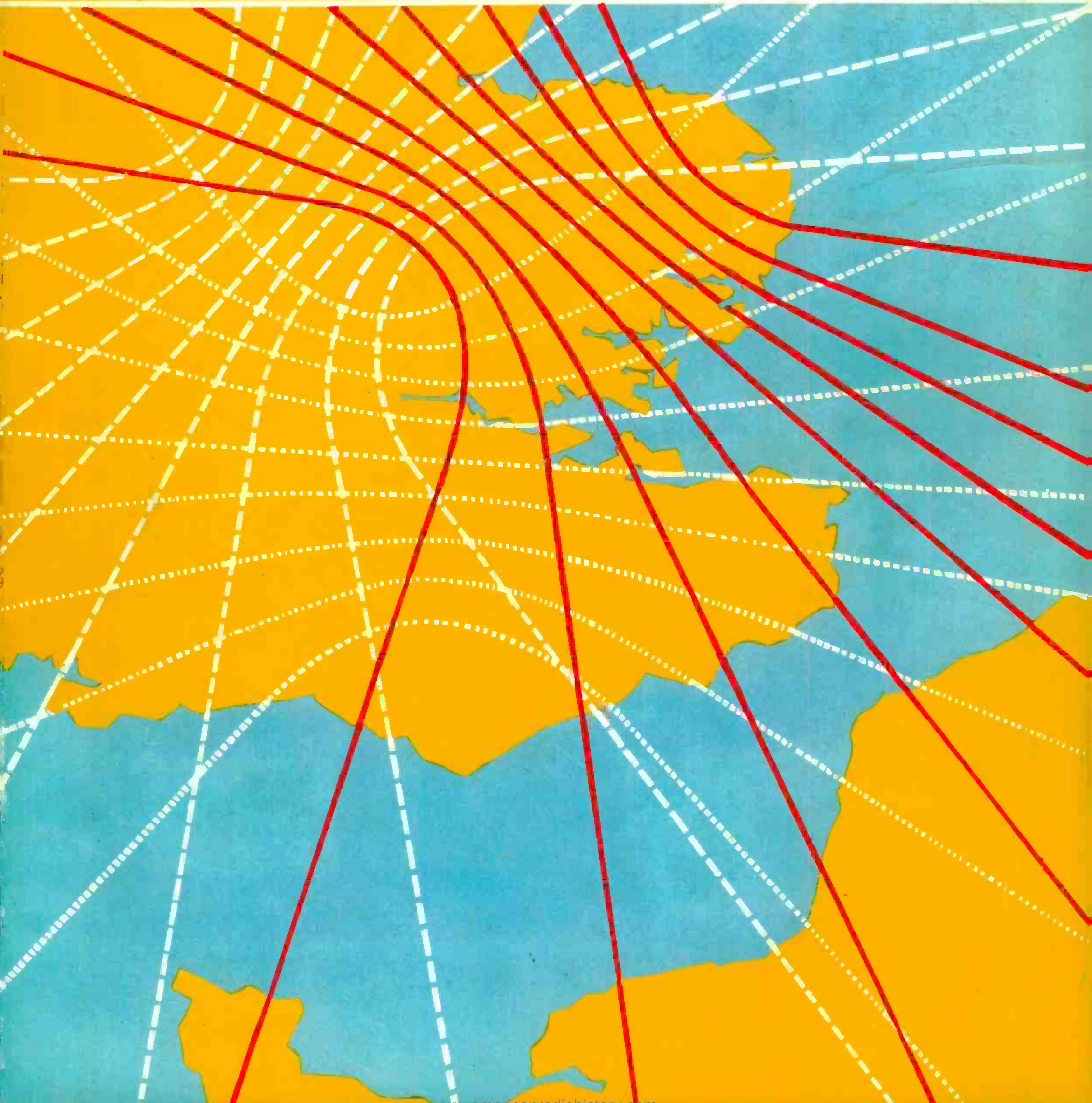
Wireless World

August 1969 Three Shillings

Lasers in electronics

Hyperbolic navigation systems



TEKTRONIX
INSTRUMENTATION FOR TELEVISION

TYPE 528. MOD 188G. Waveform Monitor for use with camera outputs, video system output lines, transmitter video input lines, CCTV systems and educational TV systems. (Also available for use on NTSC standard.) £394 plus £64.4.0. duty

TYPE RM 529. MOD 188D. Multi-standard Waveform Monitor—can be used on any of the 4 systems without internal adjustment to carry out the majority of television waveform measurements required. £641 plus £104.10.0. duty.

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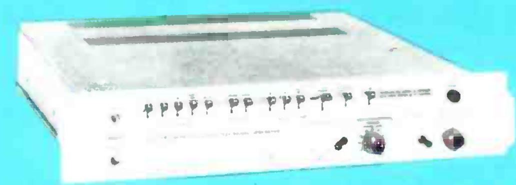
TYPE R141. PAL. Television Test Signal Generator is an all solid-state source of high-quality television test signals for 625-line, 50-cycle field standard PAL colour TV Systems. £715 plus £153. 5.0. duty.

TYPE 453. MOD 127C. DC-to-50MHz. Portable Sweep-delay Oscilloscope with built-in TV Sync Separator, solid-state design for highly-accurate work in tough environmental conditions. £948.


TYPE RM 529 MOD 188 D


TYPE R141


TYPE 528 MOD 188 G


TYPE 520 MOD 188M


TYPE 453 MOD 127C

TEKTRONIX U.K. LTD.

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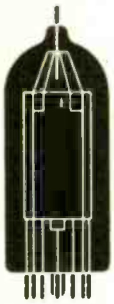
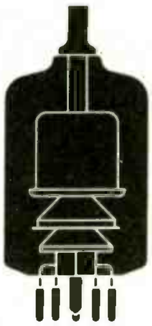
WW—001 FOR FURTHER DETAILS

New pulse tetrode for low power radars added to EEV's range

The new C1179—a high vacuum beam tetrode designed primarily for the output stage of power amplifier pulse modulators in 5kW-10kW radars.



