3618	2 20
2N3632	5 80
†2N3638	15

†2N3638A	16
†2N3641	17
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†2N3643	17
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†2N3711	11
2N3771	2 00
2N3772	2 10
2N3773	3 10
2N3789	3.00
2N3790	3 30
2N3791	3.10
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†2N3793	36
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2N3821	73
2N3822	64
2N3823	58
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2N3824	52
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2N5490	65
2N5492	68
2N5494	65
2N5496	60
†2N6027	61
†2N6028	74
3N141	90
40361	50
40362	50
40363	1 14
40411	2 60
CMOS	
4000	20
4001	20
4002	20
4006	1 90
4007	20
4008	1 08
4009	80
4010	80
4011	20
4012	20
4013	56
4014	1 86
4015	1 00
4016	56
4017	1 00
4018	1 40
4019	60
4020	1 10
4021	1 00
4022	1.00
4023	20
4024	80
4025	20
4026	1 90
4027	60
4028	90
4029	1 30
4030	65
4031	2 40
4032	1 00
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10uf 25v	.13
22uf 16v	.13
33uf 10v	.14
47uf 6.3v	.15
68 100uf 3v both values	.15

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1	.045	.05	.055	.06
1.5	.045	.05	.055	.06
2.2	.045	.05	.055	.06
3.3	.045	.05	.055	.06
4.7	.045	.05	.055	.06
6.8	.05	.055	.06	.07
10	.05	.06	.07	.09
22	.06	.07	.09	.13
33	.07	.085	.10	.15
47	.08	.10	.12	.19
100	.10	.13	.18	.26
150	.11	.15	.20	.28
220	.12	.16	.22	.32
330	.14	.18	.26	.36
470	.16	.20	.29	.40
680	.18	.24	.35	.48
1000	.20	.29	.41	
2200	.24	.38	.60	
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BC107	.085	BC159	.11
BC108	.085	BC182	.11
BC109	.09	BC182L	.11
BC147	.09	BC183	.11
BC148	.09	BC183L	.11
BC149	.09	BC184	.11
BC157	.10	BC184L	.11

BC212	.12	MPSA56	.22	IN914	.06	2N3702	.08
BC212L	.12	MPSU01	.35	IN4001	.05	2N3704	.07
BC213	.11	MPSU51	.38	IN4002	.055	2N3705	.07
BC213L	.11	OA47	.08	IN4003	.06	2N3707	.08
BC214	.13	OA79	.08	IN4004	.075	2N3710	.07
BC214L	.13	OA90	.07	IN4005	.09	2N3819	.22
BCY70	.17	OA91	.075	IN4006	.11	2N3904	.12
BCY71	.18	OC20	.98	IN4007	.11	2N3906	.12
BCY72	.15	OC28	.78	IN4148	.05	2N4058	.12
BD131	.40	OC35	.78	IN5402	.16	2N4062	.12
BD132	.41	OC36	.78	IS44	.05	CMOS	
BFX85	.25	TIP29A	.46	IS920	.06	4000	.18
BFX87	.24	TIP29B	.55	2N696	.15	4001	.20
BFX88	.24	TIP30A	.52	2N706	.20	4002	.20
BFY50	.16	TIP30B	.62	2N1306	.35	4011	.20
BFY51	.16	TIP31A	.54	2N1307	.35	4012	.20
BFY52	.16	TIP31B	.65	2N2219	.20	4013	.50
BSX19	.20	TIP32A	.62	2N2222	.20	4016	.50
BSX21	.25	TIP32B	.75	2N2222A	.20	4017	.95
MJE340	.66	TIP41A	.67	2N2368	.20	4020	1.05
MJE371	.66	TIP41B	.70	2N2646	.42	4024	.75
MJE521	.60	TIP42A	.75	2N2904	.20	4025	.20
MJE2955	.92	TIP42B	.80	2N3053	.17	4027	.60
MJE3055	.65	TIP3055	.50	2N3054	.42	4030	.55
MPSA06	.22	ZTX107	.10	2N3055	.42	4033	1.50
MPSA13	.24	ZTX304	.20	2N3440	.50	4040	1.00

4042	.80	711-14	.32	7420	.16	7495	.74
4044	.99	3045	.45	7425	.20	7496	.80
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4054	1.10	VOLTAGE REGS		7427	.30	74123	.70
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4069	.40	7805TO220	1.30	7437	.33	74145	.75
4071	.26	7812TO220	1.30	7440	.16	74147	1.40
4081	.20	7815TO220	1.30	7441	.68	74150	1.45
4093	.80	7905TO220	1.95	7442	.60	74151	.75
4501	.20	7912TO220	1.95	7445	.96	74153	.85
4502	1.00	7915TO220	1.95	7447	.76	74154	1.37
4507	.60	7400 TTL		7450	.16	74157	.70
4511	1.50	7400	.16	7451	.16	74161	1.00
4528	1.05	7401	.16	7453	.16	74173	1.50
4556	.98	7402	.16	7454	.16	74174	1.25
4583	.80	7403	.16	7460	.16	74175	.88
OP AMPS		7404	.16	7470	.30	74180	1.00
301A-8	.35	7405	.16	7472	.32	74181	2.10
709-14	.46	7406	.32	7473	.35	74185A	1.50
741-8	.22	7407	.32	7474	.35	74190	1.50
741-14	.20	7408	.16	7475	.46	74191	1.50
741 TO99	.48	7409	.16	7476	.37	74193	1.50
747-14	.70	7410	.16	7483	.92	74195	.95
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LINEAR		7412	.24	7486	.34	74197	1.25
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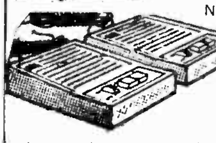

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Each kit includes a set of displays (0.5" Red LED type TIL322/FND500) and two PCBs, two 4511 and one 4518 CMOS ICs for each pair of digits, plus brackets, resistors, capacitors, a single in-line plug and socket, nuts, screws, washers, instructions, etc. IC sockets are not provided and we recommend that you order Soldercon Pins separately.
Each module consists of one vertical PCB holding the displays, fixed by two brackets to a horizontal PCB, which holds the remaining components.

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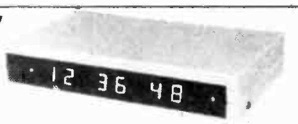

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Four bright green 0.5" digit mantlepiece or office clock ● White case ● Size h 40mm, w 154mm, d 85mm. Complete less mains cable, plug and battery.
Order as **GCK** **£14.40**
Also available with crystal control and battery back-up.
Order as **GCK + GBBK + XTK** **£19.65**

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Order as **111-222** **£15.50**
Also available with crystal control and battery backup.
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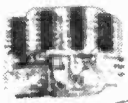

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Use to improve accuracy of your digital clock ● As a 50Hz source in a clock with battery backup ● Accurate to within a few seconds a month ● Size h 14mm, w 64mm, d 49mm.
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CCK

AUT-CK

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DATABOOKS

Intel Memory Design Handbook	£5.20
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Motorola Booklet From the Computer to the Microprocessor	£1.80
Motorola McMOS Databook (Vol. 5 Series B)	£3.50
Motorola M6800 Microprocessor Applications Manual	£12.95
Motorola M6800 Programming Manual	£5.35
National SC/MP Introkit User's Manual	£0.75
National SC/MP Technical Description	£1.95
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Texas Instruments Pin Configuration Guide A very useful set of gloss cards showing top and bottom pinout views of 7400 ICs plus many others (TTL, Memories, Op Amps, etc.)	£2.95
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CD4013	0.58	CD4033	1.44	CD4053	0.94	CD4082	0.23	CD4532	1.39
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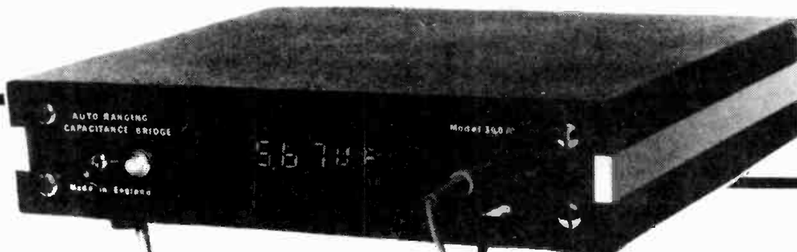

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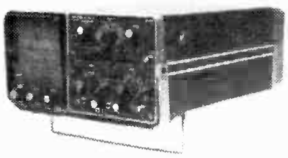

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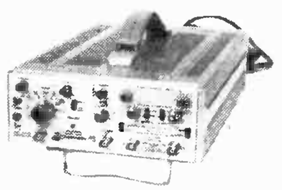

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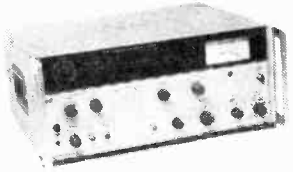

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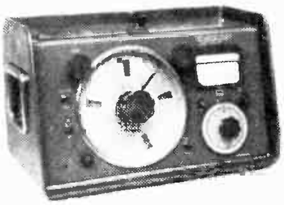

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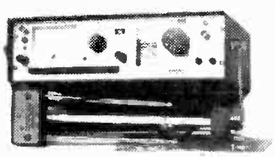

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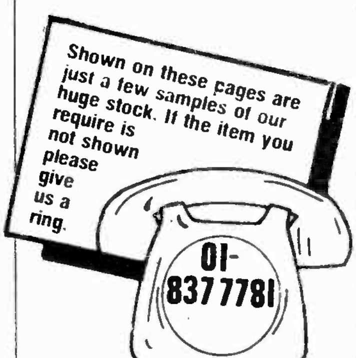

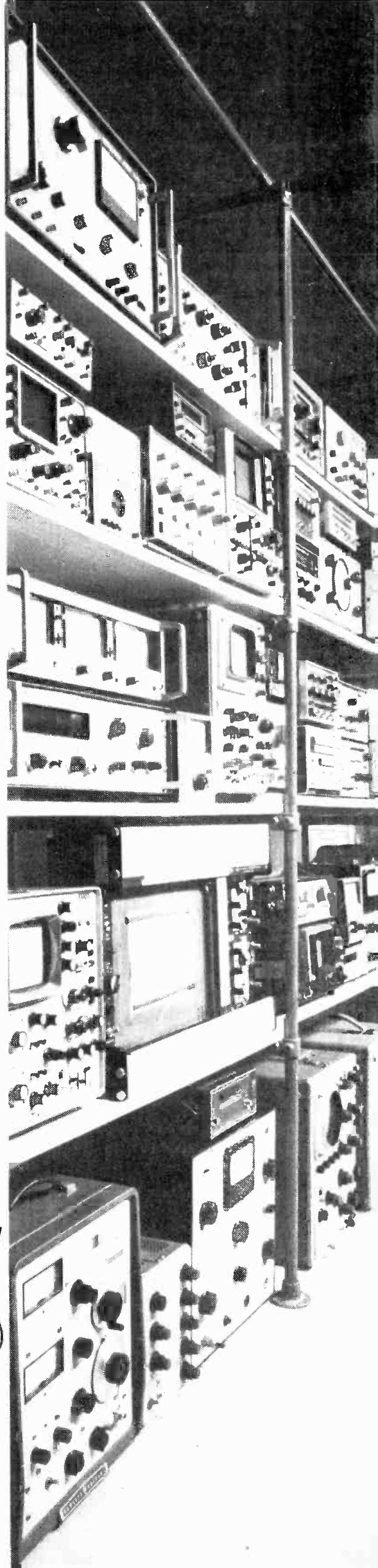

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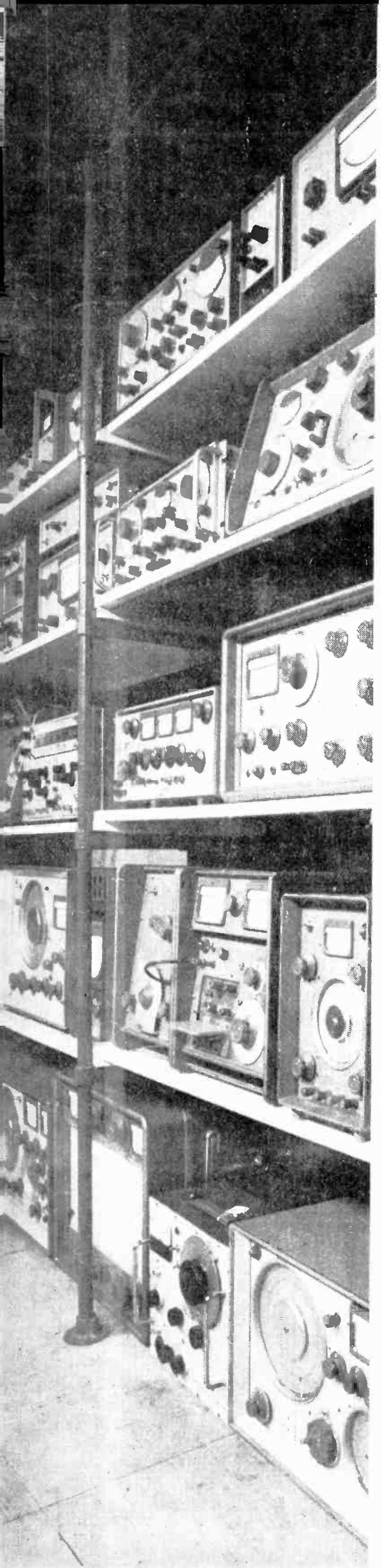