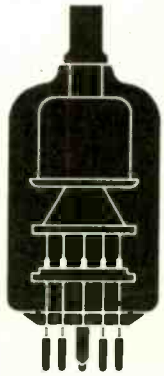
C1179



C1148

C1149/1

C1150/1



C1166

Type	Service type	Anode dissipation max. (W)	Pulse output power (kW)	Anode voltage max. D.C. (kV)	Pulse anode current max. (A)	Heater ratings (V)	Heater ratings (A)	Base
C1148	—	40	130	14.0	12	6.3	5.0	B5F
C1149/1	CV6131	60	330	20.0	18	26.0	2.15	B4A
C1150/1	CV427	60	205	17.5	15	26.0	2.15	B4A
C1166	—	60	205	17.5	15	6.3	9.0	B5F
C1179	—	18	65	8.0	9.0	6.3	2.8	B7A

Send for full data on the EEV range of pulse amplifier tetrodes

English Electric Valve Co Ltd
Chelmsford Essex England Telephone: 61777
Telex: 99103 Grams: Enelectico Chelmsford

Please send me full details on your range of pulse tetrodes.
I am particularly interested in using a pulse tetrode with the following parameters:

Pulse output power	Anode dissipation	Anode voltage	Pulse anode current

NAME POSITION

COMPANY

ADDRESS

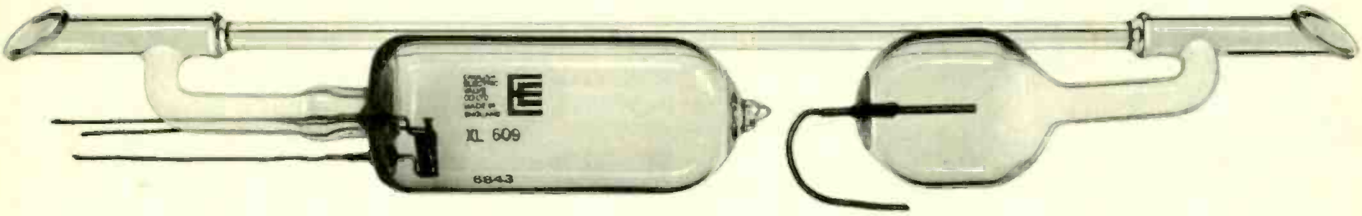
TELEPHONE NUMBER EXTENSION

WW 28
AP 362

WW—006 FOR FURTHER DETAILS

The secret is in the fixing of the Brewster window—the angled glass plate at each end of the tube. In many tubes the seal is made with an epoxy resin which eventually cracks and ruins efficiency by letting in air. EEV, on the other hand, use fusion sealed windows where the seal is as strong as any other part of the tube. Fusion sealing allows the tube to be heated to a very high temperature during manufacture, driving out all the gases in the tube surface which would otherwise contaminate the helium-neon filling. EEV tubes have been life tested up to 6000 hours which is two or three times the life generally expected from tubes employing epoxy sealing techniques. There is a standard range of EEV laser tubes available, full details of which can be obtained by filling in the coupon. If your laser design calls for a special tube give us brief details of what you need as we can probably meet your requirements.

Why EEV gas laser tubes



last longer

Type	Excitation	Output power at 632.8nm (mW)	Bore diameter (mm)	Active length (mm)
XL607	R.F. (27MHz)	3.0	7.0	483
XL609	D.C.	2.5	3.0	229
XL612	D.C.	6.0	7.0	457
XL614	D.C.	8.0	7.0	584

Send for full details of the complete range of EEV gas laser tubes.

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Please send me full data on your range of gas laser tubes.
I am particularly interested in using a tube with the following parameters.

Wavelength (nm)	Power Output (mW)	Mode (Single or Multi ?)

NAME POSITION

COMPANY

ADDRESS

TELEPHONE NUMBER EXTENSION

WW 26

AP357

Armstrong
the high fidelity sound

A STEREO TUNER-AMPLIFIER for the BUDGET SYSTEM

127 STEREO TUNER-AMPLIFIER £43-13-9
OPTIONAL CASE As illustrated £3-17-0

If you want high fidelity in the highest class don't buy the 127 Tuner-Amplifier; it isn't meant for you. But if you want a good quality system that is a great deal better than the average radiogram, and your power requirements, as well as your budget, are of modest proportions, then this is meant for you.

The 10 watts power output, 5 from each channel, won't fill a hall, but it is more than adequate for most domestic purposes. The AM-FM Tuner incorporated is doubly attractive because, as well as covering the medium wave-band, it has a performance on FM which is good enough to give excellent results on stereo radio once you add the optional M5 stereo radio decoder.

There are of course the usual facilities; pickup and tape inputs, tape recording outputs, bass and treble tone controls.

As we said at the outset, if you are after top-class hi-fi you don't want the 127, what you want is the Armstrong series 400 or series 500 models.

For details and technical specifications of all models, plus list of stockists, post coupon or write, mentioning 8WW69.

ARMSTRONG AUDIO LTD., WARLTERS ROAD N.7
Telephone 01-607 3213

name ....

address ....

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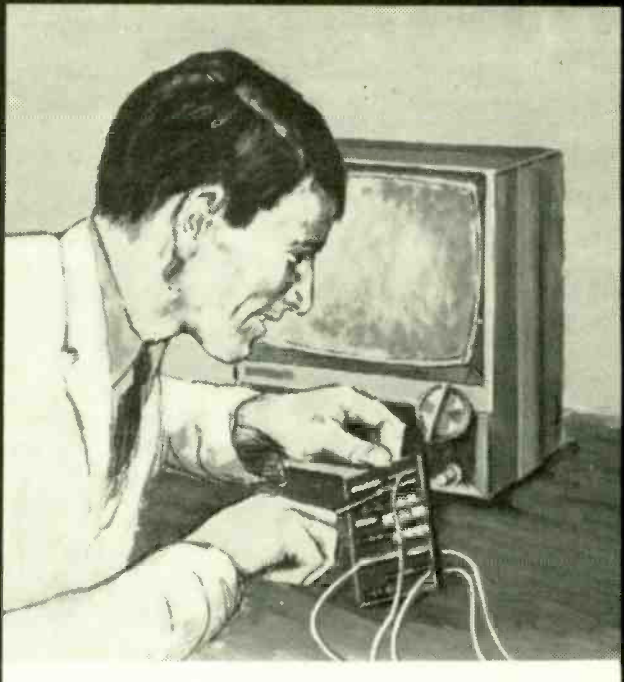

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Please send, without obligation, details of the Full-time Course in Radio and Television.

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D.C. POWER UNIT MODEL TSU·0500

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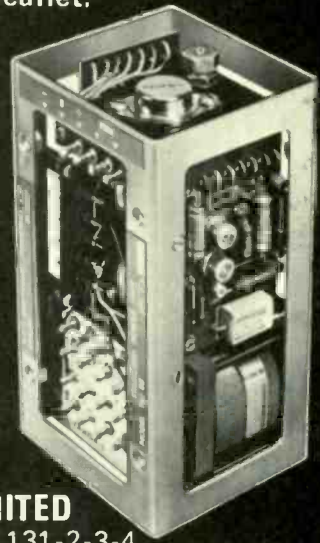
For further details send for fully descriptive leaflet.



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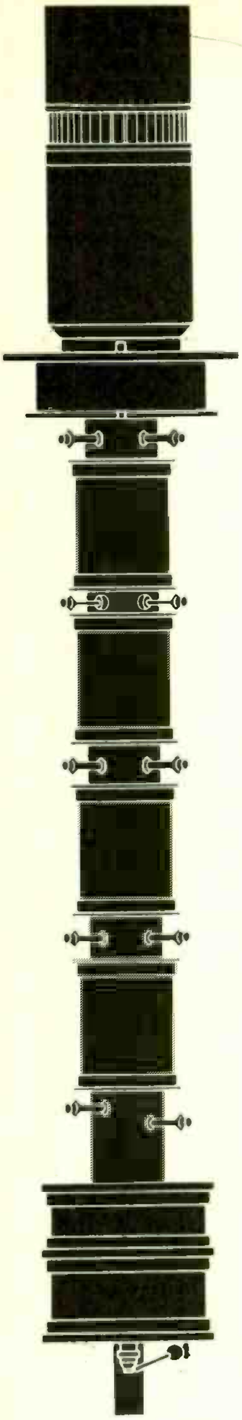
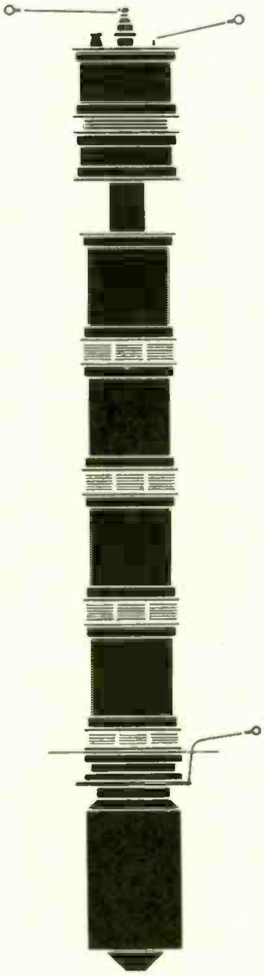
Write for brochure.

WW—014 FOR FURTHER DETAILS

EEV klystrons – a wide and flexible range for UHF TV





5 7 10 25 40 kW

EEV make amplifier klystrons for UHF TV at power levels 5, 7, 10, 25 and 40kW into the aerial. Their reliability is established, their operating efficiency is good and their design provides a high degree of operational flexibility. A 40kW tube can, for example, be operated at the same efficiency at any power level between 20kW and 40kW. When operated at 40kW the tube needs only 135kW d.c. input.

English Electric Valve Co Ltd
Chelmsford Essex England Telephone: 61777
Telex: 99103 Grams: Enelectico Chelmsford

Send for full details of the complete range of EEV amplifier klystrons.

Please send me full details of your range of UHF TV amplifier klystrons.
I am interested in a klystron with the following parameters:

Frequency Range Bandwidth Power Level

NAME POSITION

COMPANY

ADDRESS

TELEPHONE NUMBER EXTENSION WW25

AP 354

E 100-UK

Expand your Universe of Electronic Instrumentation with Hewlett-Packard

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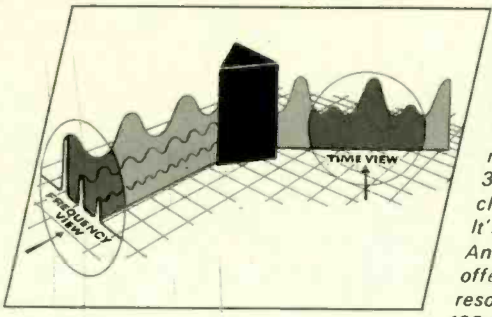
1 Frequency domain oscilloscope
2 200 MHz multichannel analyzer
3 Low-priced digital voltmeter
4 400 kHz-40 GHz sweep system
5 A new solid state digital display



1 Adding absolute amplitude calibration to frequency domain measurements

The most meaningful and practical way of evaluating circuit systems performance is in the frequency domain. Doing it in the 1 kHz-1250 MHz range—fast and accurately—is the job of hp spectrum analyzers. They let you measure the absolute magnitude of each component of a simple or complex signal. The result is shown directly without distortion or spurious responses over a 70 dB range on the hp 140S display unit. For high-resolution measurements, use the hp 141S variable persistence unit.

Using the 8553L RF unit with the 8552A IF unit, you cover 1 kHz-110 MHz in a single, highly linear sweep. Resolution is a narrow 50 Hz. Flatness (± 0.5 dB) and sensitivity (-130 dBm) are equally outstanding.

Combining the 8554L RF unit with the 8552A, your range is 500 kHz-1250 MHz—in one sweep with excellent linearity and resolution (300 Hz) and sensitivity (-120 dBm) to match.

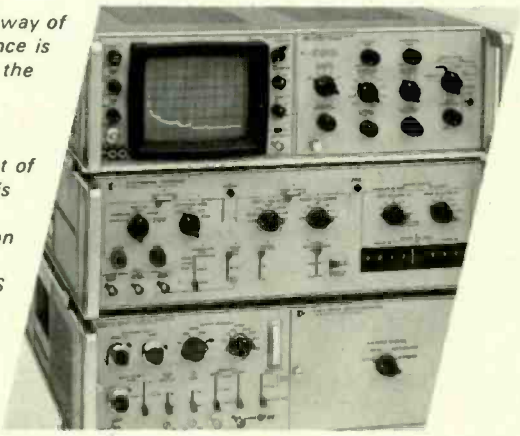
RF units. 8553L, £822
8554L, £1502
IF units. 8552A, £866
Display units. 140S, £339
141S, £704

WW—200 FOR FURTHER DETAILS

2 Fact or Fiction?

A 4096 channel analyzer with a 200 MHz clock rate? That would be just about the fastest ADC clock rate ever. And it would mean that you could count more than 30,000 impulses per second over all the channels.

It's a fact. It's the 5401A Multichannel Analyzer from hp. This precision instrument offers you a 12-bit ADC (with 4K resolution) and memory expandable from 1024 to 4096 or 8192 channels. Now you can get an extremely high digitizing rate in addition to outstanding linearity and stability specs, I/O flexibility, and multimode operation that hp has already contributed to nuclear and statistical analysis work.