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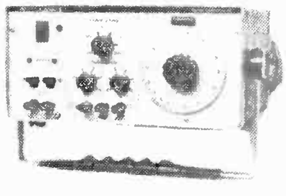

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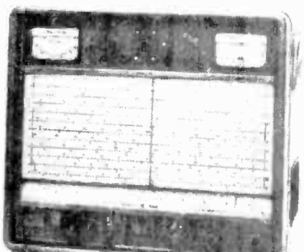

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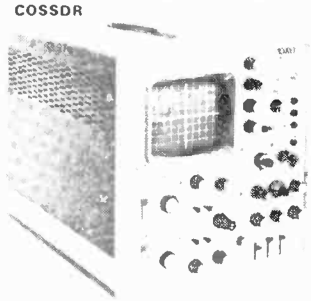

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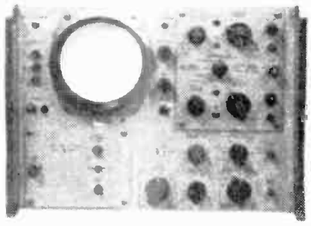

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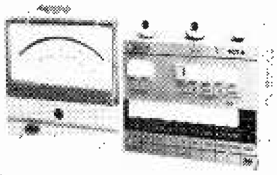

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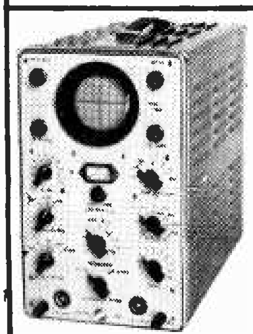

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6AL5	0.30	30A5	0.70					PCC89	0.55	UA142	0.70
6AS5	0.65	35A3	0.70	ECC84	0.35	ECL85	0.65	PCC189	0.65	UBC41	0.50
6AS6	0.80	35A5	0.80	ECC85	0.45	ECL86	0.55	PCF80	0.40	UBC81	0.50
6AT6	0.60	3585	0.70	ECC86	1.25	EF80	0.35	PCF82	0.40	UBF80	0.50
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6AU6	0.40	35W4	0.60	ECC189	0.80	EF183	0.35	PCF201	0.85	UCC85	0.50
6BA6	0.38	50C5	0.70	ECF80	0.45	EF184	0.40	PCF802	0.55	UCF80	0.75
6BE6	0.45	EABC80	0.40	ECF82	0.45	EFL200	0.75	PCH200	0.75	UCH42	0.80
6BJ6	0.75	EAC91	0.55	ECF86	0.75	EL34	0.70	PCL81	0.55	UCH81	0.50
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6BZ7	0.70	EBC41	0.75	ECH42	0.85	EL82	0.60	PCL85	0.60	UF41	0.75
6C4	0.40	EBC81	0.50	ECH81	0.50	EL83	0.60	PCL86	0.60	UF42	0.75
6CB6	0.50	EBF80	0.50	ECH83	0.50	EL84	0.35	PCL200	0.75	UF80	0.40
6EA8	0.75	EBF83	0.50	ECH84	0.50	EL95	0.70	PL33	0.40	UF85	0.50
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6J4	0.75	EC86	0.75	ECL81	0.75	EM80	0.55	PL38	0.65	UL41	0.70
6J5GT	0.55	EC88	0.75	ECL82	0.42	EM81	0.60	PL81	0.55	UL84	0.50
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7423J	7446AN	7483	74107J	74156N
7430J	7446N	7485N	74107N	74180N
7437J	7448N	7485J	74126J	74180J
7437N	7453N	7491AN	74145J	74181N
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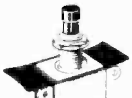

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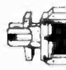

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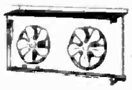

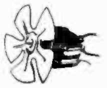

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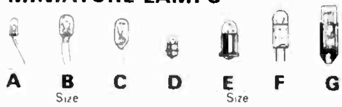

Type	(Dia.)	Volt/Curr.	Type	(Dia.)	Volt/Curr.
A	3MM	5-6V 60 MA	D	3MM	2-5V 360 MA
B	4MM	4V 250 MA			5-6 60 MA
		5V 60 MA	E	4MM	6V 200 MA
		12V 40 MA			6.3 200 MA
		12V 100 MA			14V 40 MA
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AF116	0.20	BC302	0.40	BF336	0.35★	OC84	0.40	2N3711	0.10★		
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AF118	0.50	BCY30	0.55	BF338	0.45★	OC140	1.30	2N3716	1.80		
AF124	0.25	BCY31	0.55	BFW30	1.25	OC170	0.23	2N3771	1.60		
AF125	0.25	BCY32	0.60	BFW59	0.30	TIP29A	0.44★	2N3772	1.90		
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AL102	1.45	BCY39	1.15	BFX84	0.23	TIP41A	0.68	2N4348	1.20		
AL103	1.30	BCY40	0.75	BFX85	0.25	TIP42A	0.72	2N4870	0.35★		
AU107	3.30★	BCY42	0.30	BFX86	0.25	2N404	0.40	2N4871	0.35★		
AU110	1.75★	BCY54	1.60	BFX87	0.20	2N696	0.20	2N4918	0.60★		
AU113	1.60★	BCY70	0.12	BFX88	0.20	2N697	0.20	2N4919	0.70★		
BC107	0.12	BCY71	0.18	BFX89	0.90	2N706	0.15	2N4920	0.50★		
BC107B	0.12	BCY72	0.12	BFY11	1.10	2N1131	0.15	2N4922	0.58★		
BC108	0.12	BD115	0.15	BFY18	0.50	2N1132	0.16	2N4923	0.46★		
BC108B	0.12	BD131	0.36	BFY40	0.50	2N1302	0.40				
BC109	0.12	BD132	0.40	BFY41	0.60	2N1303	0.40				
BC109B	0.12	BD135	0.36★	BFY50	0.20	2N1304	0.45				
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BC117	0.19★	BD137	0.40★	BFY52	0.19	2N1306	0.50				
BC119	0.25	BD138	0.48★	BFY53	0.25	2N1307	0.50				
BC125	0.18★	BD139	0.58★	BFY64	0.35	2N1308	0.60				
BC126	0.20★	BD144	2.20	BFY90	0.90	2N1309	0.60				
BC140	0.32	BD157	0.60	BSX19	0.16	2N1711	0.24				
BC141	0.28	BD181	0.86	BSX20	0.18	2N2102	0.44				
BC142	0.23	BD182	0.92	BSX21	0.20	2N2217	0.30				
BC143	0.23	BD183	0.97	BSY52	0.28	2N2369	0.14				
BC147	0.09★	BD184	1.20	BSY53	0.39	2N2369A	0.14				
BC148	0.09★	BD232	0.60	BSY54	0.33	2N2483	0.20				
BC149	0.09★	BD233	0.48	BSY55	0.74	2N2484	0.16				
BC157	0.09★	BD237	0.55	BSY65	0.30	2N2646	0.50				
BC158	0.09★	BD238	0.60	BSY95A	0.16	2N2711	0.20				
BC159	0.09★	BD410	0.60	BU105	1.80★	2N2712	0.15				
BC160	0.32	BDX32	2.30	BU105/02	1.90★	2N2904A	0.20				
BC161	0.38	BDY10	1.50	BU108	3.00★	2N2905	0.18				
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4024BE	0.86
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4042BE	0.83
4034BE	1.00
4044BE	0.94
4046BE	1.32
4049BE	0.54
4050BE	0.54
4069BE	0.30
4070BE	0.50
4071BE	0.26
4072BE	0.26
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7432	0.28	74145	0.68
7437	0.30	74154	1.30
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7442	0.65	74165	0.93
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BYX38—300	0.50	OA90	0.08	IN4006	0.09★
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DATA LOGGER by DYNAMCO

These are BRAND NEW — not finished — DATA LOGGERS BY **DYNAMCO.** They are completed but for the plug-in boards. The case with hinged lid is quite superb and extremely adaptable. It contains as well as the mother board an equally superb Power Supply with the following voltages +28V, +15V, +5V (2.5A) — this supply is crowbar protected, −5V, −14V, −20V, −24V, −48V and other supplies including auto 110V. This unit supplied in its original cardboard box complete with original manual and must be of serious interest to the professional constructor and anyone considering the construction of a micro processor system. Unit size 7½" high x 19" wide x 23" deep.
Price **£45** each. Carriage £2.50

PICK-A-PACK — 50 PENCE A POUND

From Our "Pick-A-Pack" area weigh up your own components. No restrictions on what you take

EX-DYNAMCO Oscilloscopes INVERTORS 30V Input 6KV Output. Size 2" x 4½" x 1½". Complete with circuit £10 each. P&P £1

MINIATURE — OXLEY PATCH PANELS — BRAND NEW **EX-DYNAMCO.** 10 x 10 complete with pins **£8** each. P&P 50p

★TELEPHONES. Post Office style 746 Black or two-tone **£6.50** ea. Modern style 706 Black or two-tone grey **£4.50** ea. P&P 75p each. Old black style **£1.50** ea. P&P £1
★HANDSETS only 706 style **£1.75** each, older style **£1.** P&P 75p
TELEPHONE EXCHANGES. Eg. 15-way automatic (exchange only) from **£95.**
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PAPST Model 240V available at **£7.50** ea. P&P 75p

SURPLUS — BRAND NEW — REPLACEMENT TUBES FOR DYNAMCO 7100 SERIES OSCILLOSCOPES TYPE BRIMAR D13-51GH
Mesh P.D.A. Transistor Scan Wide Bandwidth 60MHZ + Rectangular 6 x 10cm — 1KV EHT X Sensitivity 15V/CM. Y Sensitivity 6V/CM standard heaters. Length 13¼"
THIS IS A MUST AS A SPARE FOR THE DYNAMCO 7100 SCOPE OR IDEAL FOR THE HIGH QUALITY TRANSISTOR SCOPE BUILDER.
At **£65** each. Carriage £2.50
To Tube purchasers only. Numetal Shields at **£2.50**
ALSO AVAILABLE TUBE TYPE BRIMAR D10-210GH/32. Rectangular 7 x 5cm. Mesh P.D.A. Short 9⅛". 30MHZ+ Sensitivity x 14V/CM, Y 10V/CM. BRAND NEW at **£75** each. Carriage £2.50

PHOTOMULTIPLIER Type 931A **£4** ea. P&P 75p. Other types available.
★POTENTIOMETERS — All **5p** ea. P&P extra. Metal bodies AB Linear PCB Mount. Brand new. 10K, 100K ganged, 250K ganged, 100K ganged concentric shafts.
★BEEHIVE TRIMMERS 3/30pf. Brand New 10 off **40p** P&P 15p. 100 off **£3.50.** P&P 75p. 500 off **£15.** P&P £1.25. 1,000 off **£25.** P&P £1.50
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DON'T FORGET YOUR MANUALS. S.A.E. with requirements.
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240KV SINGLE PAHSE 20KVA. Output 2 x 2.5KV **£85.**
240V SINGLE PHASE 1KVA Output 40KV 25MA **£175.**
Many other EHT Transformers and EHT Capacitors available.

A LARGE QUANITITY OF MISCELLANEOUS TEST GEAR, CHASSIS UNITS, etc., on view at LOW COST.

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Approx. 2,000ft. **NOW 25p** each. P&P £1

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NOTE. Demand for these items already means one month delay. Save Money, save time, order "KITS" at HALF PRICE — you assemble.

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UNIVAC/HONEYWELL/ICL 1900, etc.
Boards, Power Supplies, Core Stores are available.
CALL AND SEE

ITEMS OFTEN AVAILABLE

CORE STORES with Drivers from **£100.**
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P.C. MOTORS (Disc Drives?) **£15** each.

FOR THE VDU BUILDER. New stock of Large Rectangular Screen 30 x 20cm tube. Type M38 at the ridiculous price of **£4** each. And also still available the CME1220, 24 x15cm at **£9** ea. Base connections for both tubes supplied.

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Single phase — air conditioning not required. Guaranteed fine condition **£240** each. Complete with copy of manual and 50 packs. Size approx. 2' x 2' x 3' 6" high.

SUPERB PROFESSIONAL VDU CASES, size 23" x 16" x 15" on stands. Hammer grey. BRAND NEW SCHLUMBERGER Surplus **£20** each.

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KSR33 non standard, e.g. basic ASCii-20ma loop — but small print 0 to 9, above standard 0 to 9, some of the symbols havinf been relocated **£250** ea.

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Attractive cast alloy front panel, vertical mount. Size 16½ x 15½ x 5½" containing 72 push buttons with manual or electrical reset (28V) with provision for labelling with your code, 65 illuminated symbols or functions (complete with 28V lamps) which again you can change, 16 bit front panel microswitch assembly to enable your coded cards to be read, and host of other electronic parts. **NOW £5** each.

We have been trying, and are still trying, and should soon succeed in getting a few systems up and running to enable us to demonstrate the increasing number of items that are becoming available. Most Callers will be Welcome.

NO TIME WASTERS PLEASE!
P.S. No Floppy disks — no cheap memory

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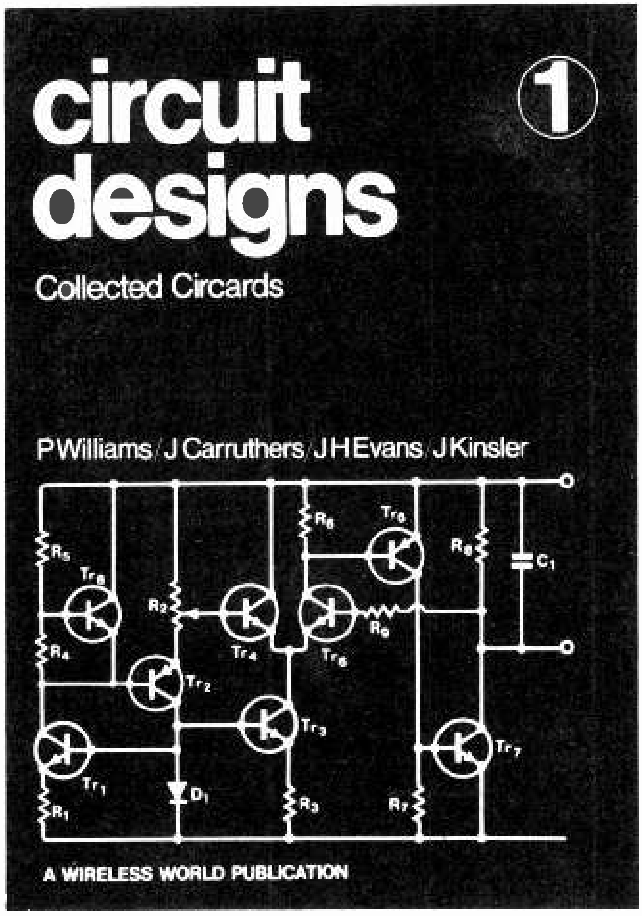
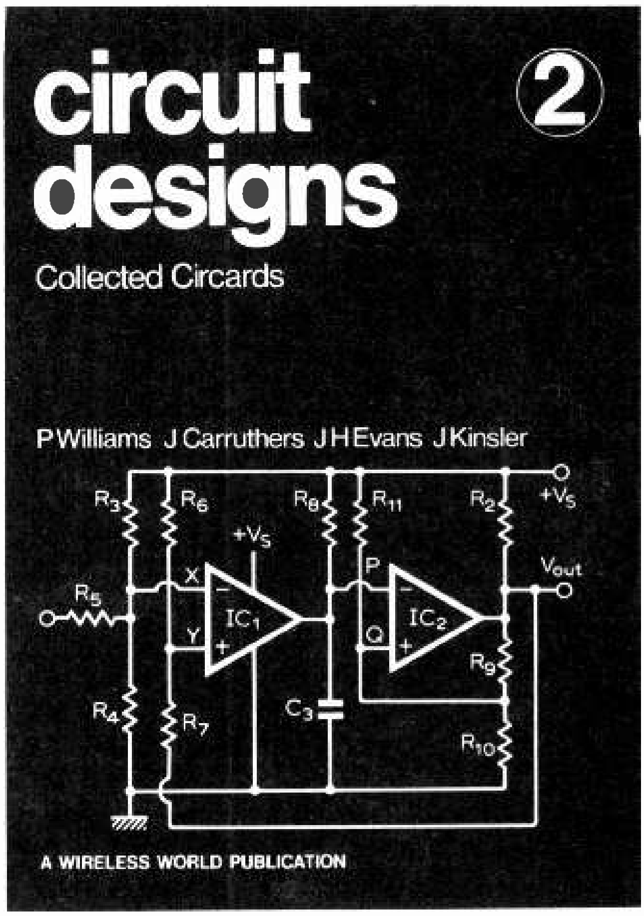
These books are of very special appeal to all concerned with designing, using and understanding electronic circuits. They comprise information previously included in Wireless World's highly successful Circards – regularly published cards giving selected and tested circuits, descriptions of circuit operation, component values and ranges, circuit limitations, modifications, performance data and graphs. Each of these magazine-size hard cover books contains ten sets of Circards plus additional circuits and explanatory introduction.





BOOK 1

- Basic active filters
- Switching circuits
- Waveform generators
- AC measurements
- Audio circuits
- Constant-current circuits
- Power amplifiers
- Astable circuits
- Optoelectronics
- Micropower circuits

BOOK 2

- Basic logic gates
- Wideband amplifiers
- Alarm circuits
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BI-PAK

High quality modules for stereo, mono and other audio equipment.

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PUSH-BUTTON STEREO FM TUNER

OUR PRICE ONLY **£20.45**

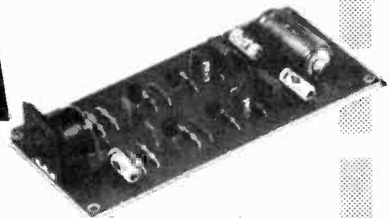
Fitted with Phase Lock-loop Decoder

The 450 Tuner provides instant program selection at the touch of a button ensuring accurate tuning of 4 pre-selected stations, any of which may be altered as often as you choose, by simply changing the settings of the pre-set controls.
Used with your existing audio equipment or with the BI-KITS **STEREO 30** or the **MK60** Kit etc. Alternatively the **PS12** can be used if no suitable supply is available, together with the Transformer **T538.**
The S450 is supplied fully built, tested and aligned. The unit is easily installed using the simple instructions supplied.

- ★ FET Input Stage
- ★ VARI-CAP diode tuning
- ★ Switched AFC
- ★ Multi turn pre-sets
- ★ LED Stereo Indicator

Typical Specification:
Sensitivity 3μ volts
Stereo separation 30db
Supply required 20-30v at 90 Ma max.

MPA 30



Enjoy the quality of a magnetic cartridge with your existing ceramic equipment using the new M.P.A. 30, a high quality pre-amplifier enabling magnetic cartridges to be used where facilities exist for the use of ceramic cartridges only.
It is provided with a standard DIN input socket for ease of connection. Full instructions supplied.

£2.85

VAT ADD 12½%

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STEREO PRE-AMPLIFIER PA100

OUR PRICE **£13.75**

A top quality stereo pre-amplifier and tone control unit. The six push-button selector switch provides a choice of inputs together with two really effective filters for high and low frequencies, plus tape output.

Frequency Response + 1dB 20Hz 20KHz. Sensitivity of inputs
1. Tape Input 100mV into 100K ohms
2. Radio Tuner 100mV into 100K ohms
3. Magnetic P.U. 3mV into 50K ohms

P.U. Input equalises to R1AA curve with 1dB from 20Hz to 20KHz.
Supply – 20-35V at 20mA.
Dimensions 299mm x 89mm x 35mm

MK. 60 AUDIO KIT: Comprising 2 x AL60's. 1 x SPM80. 1 x BTM80. 1 x PA100. 1 front panel and knobs. 1 Kit of parts to include on/off switch, neon indicator, stereo headphone sockets plus instruction booklet. **COMPLETE PRICE £29.55** plus 85p postage.

TEAK 60 AUDIO KIT:
Comprising Teak veneered cabinet size 16¾"x11½"x3¾", other parts include aluminium chassis, heatsink and front panel bracket plus back panel and appropriate sockets etc. **KIT PRICE £10.70** plus 85p postage.

NEW AL30A

10w R.M.S. AUDIO AMPLIFIER MODULE

The AL30A is a high quality audio amplifier module replacing our AL20 & 30. The versatility of its design makes it ideal for record players, tape recorders, stereo amps, cassette and cartridge players. A power supply is available comprising a PS12 together with a transformer T538, also for stereo, the pre-amp PA12.

SPECIFICATION:
- ● Output Power 10w. R.M.S.
- ● Supply 22 to 32 volts.
- ● Load Impedance 8 to 6ohms.
- ● Input Impedance 50K.
- ● Sensitivity 90mv for full output.
- ● Total Harmonic Distortion Less than .5% (Typically .3%).
- ● Frequency Response 60Hz to 25KHz ÷ 2db.
- ● Max. Heat Sink Temp 80 c.
- ● Dimensions 90 x 64 x 27mm

ONLY £3.60

STEREO 30

COMPLETE AUDIO

7+7 WATTS R.M.S.

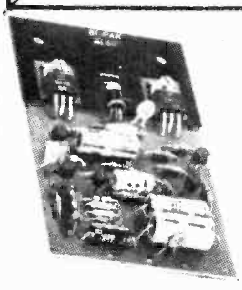
P & P 45p

£16.25

The Stereo 30 comprises a complete stereo pre-amplifier, power amplifiers and power supply. This, with only the addition of a transformer or overwind will produce a high quality audio unit suitable for use with a wide range of inputs i.e. high quality ceramic pick-up, stereo tuner, stereo tape deck etc. Simple to install, capable of producing really first class results, this unit is supplied with full instructions, black front panel knobs, main switch, fuse and fuse holder and universal mounting brackets enabling it to be installed in a record plinth, cabinets of your own construction or the cabinet available. Ideal for the beginner or the advanced constructor who requires Hi-Fi performance with a minimum of installation difficulty (can be installed in 30 mins).