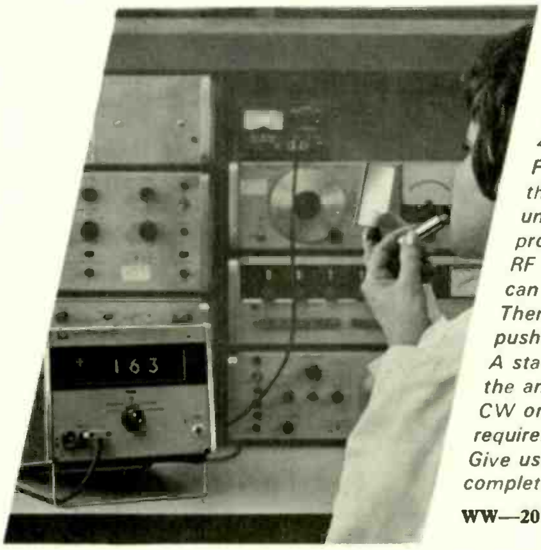


Linearity: integral, ± 0.1%, differential, ± 1% over full range above trigger level.
Stability: baseline and gain are automatically stabilized 30 times per second.
I/O flexibility: easy, with hp quick-change interface cards.
Versatility: Multi-mode operation includes pulse height analysis, multichannel scaling and sample voltage analysis.
5401A systems are priced from £5459.

WW—201 FOR FURTHER DETAILS

E 100-UK

3 A digital voltmeter for the fair sex?



Why not? Isn't many a production line staffed by girls? And don't the ladies also contribute their share to quality control? Don't they rate a rugged, foolproof digital voltmeter of their own?

Of course they do. That's why hp designed the 3430A, for use by inexperienced personnel. And this low-priced instrument is equally handy for repair and laboratory work.

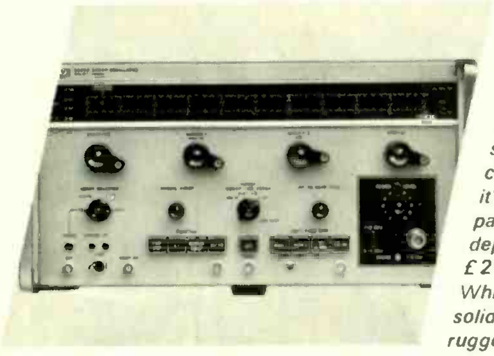
The 3430A has a large, easy-to-read 3-digit display, with a 4th digit for 60% overranging. Polarity and decimal point are indicated automatically. Measurement range: ±100 mV to ±1000 V. The chance of circuit loading is reduced by the 10 megohm input resistance in all ranges. No need for frequent calibrations either. The 3430A maintains its ±(0.1% of reading + 0.1% of range) accuracy for 90 days.

May we send you the data sheet?

The 3430A is priced at £259 and its made in Britain.

WW—202 FOR FURTHER DETAILS

4 Between 400 kHz and 40 GHz: a sweep system of great versatility



When it comes to accuracy, linearity and low residual FM, the hp 8690B sweep system has few peers. It has even fewer once you consider its versatility.

Over 20 standard RF plug-ins give the system an impressive frequency range from 400 kHz to 40 GHz. Included are two new all-solid-state plug-ins for the 400 kHz-4 GHz range.

For multiband sequential swept coverage, there is the 8706A pushbutton control unit. You'll find it a handy device in production testing. Used with up to three RF unit holders (8707A), the mainframe can drive up to nine plug-in oscillators.

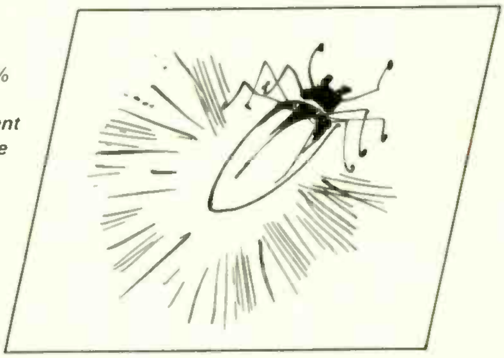
There's also a multiplexer (8705A) for push-button distribution of RF outputs.

A stabilized sweep oscillator system is the answer if it's ultra-stable phase-locked CW or swept frequency outputs you require.

Give us a call so that we can send you complete details.

WW—203 FOR FURTHER DETAILS

5 New light-emitting diode is bright idea behind all-solid-state numeric display



Like a gallium arsenide phosphide firefly, you might say.

Bright indeed. Our researchers were looking for a diode that would emit a significantly increased number of photons at energies compatible with the characteristics of the human eye.

In this they succeeded. And thus made solid-state numeric displays a practical proposition.

Practical because high-intensity, variable light output is here accompanied by the frugal power consumption of solid-state circuits...

Twenty-eight tiny GaAsPs diode chips deliver bright red numerals. The BCD driven switching logic is a monolithic integrated circuit with over 250 active elements. And it's all housed in a compact, sealed package only 25 x 15 x 4 mm. The price, depending on quantity ordered, is about £26 per unit...

Which buys you all the advantages of solid-state displays, including long life, ruggedness, and freedom from catastrophic failure. So you'll want to remember our bright idea when space is at a premium and reliability is vital.

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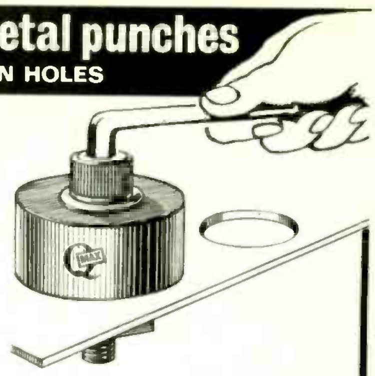

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RECTANGULAR: $\frac{21}{32}'' \times \frac{15}{16}''$
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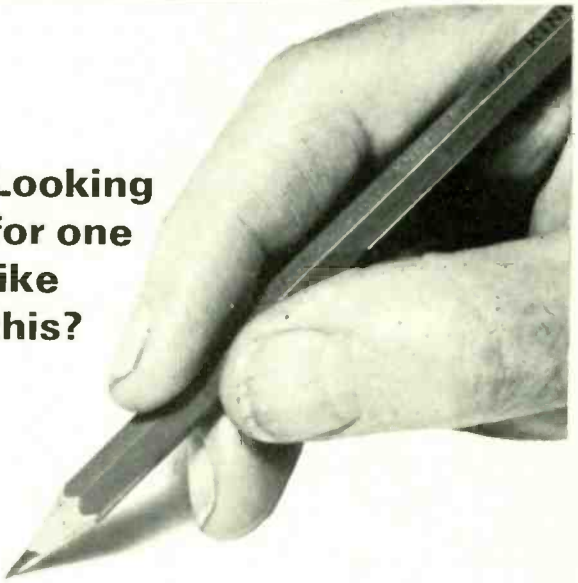