TRANSFORMER £2.45 plus 62p p &p
TEAK CASE £5.25 plus 62p p & p

AL 60 25 Watts (RMS)



★ Max Heat Sink temp 90C. ★ Frequency response 20Hz to 100KHz ★ Distortion better than 0.1 at 1KHz ★ Supply voltage 15-50v ★ Thermal Feedback ★ Latest Design Improvements ★ Load — 3,4,8, or 16 ohms ★ Signal to noise ratio 80db ★ Overall size 63mm. 105mm. 13mm.

Especially designed to a strict specification. Only the finest components have been used and the latest solid state circuitry incorporated in this powerful little amplifier which should satisfy the most critical A.F. enthusiast.

£4.35

NEW PA12

NEW PA12 Stereo Pre-Amplifier completely redesigned for use with AL30A Amplifier Modules. Features include on/off volume, Balance, Bass and Treble controls. Complete with tape output.

Frequency Response 20Hz-20KHz (—3dB). Bass and Treble range 12dB. Input Impedence 1 meg ohm. Input Sensitivity 300mV. Supply requirements 24V. 5mA. Size 152mm x 84mm x 33mm.

£6.70

PS12

Power supply for **AL30A, PA12, SA450,** etc.

Input voltage 15-20v A.C. Output voltage 22-30v D.C. Output current 800 mA Max. Size 60mm x 43mm x 26mm.
Transformer T538 £2.30

OUR PRICE **£1.30**

Stabilised Power Supply Type SPM80

SPM80 is especially designed to power 2 of the AL60 Amplifiers, up to 15 watts (R.M.S.) per channel simultaneously. With the addition of the Mains Transformer **BMT80,** the unit will provide outputs of up to 1.5A at 35V. Size 63mm. 105mm. 30mm.
Incorporating short circuit protection.
Transformer BMT80
£2.60 + 62p postage

£3.75

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AUDIO KIT SUPPLIERS TO THE WORLD

T20+20 AND T30+30
20W, 30W AMPLIFIERS

Designed by Texas engineers and described in Practical Wireless the Texan was an immediate success Now developed further in our laboratories to include a Toroidal transformer and additional improvements, the slimline T20 + 20 delivers 20W per channel of true Hi-Fi at exceptionally low cost The design is based on a single F/Glass PCB and features all the normal facilities found on quality amplifiers, including scratch and rumble filters, adaptable input selector and head phones socket In a follow up article in Practical Wireless further modifications were suggested and these have been incorporated into the T30 + 30 These include RF interference filters and a tape monitor facility Power output of this new model is 30W per channel

Pack	T20	T30
1. Set of low noise resistors	1.60	1.70
2. Set of small capacitors	2.60	3.40
3. Set of power supply capacitors	2.20	2.50
4. Set of miscellaneous parts	3.50	3.50
5. Set of slide, mains, P.B. switches	1.50	1.50
6. Set of pots, selector switch	2.80	2.80
7. Set of semiconductors, ICs, skts.	7.25	7.75
8. Toroidal transformer – 240V prim. a.s. screen	5.60	7.20
9. Fibreglass PCB	3.50	3.90
10. Set of metalwork, fixing parts	5.20	6.20
11. Set of cables, mains lead	0.40	0.40
12. Handbook (free with complete kit)	0.25	0.25
13 Teak cabinet 15.4" x 6.7" x 2.8"	4.50	4.50

SPECIAL PRICES
FOR COMPLETE KITS!

T20+20 KIT PRICE only **£34.20**

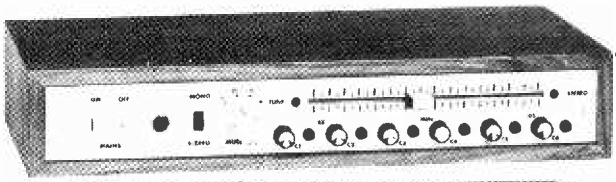
T30+30 KIT PRICE only **£39.50**

2 MATCHING TUNERS!

WW SFMT II

Following the success of our Wireless World FM Tuner kit we are now pleased to introduce our new cost reduced model, designed to complement the T20 and T30 amplifiers. The frequency meter of the more advanced model has been omitted and the mechanics simplified, however the circuitry is identical and this new kit offers most exceptional value for money. Facilities included are switchable afc, adjustable, switchable muting, channel selection by slider or readily adjustable pre-set push-button controls and LED tuning indication. Individual pack prices in our free list.

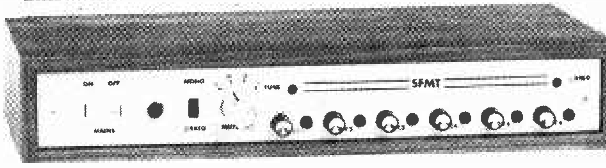
KIT PRICE **£47.70**



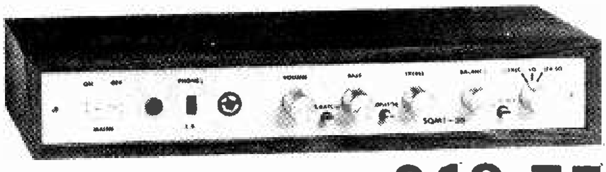
POWERTRAN SFMT

This easy to construct tuner using our own circuit design includes a pre-aligned front end module, PLL stereo decoder, adjustable, switchable muting, switchable afc and push-button channel selection As with all our full kits, all components down to the last nut and bolt are supplied together with full constructional details

KIT PRICE **£35.90**



CONVERT NOW TO QUADRAPHONICS!



SQM1 — 30 KIT PRICE £40.75

With 100s of titles now available no longer is there any problem over suitable software No problems with hardware either Our new unit the SQM1-30 simply plugs into the tape monitor socket of your existing amplifier and drives two additional speakers at 30W per channel A full complement of controls including volume, bass, treble and balance are provided as are comprehensive switching facilities enabling the unit to be used for either front or rear channels, by-passing the decoder for stereo-only use and exchanging left and right channels The SQ matrix decoder is based upon a single integrated circuit and was designed by CBS whilst the power and tone control sections are identical to those used in our T30 + 30 amplifier which the SQM1-30 matches perfectly. Kit price includes CBS licence fee

SQ is a trade mark of CBS inc

Special offer to T20 + 20 and Texan owners!
Owners of T20 + 20 and Texan amplifiers, which have no tape monitor outlet, purchasing an SQM 1-30 will be supplied on request, a free conversion kit to fit a tape monitoring facility to the existing amplifier This makes simple the connection to the highly adaptable SQM 1-30 quadrophonic decoder/rear channel amplifier

Wireless World Amplifier Designs. Full kits are not available for these projects but component packs and PCBs are stocked for the highly regarded Bailey and 20W class AB Linsley Hood designs, together with an efficient regulated power supply of our own design Suitable for driving these amplifiers is the Bailey Burrows pre-amplifier and our circuit board, for the stereo version of it features 6 inputs, scratch and rumble filters and wide range tone controls which may be either rotary or slider operating For those intending to get the best out of their speakers, we also offer an active filter system described by D C Read, which splits the output of each channel from the pre-amplifier into three channels each of which is fed to the appropriate speaker by its own power amplifier The Read/Texas 20W, or any of our other kits are suitable for these For tape systems a set of three PCBs have been prepared for the integrated circuit based, high performance stereo Stuart design Details of component packs are in our free catalogue

30W Bailey Amplifier	
BAIL Pk 1 F/Glass PCB	£1.00
BAIL Pk. 2 Resistors, Capacitors, Potentiometer set	£2.35
BAIL Pk. 3 Semiconductor set	£4.70
20W Linsley Hood Class AB	
LHAB Pk. 1 F/Glass PCB	£1.05
LHAB Pk 2 Resistor, Capacitor, Potentiometer set	£3.20
LHAB Pk. 3 Semiconductor set	£3.35
Regulator Power Supply	
60VS Pk. 1 F/Glass PCB	£0.85
60VS Pk. 2 Resistor, Capacitor set	£2.20
60VS Pk. 3 Semiconductor set	£3.10
60VS Pk 6A Toroidal transformer (for use with Bailey)	£8.80
60VS Pk. 6B Toroidal transformer (for use with 20W LH)	£7.25
Bailey Burrows Stereo Pre-Amp	
BBPA Pk 1 F/Glass PCB (stereo)	£2.80
BBPA Pk 2 Resistor capacitor semiconductor set (stereo)	£6.70
BBPA Pk 3R Rotary Potentiometer set (Stereo)	£2.85
BBPA Pk 3S Slider Potentiometer set with knobs (Stereo)	£3.10
Active Filter	
FILT Pk 1 F/Glass PCB	£1.40
FILT Pk. 2 Resistor, Capacitor set (metal oxide 2%, polystyrene 2½%)	£4.20
FILT Pk 3 Semiconductor set	£2.25
2 off Pks 1, 2, 3 rqd for stereo active filter system	
Read/Texas 20W Amp	
READ Pk. 1 F/Glass PCB	£1.00
READ Pk. 2 Resistor, Capacitor set	£1.20
READ Pk. 3 Semiconductor set	£2.30
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Stuart Tape Recorder	
TRRP Pk 1 Replay Amp F Glass PCB (stereo)	£1.30
TRRC Pk 1 Record Amp F Glass PCB Stereo	£1.70
TROS Pk 1 Bias/Erase/Stabilizer F Glass PCB (stereo)	£1.20

Further details of above and additional packs given in our FREE LIST

SQ QUADRAPHONIC DECODERS

Feed 2 channels (200-1000mV as obtainable from most pre-amplifiers or amplifier tape monitor outlets) into any one of our 3 decoders and take 4 channels out with no overall signal level reduction On the logic enhanced decoders Volume, Front-Back, LF-RF balance LB-RB balance and Dimension controls can all be implemented by simple single gang potentiometers

These state-of-the-art circuits used under licence from CBS are offered in kits of superior quality with close tolerance capacitors, metal oxide resistors and fibre-glass PCBs designed for edge connector insertion All kit prices include CBS licence fee.

M1 Basic matrix decoder with fixed 10-40 blend All components, PCB	£5.90
L1. Full logic controlled decoder with 'wave matching' and front back logic for enhanced channel separation All components PCB	£17.20
L2A. More advanced full logic decoder with "variable blend" for increased front back separation All components, PCB	£22.60
L3A. Decoder similar to L2A but with discreet component front end with high precision 6-pole phase shift networks for increased frequency response. All components (carbon film resistors), PCB	£25.90
Also available with M.O resistors, cermet pre-set — add	£4.20

SEMICONDUCTORS as used in our range of quality audio equipment.

2N699	£0.20	BC109	£0.10	BF259	£0.47	MPSA12	£0.35	TIP41A	£0.70
2N3055	£0.45	BC109C	£0.12	BFR39	£0.30	MPSA55	£0.25	TIP42A	£0.80
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2N5457	£0.45	BC184L	£0 11	MC1310	£2.20	SL3045	£1.20		
2N5459	£0.45	BC212L	£0.12	MC1351	£1.05	SN72741P	£0.40		
2N5461	£0.50	BC214L	£0.14	MC1741CG	£0.65	SN72748P	£0.40		
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40361	£0.40	BD529	£0.55	MJ481	£1.20	TIP29A	£0.40		
40362	£0.45	BD530	£0.55	MJ491	£1.45	TIP30A	£0.45	FM4	£1.00
BC107	£0.10	BDY56	£1.60	MJE521	£0.60	TIP29C	£0.55	SFJ10 7MA	£1.50
BC108	£0.10	BF257	£0.40	MPSA05	£0.25	TIP30C	£0.60		

EXPORT NO PROBLEM

Our Export Department will be pleased to advise on postal costs to any country in the world Some of the countries to which we sent kits in 1976 are shown surrounding this advertisement

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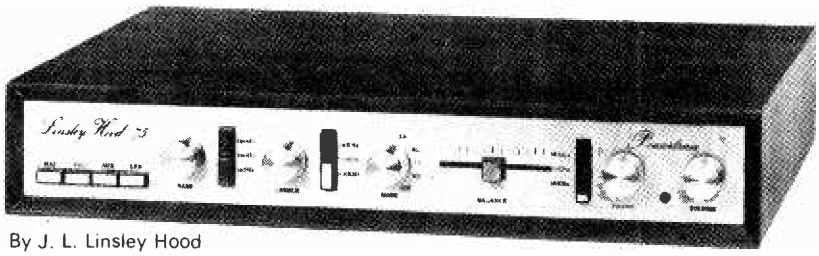
POWERTRAN ELECTRONICS

INCORPORATING AMBIENTACOUSTICS

HI-FI NEWS 75W/CHANNEL AMPLIFIER



By J. L. Linsley Hood

In Hi-Fi News there was published by Mr Linsley-Hood a series of four articles (November, 1972-February, 1973) and a subsequent follow-up article (April, 1974) on a design for an amplifier of exceptional performance which has as its principal feature an ability to supply from a direct coupled fully protected output stage, power in excess of 75 watts whilst maintaining distortion at less than 0 01% even at very low power levels The power amplifier is complemented by a pre-amplifier based on a discrete component operational amplifier referred to as the Liniac which is employed in the two most critical points of the system namely the equalization stage and tone control stage positions where most conventional designs run out of gain at the extremes of the frequency spectrum. Unusual features of the design are the variable transition frequencies of the tone controls and the variable slope of the scratch filter There is a choice of four inputs, two equalized and two linear, each having independently adjustable signal level The attractive slimline unit pictured has been made practical by highly compact PCBs and a specially designed Toroidal transformer

Pack	Price
1. Fibreglass printed-circuit board for power amp	£1.15
2. Set of resistors, capacitors, pre-sets for power amp	£2.5
3. Set of semiconductors for power amp	£6.50
4. Pair of 2 drilled, finned heat sinks	£1.10
5. Fibreglass printed-circuit board for pre-amp	£1.90
6. Set of low noise resistors, capacitors, pre-sets for pre-amp	£4.10
7. Set of low noise, high gain semiconductors for pre-amp	£2.40
8. Set of potentiometers (including mains switch)	£3.50
9. Set of 4 push-button switches, rotary mode switch	£5.40
10. Toroidal transformer complete with magnetic screen/housing primary: 0 117-234 V; secondaries: 33-0-33 V, 25-0-25 V	£10.95
11. Fibreglass printed-circuit board for power supply	£0.85
12. Set of resistors, capacitors, secondary fuses, semi-conductors for power supply	£5.40
13. Set of miscellaneous parts including DIN skts, mains input skt, fuse holder, inter-connecting cable, control knobs	£6.20
14. Set of metalwork parts including silk screen printed fascia panel and all brackets, fixing parts, etc	£8.20
15. Handbook (free with complete kit)	£0.30
16. Teak cabinet 18.3" x 12.7" x 3.1"	£10.70

2 each of packs 1-7 inclusive are required for complete stereo system. Total cost of individually purchased packs £90.80

FREE TEAK CASE WITH FULL KITS

KIT PRICE ONLY **£79.80**

WIRELESS WORLD FM TUNER

Designed in response to demand for a tuner to complement the world-wide acclaimed Linsley Hood 75W Amplifier, this kit provides the perfect match. The Wireless World (Skingley and Thompson — April, May 1974) published original circuit has been developed further for inclusion into this outstanding slimline unit and features a pre-aligned front end module, excellent a.m. rejection and temperature compensated varicap tuning, which may be controlled either continuously or by push button pre-selection Frequencies are indicated by a frequency meter and sliding LED indicators, attached to each channel selector pre-set The PLL stereo decoder incorporates active filters for "birdy" suppression and power is supplied via a toroidal transformer and integrated regulator For long term stability metal oxide resistors are used throughout.

Pack	Price
1. Fibreglass printed board for front end IF strip, demodulator, AFC and mute circuits	£2.15
2. Set of metal oxide resistors, thermistor, capacitors, cermet preset for mounting on pack 1	£4.80
3. Set of transistors, diodes, LED, integrated circuits for mounting on pack 1	£5.25
4. Pre-aligned front end module, coil assembly, three section ceramic filter	£8.50
5. Fibreglass printed circuit board for stereo decoder	£1.10
6. Set of metal oxide resistors, capacitors, cermet preset for decoder	£2.60
7. Set of transistors LED, integrated circuit for decoder	£2.90
8. Set of components for channel selector switch module including fibreglass printed circuit board, push-button switches, knobs, LEDs, preset adjusters, etc.	£9.40
9. Function switch, 10 turn tuning potentiometer, knobs	£5.80
10. Frequency meter, meter drive components, fibreglass printed circuit board	£10.35
11. Toroidal transformer with electrostatic screen. Primary: 0-117V 234V	£4.90
12. Set of capacitors, rectifiers, voltage regulator for power supply	£2.10
13. Set of miscellaneous parts, including sockets, fuse holder, fuses, inter-connecting wire, etc.	£2.05
14. Set of metal work parts including silk screen printed facia panel, acrylic silk screen printed tuning indicator panel insert, internal screen, fixing parts, etc.	£8.30
15. Construction notes (free with complete kit)	£0.25
16. Teak cabinet 10.3" x 12.7" x 3.1"	£10.70

One each of packs 1-16 inclusive are required for complete stereo FM tuner. Total cost of individually purchased packs £81.15

FREE TEAK CASE WITH FULL KITS

KIT PRICE only **£70.20**

LINSLEY-HOOD CASSETTE DECK

Published in Wireless World (May, June, August 1976) by Mr Linsley-Hood, this design, although straightforward and relatively low cost nevertheless provides a very high standard of performance. To permit circuit optimization separate record and replay amplifiers are used, the latter using a discrete component front-end designed such that the noise level is below that of the tape background. Push button switches are used to provide a choice of equalization time constants, a choice of bias levels and also an option of using an additional pre-amplifier for microphone use The mechanism used is the Goldring-Lenco CRV, a unit distinguished in its robustness and ease of operation. Speed control and automatic cassette ejection are both implemented by electronic circuitry This unit which is powered by a toroidal transformer and uses metal oxide resistors throughout offers an excellent match for the Wireless World Tuner and the Linsley-Hood 75 Watt Amplifier

Pack	Price
1. Stereo PCB (accommodates 2 rep. amps, 2 rec. amps, 2 meter amps, bias/erase osc. relay)	£3.35
2. Stereo set of capitors, M.O. resistors, potentiometers for above	£9.80
3. Stereo set of semiconductors for above	£8.50
4. Miniature relay with socket	£2.90
5. PCB, all components for solenoid, speed control circuits	£3.80
6. Goldring Lenco mechanism as specified	£21.95
7. Function switch, knobs	£1.90
8. Dual VU meter with illuminating lamp	£8.70
9. Toroidal transformer with E.S. screen prim. 0-117V, 234V, Sec. 15V	£4.90
10. Set of capacitors, rectifiers, I.C. voltage regulator for power supply (Powertran design)	£2.80
11. Set of miscellaneous parts, including sockets, fuse holder, fuses, interconnecting wire, etc.	£3.40
12. Set of metalwork including silk screened facia panel, internal screen, fixing parts, etc.	£7.10
13. Construction notes	£0.25
14. Teak cabinet 18.3" x 12.7" x 3.1"	£10.70

One each of packs 1-14 inclusive are required for compete stereo cassette deck. Total cost of individually purchased packs £90.05

SPECIAL PRICE FOR COMPLETE KITS £85.90

PRICE STABILITY

Order with confidence! Irrespective of any price changes we will honour all prices in this advertisement until September 30th 1977 provided that this month's advertisement is quoted with your order E&OE VAT rate changes excluded

All components are brand new first grade full specification devices. All resistors (except where stated) are low noise carbon film types. All printed circuit boards are fibre-glass, drilled, roller tinned and supplied with circuit diagrams and construction layouts.

Value Added Tax not included in prices.

EXPORT ORDERS No VAT charged Postage charged at actual cost plus 50p documentation and handling Please make payment by irrevocable Letter of Credit £500 minimum, Bank Draft Postal Order International Money Order in Sterling
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POWERTRAN ELECTRONICS

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BSR HI-FI AUTOCHANGER

STEREO AND MONO £11.95 Post 75p

Plays 12", 10" or 7" records. Auto or Manual. A high quality unit backed by BSR reliability with 12 months' guarantee. A.C. 200/250V. Size 13½-11¼in. 3 speeds. Above motor board 3¾in. Below motor board 2½in. with STEREO and MONO CARTRIDGE

B.S.R. SINGLE PLAYER similar to above with stereo cartridge and cueing device, large turntable **£13.50**

B.S.R. P128 with magnetic cartridge. Balanced arm cueing device **£24.50.** Post £1

PORTABLE PLAYER CABINET

Modern design. Rexine covered. Vynair front grille. Chrome fittings. Size 17 x 15 x 8in. approx. **£4.50** Post 75p

Motor board cut for BSR or Garrard deck

HEAVY METAL PLINTHS £6.50

With P.V.C. Cover. Cut out for most B.S.R. or Garrard decks. Silver grey finish. Post £1.50

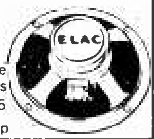
Model "A" Size 12½ x 14¾ x 7½in.
Model "B" Size 16 x 13¾ x 7in. **£7.50**

Extra large plinth & cover, teak wood base Size 20" x 17½" x 9" **£19.50.** Callers only.

COMPLETE STEREO SYSTEM

Two full size loudspeakers 13¾ x 10 x 3¾in. Player unit clips to loudspeakers making it extremely compact, overall size only 13¾ x 10 x 8½in., 3 watts per channel, plays all records 33 r.p.m., 45 r.p.m. Separate volume and tone controls. Attractive Teak finish. 240V a.c. mains **£22.50** £1 carriage

ELAC HI-FI SPEAKER 8in. TWIN CONE



Dual cone plastic roll surround. Large ceramic magnet 50-16,000 c/s. Bass resonance 40 c/s. 8 ohm impedance. 15 watts. RMS **£5.95** Post 35p

SMITH'S CLOCKWORK 15 AMP TIME SWITCH

0—6 HOURS £3.30 Post 35p

Single pole two-way. Surface mounting with fixing screws. Will replace existing wall switch to give light for return home, garage, automatic anti-burglar lights, etc. Variable knob. Turn on or off at full or intermediate settings. Brand new and fully guaranteed

TEAKWOOD LOUDSPEAKER GRILLES will easily fit to baffle board. Size 10½ x 7⅞in.—**45p.**

R.C.S. "MINOR" 10 watt AMPLIFIER KIT

This kit is suitable for record players, guitars, tape playback, electronic instruments or small P.A. systems. Two versions available Mono, **£11.25;** Stereo, **£18.** Post 45p. Specification 10W per channel; input 100mV. size 9½ x 3 x 2in., approx. S.A.E. details. Full instructions supplied. AC mains powered

VOLUME CONTROLS

5k to 2M LOG or LIN. L/S **35p.** D.P. **60p.** STEREO L/S **85p.** D.P. **£1.** Edge 5K S.P. Transistor **45p.**

80 Ohm Coax 8p yd.

STANDARD TYPE VHF FRINGE LOW LOSS **15p** yd. Ideal 625 and colour. PLUGS **10p.** SOCKETS **10p.** LINE SOCKETS **18p.** OUTLET BOXES **50p.**

RCS DRILL SPEED CONTROLLER/LIGHT DIMMER KIT. Easy to build kit. Will control up to 500 watts AC mains **£3.25** Post 35p

RCS STEREO PRE-AMP KIT. All parts to build this pre-amp. Inputs for high, medium or low imp per channel, with volume control and P.C. Board. Can be ganged to make multi-way stereo mixers **£2.95** Post 35p

E.M.I. 13½ x 8in. SPEAKER SALE!