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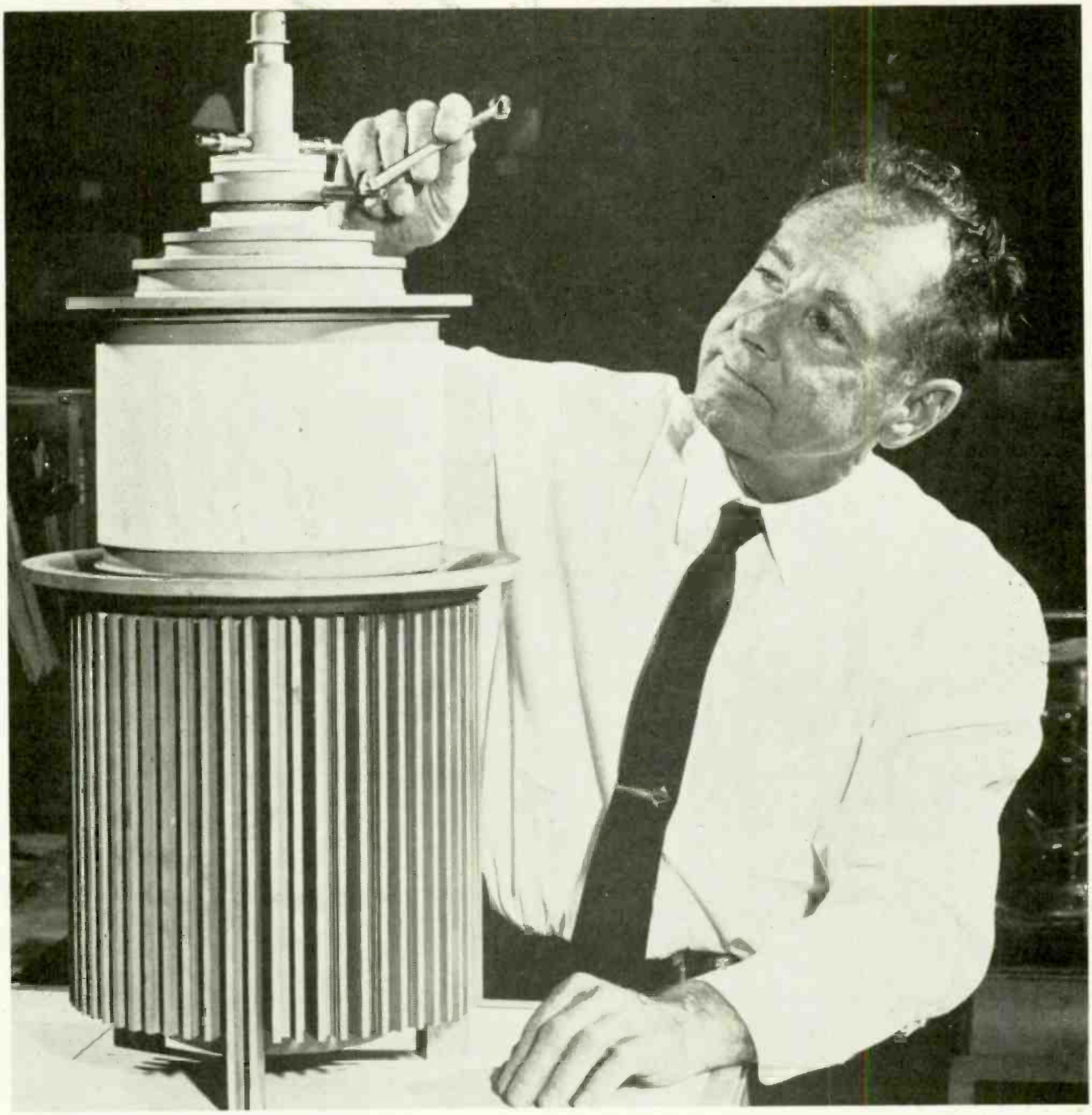
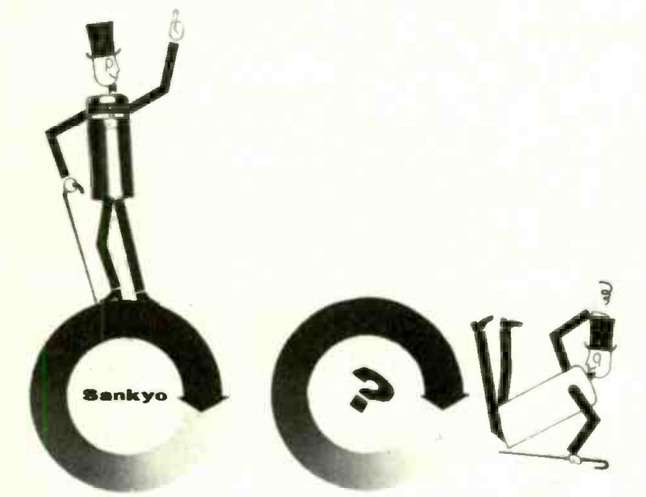
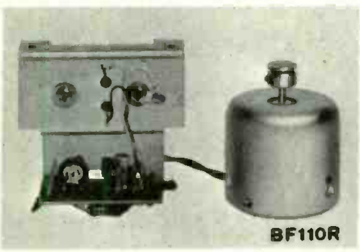


The Big Little Integrals That Can Make Or Break Your Product.





SY173L Single speed (2000 rpm). For record players.
DMF54R-02 Single speed (2400 rpm). For tape racorders.
RK201R Single speed (2400 rpm). For car players.
BF110R Single speed (2000 rpm). With electrical governor motor. For tape recorders.
BF200R Single speed (2200 rpm). For car recorders & players.
ZF200R Variable speed (such as 1100, 2200 and 2800 rpm). With brushless & transistor motors. For de luxe record players & electronic calculators.
VM250B Single speed (3600 rpm). For auto tuners.

Specification for Sankyo micro motors

TYPE	Dimensions ø (m/m)	Dimensions Length (m/m)	Rated Voltage (V)	Range of Voltage (V)	Rated Torque (gr-cm)	Rated Speed (rpm)	Load Current (mA)	Starting Torque (gr-cm)	Life (Hr)	Direction of Revolution
SY173L	40	32.4	6	4.5 ~ 6	3	2000	80	35	600	Left
DMF54R-02	38	34.8	6	4.5 ~ 6	9	2400	140	30	600	Right
RK201R	47.9	48	13.2	10 ~ 16	30	2400	210	100	1000	Right
BF110R	38	30	4.5	3.5 ~ 5.7	8	2000	160	30	1500	Right
BF200R	38	34.1	13.2	(5.5 ~) 9 ~ 16	15	2200	180	30	1500	Right
ZF200	46	50	9	6 ~ 9	20	2200	300	45	3000	Left, Right
UP550R	20	44.5	4.5	4 ~ 6 4.5 ~ 6	14	3700 5000	160	60	30	Right
VM250B	25	36.5	7	6.5 ~ 7.5	0.4	3600	45	25	500	Left, Right

Sankyo

Sankyo (Europe) Export und Import G.m.b.H.: 4 Düsseldorf, Bahnstraße 45-47, W. Germany. Tel: 325652/3 Telex: 8587097
Cables: SANKYORGEL DÜSSELDORF
Sankyo Seiki Mfg. Co., Ltd.: 17-2, Shinbashi 1-chome, Minato-ku, Tokyo 105, Japan. Tel: Tokyo 591-8371
Cables: SANYORGEL TOKYO
American Sankyo Corp.: Rm. 801-3, 95 Madison Ave., New York, N.Y. 10016, U.S.A. Tel: LE-2-8020

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Recommended retail price from £12 including built-in cable and quick release stand adaptor, depending on impedances.