With tweeter and crossover. 10 watt. State 3 or 8 ohm. As illustrated **£6.50** Post 45p

Ditto 15 watts. 8 ohm **£8.50** Post 65p

With tweeter and crossover 20 watt. Bass res 25 c.p.s. Flux = 11 000 gauss. 4 or 8 or 15 ohm. 20 to 20,000 c.p.s. **£9.50** Post 75p

Bookshelf Cabinet Teak finish. For EMI 13 x 8 speakers **£8.50** Post £1.00

THE "INSTANT" BULK TAPE ERASER AND HEAD DEMAGNETISER. Suitable for cassettes, and all sizes of tape reels. A.C. mains 200/250V. Leaflet S.A.E. Will also demagnetise small tools. **£4.95** Post 50p

BLANK ALUMINIUM CHASSIS. 6 x 4—**70p;** 8 x 6—**90p;** 10 x 7—**£1.15;** 12 x 8—**£1.35;** 14 x 9—**£1.50;** 16 x 6—**£1.45;** 16 x 10—**£1.70. ANGLE ALI.** 6 x ¾ x ¾in—**15p.**

ALUMINIUM PANELS. 6 x 4—**17p;** 8 x 6—**24p;** 14 x 3—**25p;** 10 x 7—**35p;** 12 x 8—**43p;** 12 x 5—**30p;** 16 x 6—**43p;** 14 x 9—**52p;** 12 x 12—**68p;** 16 x 10—**75p.**

MANY ALI BOXES IN STOCK. MANY SIZES

ELAC 9 x 5in HI-FI SPEAKER TYPE 59RM £3.45

Post 35p. This famous unit now available. 10 watts. 8 ohm.

R.C.S. LOW VOLTAGE STABILISED POWER PACK KITS £2.95

All parts and instructions with Zener diode, printed circuit rectifiers and double wound mains transformer. Input 200/240V a.c. Output voltages available, 6 or 7.5 or 9 or 12V d.c. up to 100mA or less. Size 3 x 2½ x 1½in. Please state voltage required. Post 45p

R.C.S. POWER PACK KIT £3.35

12 VOLT, 750mA. Complete with printed circuit board and assembly instructions. Post 30p

12 VOLT 300mA KIT **£3.15.** 9 VOLT 1 AMP KIT **£3.35.**

R.C.S. GENERAL PURPOSE TRANSISTOR PRE-AMPLIFIER — BRITISH MADE

Ideal for Mike, Tape, P.U., Guitar, etc. Can be used with battery 9-12V or H.T. line 200-300V d.c. operation. Size 1¾ x 1¼ x ¾in. Response 25 c/s to 25 kc/s. 26 dB gain. For use with valve or transistor equipment. Full instructions supplied. Details S.A.E. **£1.45** Post 30p

ELECTRO MAGNETIC PENDULUM MECHANISM

1.5V d.c. operation over 300 hours continuous on SP2 battery, fully adjustable swing and speed. Ideal displays, teaching electro magnetism or for metronome, strobe, etc. **95p** Post 30p

MAINS TRANSFORMERS

ALL POST 50p

250-0-250V 70mA, 6.5V, 2A	£3.45
250-0-250 80mA, 6.3V 3.5A, 6.3V 1A or 5V 2A	£4.60
350-0-350 80mA, 6.3V 3.5A, 6.3V 1A or 5V 2A	£5.80
300-0-300V 120mA, 2 x 6.3V 2A C.T., 5V 2A	£8.50
220V 45mA, 6.3V 2A	£1.75
HEATED TRANS. 6.3V ½ amp £1; 3 amp	£1.40

GENERAL PURPOSE LOW VOLTAGE. Tapped outputs at 2 amp 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 25 and 30V **£4.60.** 1 amp 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 **£4.60.** 2 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 **£7.** 3 amp 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 **£8.70.** 5 amp 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 **£11.25.** 12V 100mA **£1.** 9V 1 amp **£1,** 12V 300mA, **£1,** 12V 500mA, **£1,** 12V 750mA, **£1,** 10V, 30V, 40V, 2 amp., **£2.75,** 20V, 3 amp., **£2.45,** 40V, 2 amp., **£2.95,** 30V 5A and 34V 2ACT **£3.45,** 0, 5, 8, 10, 16V, ½ amp., **£1.95,** 20V ½ amp., **£1.75,** 20V, 1 amp., **£2.20,** 20V 3 amp., **£2.50,** 20-0-20V 1 amp., **£2.95,** 30V 1½ amp., **£2.75;** 20V, 40V, 60V or 20-0-20V, 1 amp, **£3.50.** 30-0-30V 3 Amp **£7.**

AUTO TRANSFORMERS, 115V to 230V or 230V to 115V 150W **£5;** 250W **£6;** 400W **£7;** 500W **£8.**

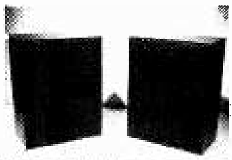
FULL WAVE BRIDGE CHARGER RECTIFIERS 6 or 12V outputs. 1½ amp **40p;** 2 amp **55p;** 4 amp **85p.**

CHARGER TRANSFORMERS 1½ amp **£2.75;** 4 amp **£4.60.**

12V 1½A HALF WAVE Selenium Rectifier, **25p.**

R.C.S. BOOKSHELF SPEAKERS

13 x 10 x 6in. 50 to 14,000 cps. 8 watts rms. 8 ohms



£16 pair Post £1.30

KUBA-KOPENHAGEN STEREO

TUNER-AMPLIFIER CHASSIS AM-FM 5+5 WATT

This Continental 4-band radiogram chassis uses first class quality components throughout. Features: Large facia panel with 7 push buttons for medium, long, short, VHF-FM, AFC, phono, mains on-off. 4-rotary controls, tuning, volume, tone, balance. Facia size 17 x 4½ inches. Chassis size 17 x 4½ x 5½ inches. DIN-connector sockets for tape record/playback, loudspeakers, phono pick-up, external FM-AM aerials. Automatic stereo beacon light. Built-in ferrite rod aerial for medium/longwave. A.C. 240V mains. Circuit supplied. Above speakers are suitable **£33.50** Post £1.50

LOW VOLTAGE ELECTROLYTICS

1, 2, 4, 5, 8, 16, 25, 30, 50, 100, 200mF 15V **10p.**
500mF 12V **15p;** 25V **20p;** 50V **30p;** 420/500V **£1.30**
1000mF 12V **17p;** 25V **35p;** 50V **47p;** 100V **70p.**
2000mF 6V **25p;** 25V **42p;** 420/500V **£1.30.**
2500mF 50V **62p;** 3000mF 25V **47p;** 50V **65p.**
3900mF 100V **£1.60.** 4700mF 63V **£1.20.**
5000mF 6V **25p;** 12V **42p;** 35V **85p.**

MANY OTHER ELECTROLYTICS IN STOCK

SHORT WAVE 100pF air spaced gangable tuner, **95p.**
TRIMMERS 10pF, 30pF, 50pF, **5p.** 100pF, 150pF, **15p.**
CERAMIC, 1pF to 0.01mF, **5p.** Silver Mica 2 to 5000pF **5p.**
PAPER 350V-0.1 **7p;** 0.5 **13p;** 1mF 150V **20p;** 2mF 150V **20p;** 500V-0.001 to 0.05 **5p;** 0.1 **10p;** 0.25 **13p;** 0.47 **25p.**
MICRO SWITCH SINGLE POLE CHANGEOVER 20p.
SUB-MIN MICRO SWITCH, 25p. Single pole change over
TWIN GANG, 385 + 385pF **50p;** 500pF standard **75p;** 365 + 365 + 25 + 25pF, Slow motion drive **65p.**
120pF **TWIN GANG, 50p;** 365pF **TWIN GANG, 50p.**
NEON PANEL INDICATORS 250V. Amber or red **30p.**
RESISTORS. ¼W, ½W, 1W, 20% **2p;** 2W, **10p;** 10Ω to 10M
HIGH STABILITY. ½W 2% 10 ohms to 6 meg., **12p.**
Ditto 5% Preferred values 10 ohms to 10 meg **5p.**
WIRE-WOUND RESISTORS 5 watt, 10 watt, 15 watt. 10 ohms to 100K **12p** each
TAG STRIP 28-way **12p.**
TAPE OSCILLATOR COIL. Valve type, **35p.**
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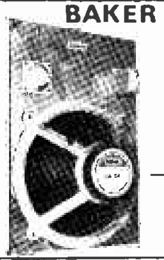
TOGGLE SWITCHES S.P. **20p.** D.P.S.T. **25p.** D.P.D.T. **30p.**
MANY OTHER TOGGLES IN STOCK
PICK-UP CARTRIDGES ACOS GP91 **£1.50.** GP93 **£2.50.**
SONOTONE stereo **£2.00. SHURE** M75 ECS **£8.**

BAKER MAJOR 12" £15.00



Post £1.00. 30-14,500 c/s, 12in double cone, woofer and tweeter cone together with a BAKER ceramic magnet assembly having a flux density of 14,000 gauss and a total flux of 145,000 Maxwells. Bass resonance 40 c/s. Rated 25W. NOTE 4 or 8 or 16 ohms must be stated

Module kit, 30-17,000 c/s with tweeter, crossover, baffle and instructions **£18.95** Post £1.60p each. Please state 4 or 8 or 16 ohms

BAKER "BIG-SOUND" SPEAKERS. Post £1.00 each

'Group 25'	'Group 35'	'Group 50/15'
12in 30W **£12.00**	12in 40W **£14.00**	15in 75W **£26.00**
4 or 8 or 16 ohm	4 or 8 or 16 ohm	8 or 16 ohm

BAKER LOUDSPEAKER, 12 INCH, 60 WATT. GROUP 50/12, 8 OR 15 OHM HIGH POWER. FULL RANGE PROFESSIONAL QUALITY. RESPONSE 30-16,000 CPS. MASSIVE CERAMIC MAGNET WITH ALUMINIUM PRESENCE CENTRE DOME. **£21.00** Post £1.60

TEAK VENEERED HI-FI SPEAKERS AND CABINETS
For 12in or 10in speaker 20x13x12in **£14.50** Post £2
For 13x8in or 8in speaker **8.50** Post £1
For 6½in speaker and tweeter 12x8x6in **£5.80** Post 75p
Many other cabinets in stock. Phone your requirements

R.C.S. 100 watt VALVE AMPLIFIER CHASSIS

Four inputs. Four way mixing, master volume, treble and bass controls. Suits all speakers. This professional quality amplifier chassis is suitable for all groups, disco, P.A., where high quality power is required. 5 speaker outputs. A/C mains operated. Slave output socket. Produced by demand for a quality valve amplifier. 100V line output to order. Send for leaflet. Suitable carrying cab **£16.50** Price **£85** carr £2.50

SPEAKER COVERING MATERIALS. Samples Large S.A.E.
LOUDSPEAKER CABINET WADDING 18in wide **20p** ft.
Horn Tweeters 2-16kc/s. 10W 8 ohm or 16 ohm **£3.60**
De Luxe Horn Tweeters 3-18kc/s, 30W, 8 ohm. **£7.50.**
CROSSOVERS. TWO-WAY 3000 c/s 3 or 8 or 15 ohm **£1.90.** 3-way 950 cps/3000 cps. **£2.20.**
LOUDSPEAKERS P.M. 3 OHM 7x4in. **£1.50;** 6½in., **£1.80;** 8x5in., **£1.90;** 8in., **£1.95.**
SPECIAL OFFER: 80 ohm 2¼in., 2¾in., 35 ohm, 3in., 25 ohm, 2½in., 3in., 5x3in., 7x4in., 8 ohm, 2½in., 3in., 3½in., 5in., 15 ohm, 3½in dia, 6x4in., 7x4in., 5x3in., 3 ohm 2½in 2⅝in 3½in 5in dia **£1.60 each.**
PHILIPS LOUDSPEAKER, 8in., 4 ohms, 4 watts. **£1.95**
RICHARD ALLAN TWIN CONE LOUDSPEAKERS 8in. diameter 4W **£2.50.** 10in. diameter 5W **£2.95;** 12in diameter 6W **£3.50.** 3/8/15 ohms, please state
PIEZO ELECTRIC HORN TWEETER. Handles up to 100 watts. No crossover required **£7.95**

Tweeter Volume Control 15 ohms 10W with one inch long threaded bush for wood panel mounting ¼in. spindle. **65p.**

BAKER 150 WATT PROFESSIONAL MIXER AMPLIFIER

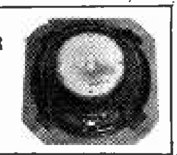
All purpose transistorised. Ideal for Groups, Disco and P.A. 4 inputs speech and music. 4 way mixing. Output 4/8/16 ohms a.c. Mains. Separate treble and bass controls. Master volume control. Guaranteed. Details S.A.E. **£68** £1.50 carr

NEW MODEL MAJOR—50 watt, 4 input, 2 vol. Treble and bass. Ideal disco amplifier **£49** Carr £1

100 WATT DISCO AMPLIFIER

volume, treble, bass controls 500 M V or 1 volt input. Four loudspeaker outputs 4 to 16 ohm. All transistor **£59**

GOODMANS COMPACT 12-INCH BASS WOOFER



Standard 12in diameter fixing with cut sides 10⅜ square 14 000 Gauss magnet 30 watts R.M.S. 4 ohm imp. Bass resonance = 30 cps. Frequency response 30-8000 c.p.s. **£10.95 each** Post £1

ALUMINIUM HEAT SINKS. FINNED TYPE. Sizes 6½" x 4½" x 2¼" **95p.** 6½" x 2" x 2¼" **65p.**
BALANCED TWIN RIBBON FEEDER 300 ohms. 5p yd.
JACK SOCKET Std. open-circuit 20p, closed circuit 25p; Chrome Lead-Socket 45p. Mono or Stereo.
Phono Plugs 8p. Phono Socket 8p.
JACK PLUGS Std. Chrome 30p; Plastic 25p; 3.5mm 15p.
STEREO JACK PLUG 30p. SOCKET 25p.
DIN SOCKETS Chassis 3-pin 10p. 5-pin 10p.
DIN SOCKETS FREE 3-pin 25p; 5-pin 25p. DIN PLUGS 3-pin 25p; 5-pin 25p. VALVE HOLDERS, 10p; CANS 10p.
TV CONVERGENCE POTS 15p Each. Values = 5, 7, 10, 20, 50, 100, 200, 250, 470, 2000 ohms

R.C.S. SOUND TO LIGHT KIT

Kit of parts to build a 3 channel sound to light unit 1,000 watts per channel **£14.** Post 35p. Easy to build. Full instructions supplied. Cabinet **£3.**

PERIOD LOUDSPEAKER CABINETS. Two styles available, Regency and Queen Anne. Size approximately 34 x 19 x 16in. These cabinets are slightly soiled and are priced from £10 each. Callers only.

RADIO COMPONENT SPECIALISTS

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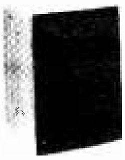
DIY SPEAKER KITS

15-WATT KIT IN CHASSIS FORM

When you are looking for a good speaker, why not build your own from this kit.

It's the unit which we supply with the enclosures illustrated below Size 13" · 8" (approx.) woofer (EMI), tweeter, and matching crossover components. Power handling capacity 15 watts rms. 30 watts peak.

£17.00 PER STEREO PAIR + P & P £3.40



EASY-TO-BUILD WITH ENCLOSURE

Specially designed by RT-VC for cost-conscious hi-fi enthusiasts, these kits incorporate two teak-simulate enclosures, two EMI 13" × 8" (approx.) woofers, two tweeters and a pair of matching crossovers. Easily constructed, using a few basic tools. Supplied complete with an easy-to-follow circuit diagram, and crossover components. Input 15 watts rms. 30 watts peak, each unit.
Cabinet size 20" · 11" · 9½" (approx.).

£25.50 PER STEREO PAIR + p & p £5.50

COMPACT' FOR TOP VALUE

How about this for incredible bookshelf value from RT-VC! A pair of high efficiency units for only £7.50 – just what you need for low-power amplifiers. These infinite baffle enclosures come to you ready mitred and professionally finished. Each cabinet measures 12" × 9" × 5" (approx.) deep, and is in wood simulate. Complete with two 8" (approx.) speakers for max. power handling of 7 watts.

per stereo pair £7.50 + p & p £1.70

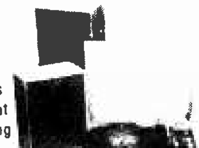
SPEAKERS Two models – Duo IIb, teak veneer, 12 watts rms, 24 watts peak, 18½" · 13½" · 7¼" (approx.).

★£34 PER PAIR + p & p £6.50

Duo III, 20 watts rms, 40 watts peak, 27" · 13" · 11½" (approx.)

★£52 PER PAIR + p & p £7.50

EASY TO BUILD RECORD PLAYER KIT



Ideally suited for the constructor who requires a complete stereo unit at a budget price, comprising ready assembled stereo amp. module, Garrard auto/manual deck with cueing device, pre-cut and finished cabinet work. Output 4 watts per channel, phones socket and record / replay socket

£26.95 · p & p £4.05

CAR RADIO KIT

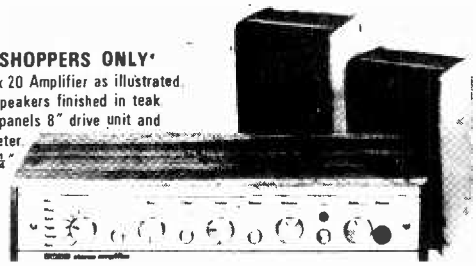
Complete with speaker, baffle and fixing strip. The Tourist IV for the experienced constructor only. The Tourist IV has five push buttons, four medium band and one for long wave band. The tuning scale is illuminated and attractive small aluminium control knobs are used for manual tuning and volume control. The modern style fascia has been designed to blend with most car interiors and the finished radio will slot into a standard car radio aperture. Size approx. 7" · 2" · 4½". Power Supply Nominal 12 volts positive or negative earth (altered internally) Power Output 4 watts into 4 ohms.

MOTOR TOP 10 AWARD

£12.50 + p & p £1.50

PERSONAL SHOPPERS ONLY·

Viscount IV 20 x 20 Amplifier as illustrated plus 1 pair of speakers finished in teak with melamine panels 8" drive unit and 3½" approx tweeter 22" 13" · 10½" size approx.



£45.00

SPECIAL OFFER illustrated

20 x 20 WATT STEREO AMPLIFIER ★

Superb Viscount IV unit in teak-finished cabinet. Silver fascia with alimunium rotary controls and pushbuttons, red mains indicator and stereo jack socket Function switch for mic. magnetic and crystal pick-ups, tape, tuner, and auxiliary Rear panel features two mains outlets. DIN speaker and input sockets, plus fuse. 20 + 20 watts rms, 40 + 40 watts peak.

£29.90 + p & p £2.10

FREE 'Limited Period' A Free 4 Channel Stereo Adaptor to all purchasers of the Viscount Amplifier. Available separately. £3.95 + p & p £1.00

SPECIAL OFFERS

DEDUCT 10% DEDUCT 15%

Mail order only (not on prepaid) · Personal Shoppers only

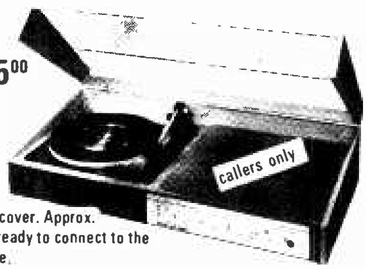
★ on complete stereo systems using ★ starred Products

For example- Duo speaker system II or III Viscount Amplifier, MP60 type turntable complete

PERSONAL SHOPPERS ONLY

DECCA DC1000 Stereo cassette, ready built tape deck, replay / record P.C.B. with pair record / replay heads	£3.95
AM. FM. TUNER P.C.B. with Mullard L.P. 1186, 1185 1181 modules	£9.50
CROWN 5 push button car radio, LW, MW, 12v Pos. neg. earth 5 watts output, tone control complete with speaker and fixing kit, in dash type	£15.95
STEREO CASSETTE TAPE PLAYER Negative earth only. 3 watts per channel output	£16.50
AM. FM. STEREO MULTIPLEX CAR RADIO/cassette player in dash fixing Negative earth 5 watts output	£36.00
I.C. Stereo 8 Track to Cassette adaptor converts, any 8 track player to cassette player.	£18.95
GLOBAL Spherical speaker 8 ohms. 5 watts	£3.50
100K Multiturn Varicap tuning pots 6 for	£1.00

VISCOUNT COMBI £65.00



For personal shoppers only, this unit comprises: The 20 × 20 Viscount amplifier BSR MP60 Type turntable housed in an attractive teak finished console with smoked acrylic cover. Approx. 30¼" × 14½" × 7½" complete ready to connect to the speaker system of your choice.

callers only

BSR TURNTABLES

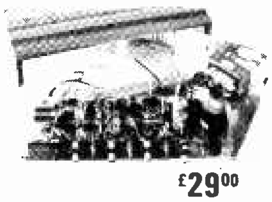
BSR MP60 TYPE Single play record player (Chassis form) £15.95 less cartridge. P & P £2.00

BSR automatic record player deck (Chassis form) with cueing device and stereo ceramic head. £9.95 P & P £2.00

Cartridges to suit above ACOS MAGNETIC STEREO ...... £4.95 CERAMIC STEREO £1.95

TURNTABLE illus. Popular BSR MP 60 type, complete with magnetic cartridge, diamond stylus, and de luxe plinth and cover. Ready wired ★ £29 + p & p £4.50

30 x 30 WATT AMPLIFIER KIT



Specially designed by RT-VC for the experienced constructor, this kit comes complete in every detail. Same facilities as Viscount IV amplifier. Chassis is ready punched, drilled and formed Cabinet is finished in teak veneer. Silver fascia and easy-to-handle aluminium knobs.

Output 30 + 30 WATTS rms. 60 + 60 peak.

£29.00 + p & p £2.10

DECCA 20 WATTS STEREO SPEAKER

This matching loudspeaker system is hand made, kit comprises of two 8" diameter approx. base drive unit, with heavy die cast chassis laminated cones with rolled P.V.C. surrounds, two 3½" diameter approx. domed tweeters comp with crossover networks £4.00 p & p stereo pair £20.00

Order giving your credit card number ONLY

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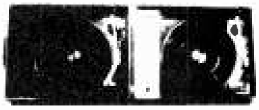
PORTABLE MONO DISCO CONSOLE



with built-in pre-amplifiers

Here's the big-value portable disco console from RT-VC! It features a pair of BSR MP 60 type auto-return, single play professional series record decks. Plus all the controls and features you need to give fabulous disco performances. Simply connects into your existing slave or external amplifier.

p & p £6.50 £64.00

35-WATT MONO DISCO AMP

£27.50 + p & p £2.50

Size approx 13⅜" · 5¼" · 6¾"

Here's the mono unit you need to start off with. Gives you a good solid 35 watts rms, 70 watts peak output. Big features include two disc inputs, both for ceramic cartridges, tape input and microphone input. Level mixing controls fitted with integral push-pull switches. Independent bass and treble controls and master volume.

100 WATT MONO DISCO AMP

Size approx. 14" · 4" · 10¼".

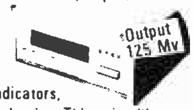
Sloping facia, you can use the controls without fuss or bother. Brushed alumimium fascia and rotary controls. Five smooth acting, vertically-mounted slide controls – master volume, tape level, mic level, deck level, PLUS INTER-DECK FADER for perfect graduated change from record deck No. 1 to No. 2, or vice versa. Pre-fade level control (PFL) lets YOU hear next disc before fading it in. VU meter monitors output level. Output 100 watts RMS 200 watts peak.