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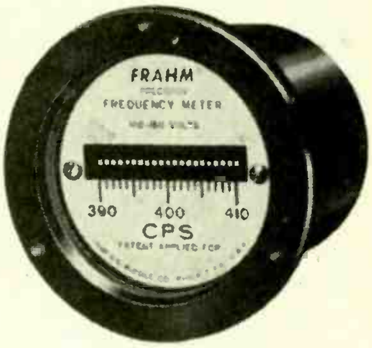

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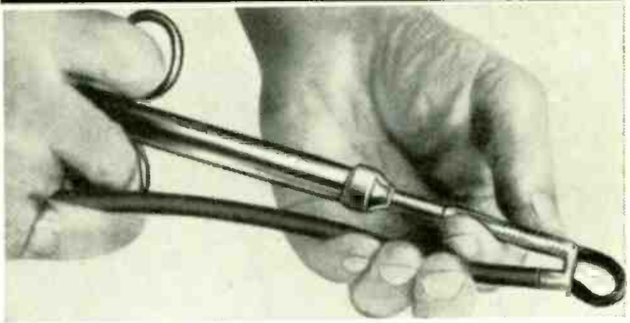

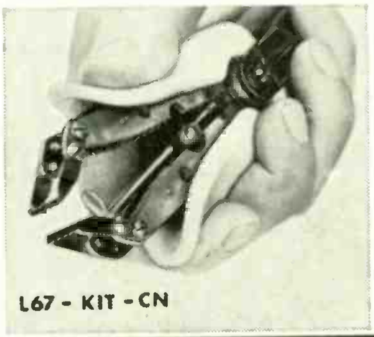

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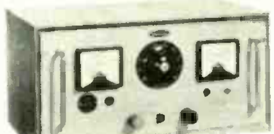

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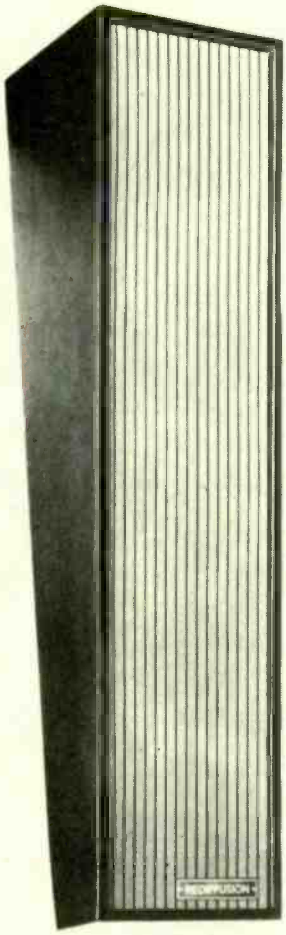

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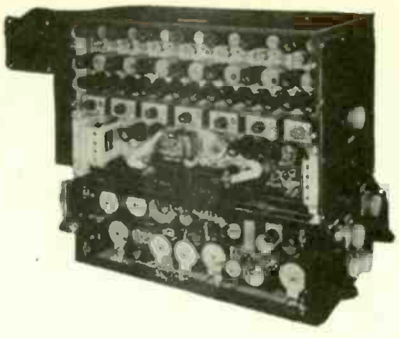

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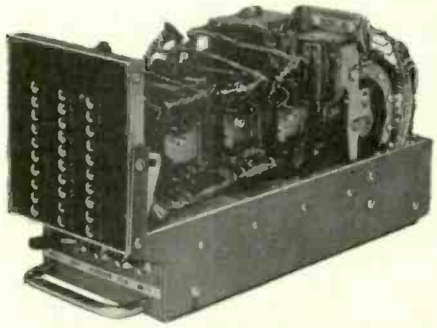

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The range is covered by three basic groups, having distinct characteristics, broadly as follows:

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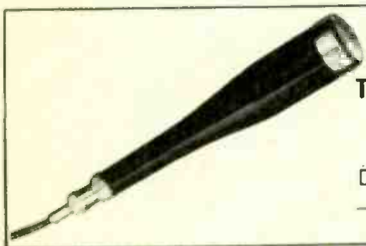
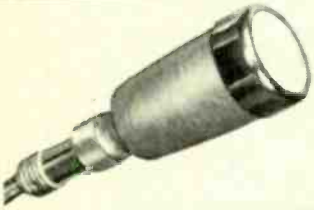
Microphones
for every purpose



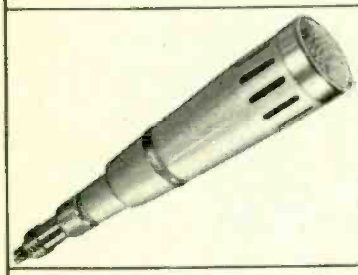
The DP4

Designed for general use —P.A., tape recording etc.



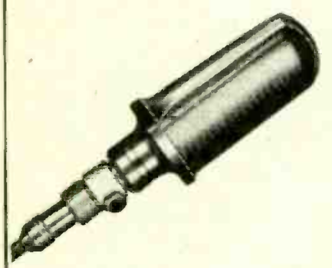
The DP6

Small in size, large in performance. As a lavalier type and for panel mounting on control units etc.



The GC/1 Cardioid

For stage and church work, P.A. use, lecture halls etc., where acoustic feedback is a serious problem.



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Integrity that you hear

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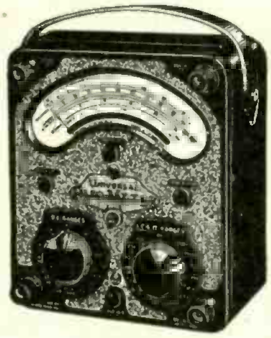

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- **ULTRA-SMALL SIZE**

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- **EXTRA-HIGH PERFORMANCE**

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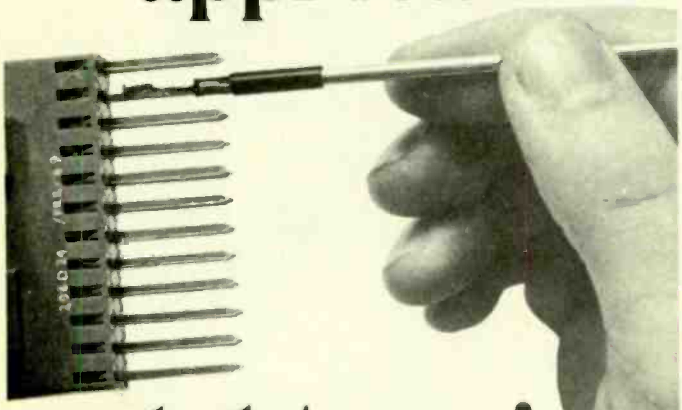

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The new Ferranti EPP Edge Connector has been designed for electronic telephone exchange equipment, and has Post Office Approval to Specification D2343, TYPE 206D.

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EPP is a new generation of Edge Connectors — offering many new features designed to improve efficiency and reliability.

Such as the one-piece construction of the wrapping post and spring contact. This form of construction removes the possible source of unreliability in two part welded constructions.

Such as the brand new design which allows each wrapping post/contact unit to be removed from behind the equipment. This operation can be carried out in seconds using a simple extraction tool, without even disturbing the printed-circuit board.

Such as the remarkably low insertion force required — only 6oz maximum per pair of non-bridging contacts.

In addition to these new features, Ferranti EPP Edge Connectors retain many of the successful characteristics of earlier types — including the unique Ferranti 'rolling-leaf' spring contact with inherant stress-limiting properties, and the non-porous hard-gold plating 5 microns thick on the contact area.

12 and 18 pole single-sided 12 + 12 and 18 + 18 pole double-sided contacts are available.

Pole spacing 0.200 in (5.08mm).

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FERRANTI

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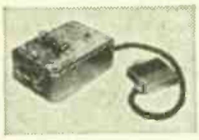

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525-0-525V. 0.5A., 6.3V., 6 Act., 6.3V. 6 Act., 5V. 6A.	5	13	6

*Low Voltage

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30-0-30V. 4A.	2	19	0
28V. 1A., 28V. 1A., 28V. 1A., 28V. 1A., 30V. 250mA.	4	15	0

*Primaries 10-0-200-220-240V.

20W Transistor Amplifier (W.W. Nov. 1966)

	£	s.	d.
Driver	1	4	6
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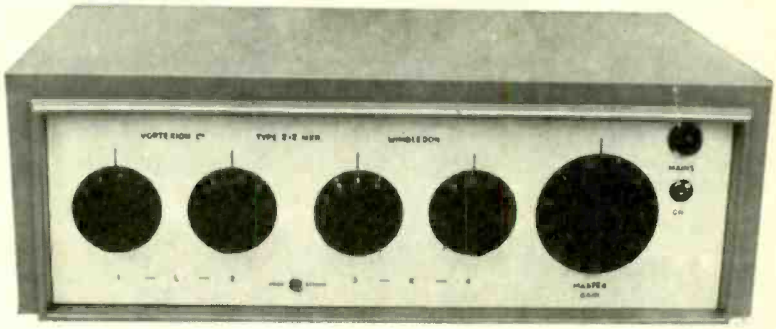

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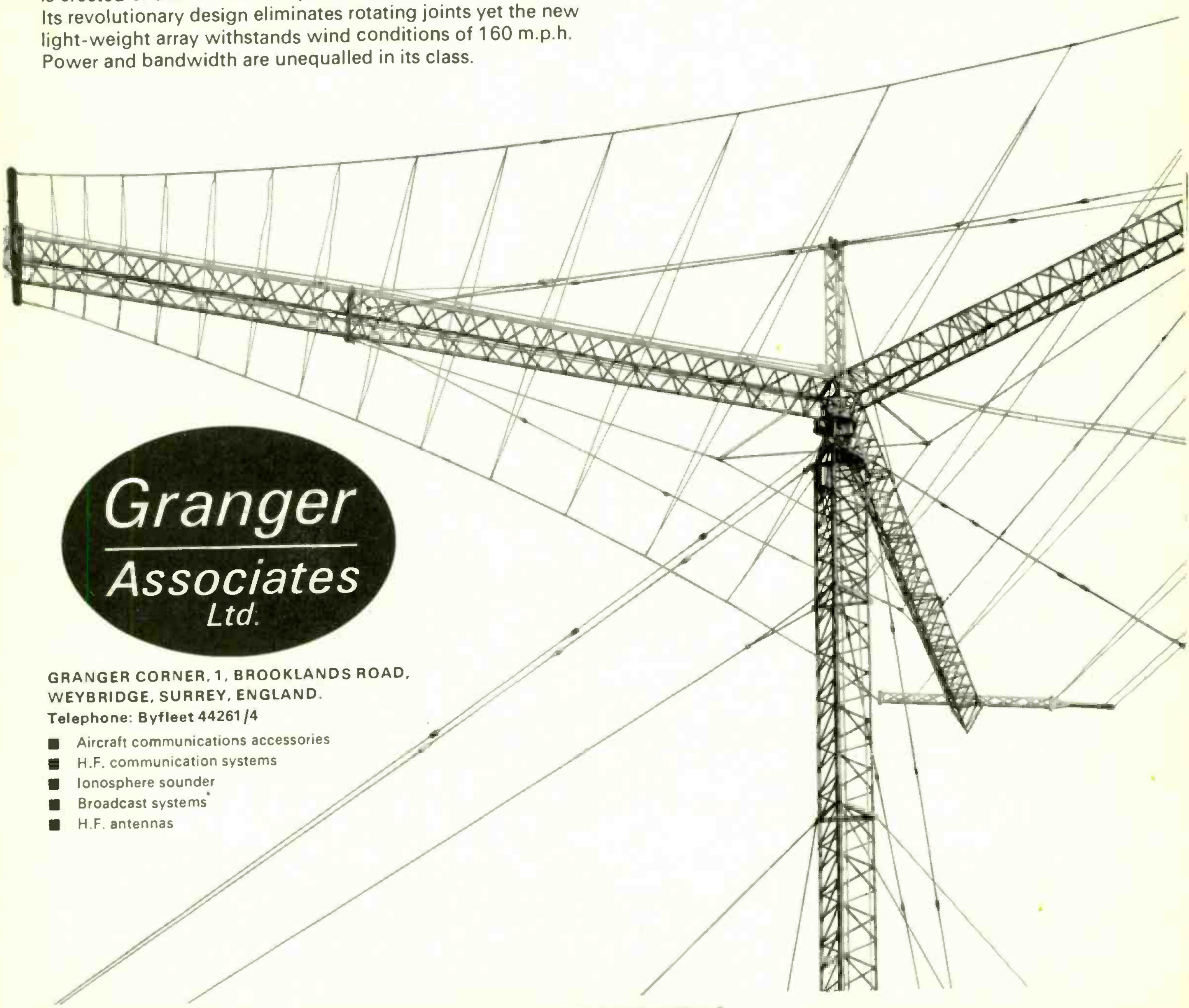