£65.00 p & p £4.00

PRACTICE GUITAR AMPLIFIER WITH BUILT-IN SPEAKER

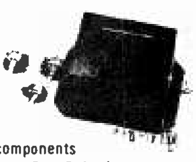
This budget practice amplifier, has been specially designed for the amateur, who requires a quality self-contained unit with all facilities, 2 inputs – 1 for mic or guitar, the 2nd for record player or cassette deck, it also can be used for cine-sound amplification. 2 volume controls, 1 for each input, also base and treble controls. Power output with internal speaker, 12 watts RMS, with remote speaker (not supplied) 20 watts RMS. Size approx. 17" + 9" × 11". £32.50 + p & p £3.00

HOME 8 TRACK CARTRIDGE PLAYER



Automatically switches programmes monitored by indicators, with manual override track selection. This unit will match with the Unisound modules and is compatable with the Viscount IV amplifier with Sim teak cabinet. approx. 9" 8" 3½". p & p £1.50 £14.60

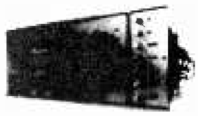
4 x 4 STEREO AMP KIT £14.50 P & P £2.



For the experienced constructor who wants to design his own stereo. Kit includes all necessary components including constructors manual. Plus Pair of easy to build 4 watt speakers in kit form, with teak simulate finish cabinets 12" x 9" x 5" approx.

PYE STEREO GRAM CHASSIS

(Complete with circuit-diagrams)



Complete ready to install–Wave bands LM, VHF STEREO, VHF MONO. Controls for tuning volume, balance, bass and treble. Power output 7 watts R.M.S per channel 14 watts peak 8 ohms 2" × 8" approx chassis speakers and BSR auto record player deck.

PERSONAL SHOPPERS ONLY £35.00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The year's biggest public hi-fi and audio fair is nearly here. Your chance to see and compare the newest, most intriguing, most sophisticated products across the span of hi-fi, radio, tapes and music-making.
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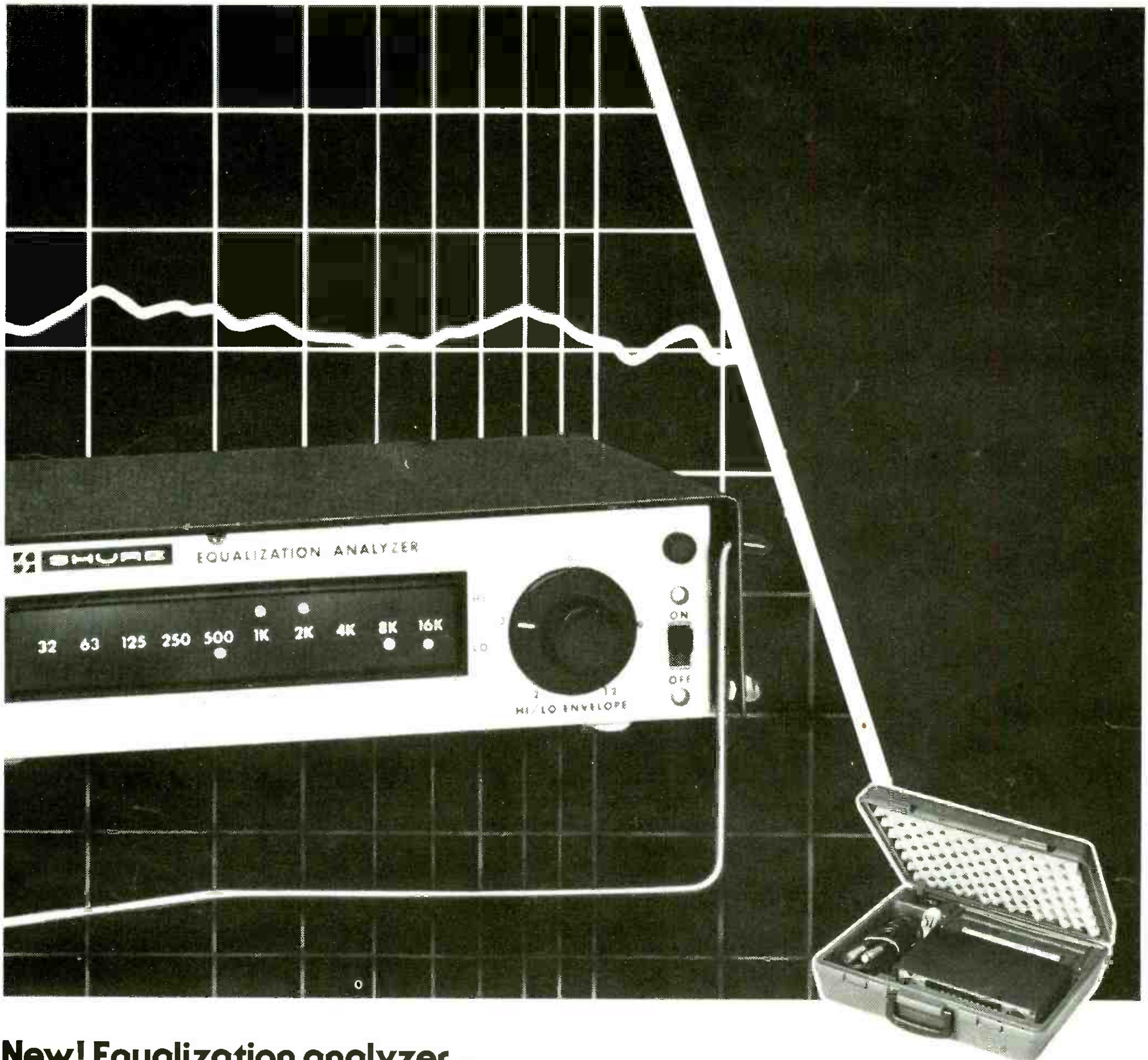


New! Equalization analyzer...

Balance a system...Balance a budget.

Quick and accurate adjustment of sound system frequency response is finally within the reach of most budgets. The Shure M615AS Equalization Analyzer System is a revolutionary breakthrough that lets you "see" room response trouble spots in sound reinforcement and hi-fi systems—without bulky equipment, and at a fraction of the cost of conventional analyzers.

The portable, 11-pound system (which includes the analyzer, special microphone, accessories, and carrying case) puts an equal-energy-per-octave "pink noise" test signal into your sound system. You place the microphone in the listening area and simply adjust the filters of an octave equalizer (such as the Shure SR107 or M610) until the M615 display indicates that each of 10 octaves are properly balanced. You can achieve accuracy within ± 1 dB, without having to "play it by ear."

Send for complete descriptive brochure.

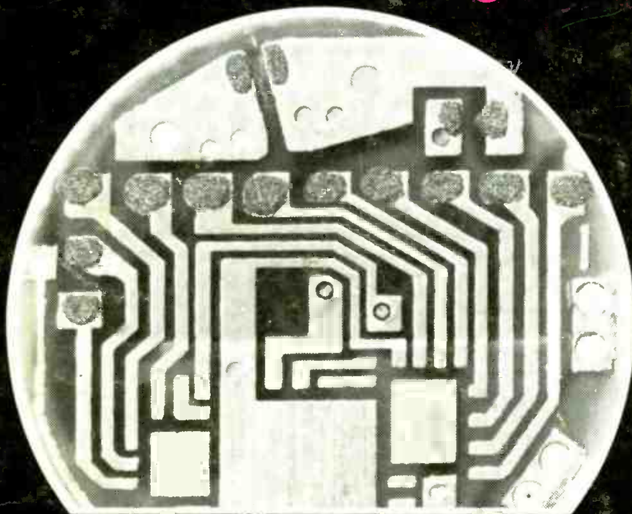
Shure Electronics Limited
Eccleston Road
Maidstone ME15 6AU
Telephone: Maidstone (0622) 59881

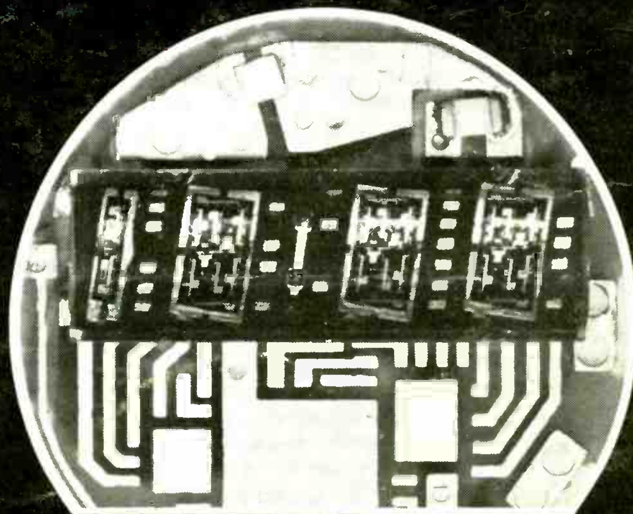
TECHNICORNER

The M615 Analyzer's display contains 20 LEDs that indicate frequency response level in each of 10 octave bands from 32 Hz to 16,000 Hz.
A rotary hi/lo envelope control adjusts the HI LED threshold relative to the LO LED threshold. At minimum setting, the resulting frequency response is correct within ± 1 dB. Includes input and microphone preamplifier overload LEDs.
A front panel switch selects either flat or "house curve" equalization.
The ES615 Omnidirectional Analyzer Microphone (also available separately) is designed specifically for equalization analyzer systems.

SHURE ®

To see how Multicore Oxide-Free Solder Creams offer you higher profits – just watch





Applications don't come much more critical than digital watch manufacture.
Here, discrete deposits of Multicore Oxide-Free Solder Cream are screened onto the PCB. A precision job, with no risk of operator error or fatigue. And, a convenient temporary adhesive for the positioning of components.

Solder-flow is accomplished by simply passing the units over a hot plate.
Fast. No oxide to contend with. No dirty residues.
This manufacturer says Multicore Oxide-Free Solder Cream has *reduced reject rate substantially* and offers superior soldering quality.

ordinary solder creams cannot match this profitable performance. Here's why...

...because ordinary solder creams or pastes contain rosin-based flux mixed with solder powder produced by atomisation. This means that every particle of the powder is covered with a layer of oxide – slowing down the soldering process, leaving a dirty flux residue and causing solder globules to stick to the flux and possibly fall loose into the equipment after shock or vibration. But, Multicore have developed a very special method of producing solder powders that are virtually oxide-free.

These can be used in cream form – comprising an homogeneous stable mixture of pre-alloyed powder and flux, designed specifically for hybrid microcircuits, PCB's and critical component joints.

When heated, Multicore Oxide-Free Solder Creams melt and flow as quickly and cleanly as rosin-cored solder wire, leaving a pale clear flux residue without solder globules.

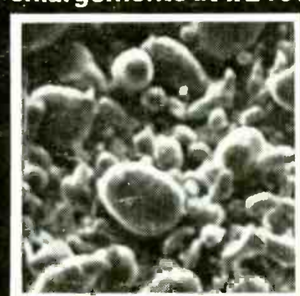
The in-built quality of Multicore Oxide-Free Solder Creams make them the ideal specification for almost any application calling for low cost yet high reliability.

They are available in a wide range of combinations of solder alloys, fluxes, particle sizes, flux contents and viscosities – often replacing solder preforms.

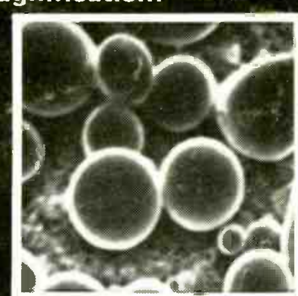
However, if you have an application that specifically requires preforms, remember that Multicore supply a wide variety of those as well.

Multicore Solders Ltd are Ministry of Defence Registered Contractors and on Qualified Products List QQ-S-571E of U.S. Defense Supply Agency for solder creams and preforms.

Compare these electron-microscope enlargements at x 240 magnification:



'Ordinary' cream solder powder, revealing poor particle shape and dross.



Solder powder from Multicore Oxide-Free Solder Cream displays clean, uniform particles.

Multicore

For full information on Oxide-Free Solder Creams or any other Multicore products, please write on your company's letterhead direct to:

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Telephone: Hemel Hempstead 3636. Telex: 82363.