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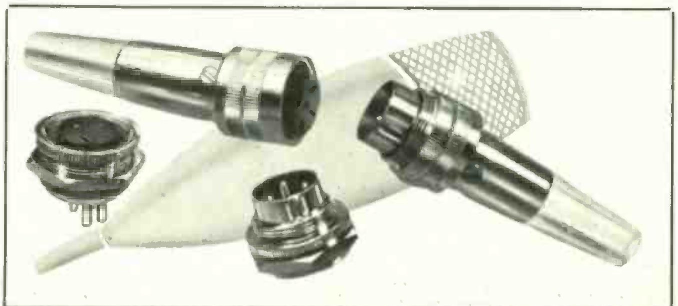

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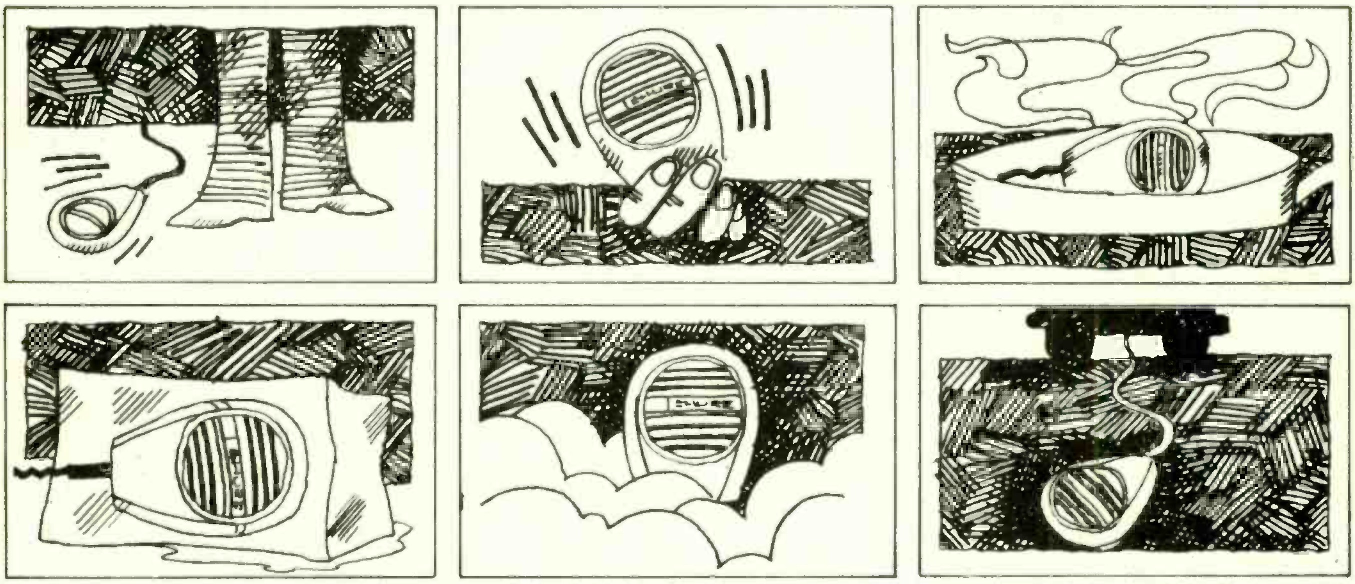

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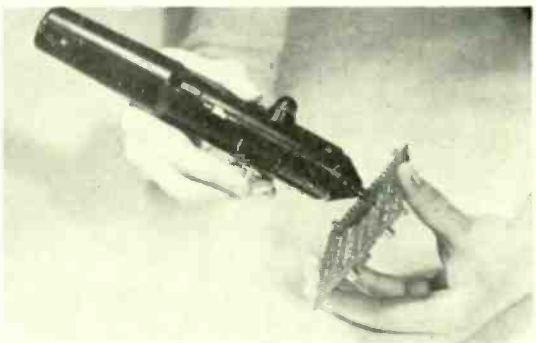

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Some notes on Bridge Measurement by WAYNE KERR

Number 1
The Transformer Ratio-Arm Bridge

This is the first of a series of notes describing a measurement technique which is becoming more generally accepted for its precision and reliability.

Like many sound scientific principles, the basic idea of this bridge goes back to the end of the 19th Century. However, at that time, technology had not evolved the high permeability nickel iron alloys and ferrites that we know today, and it is only comparatively recently that the full potentialities of this type of bridge network and its application to the science of measurement have been realised.

Figure 1 shows the simplest form of the transformer ratio-arm bridge.

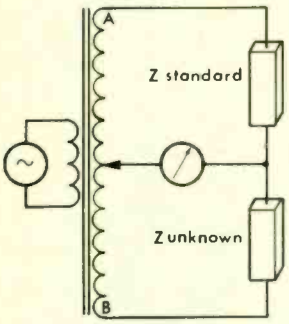

Fig. 1

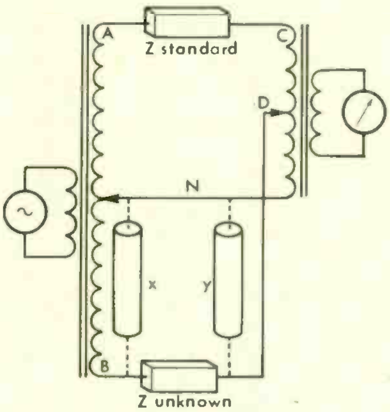

Fig. 2

The derivation of this network from the classical Wheatstone bridge can easily be seen, but the advantages are, perhaps, not quite so obvious. If the ratio arms A and B were resistors or capacitors, a large number would be necessary in order to make a wide range impedance bridge; but, by using a transformer, taps in the ratio 1, 10, 100 and 1000 can be readily achieved, and only one standard of reactance and one of resistance are required.

Furthermore, the accuracy of these ratios depends, in practical terms, only on the geometry of the windings and the difficulties of long term stability and component drift do not arise. With careful attention to the design of transformers, voltage ratios can be established to an accuracy of better than one part in a million, independent of normal changes in ambient temperature. This stability is to be compared with ratio arms made from resistors or capacitors in a conventional bridge.

Although the basic bridge circuit of Fig. 1 is still used in some instances, the incorporation of a second transformer, shown in figure 2, provides a bridge network of even wider range.

In addition to ratio arms A and B, the transformer on the detector side of the network can have variable ratios C and D, so that a further series of tappings from 1 to 1000 multiply with the original series to give an overall ratio of 10^6 to 1.

The operation of the bridge can now be explained quite simply. The voltage A produces a current when it is applied to the standard impedance. Likewise the voltage B, 180° out of phase with the voltage A, produces a current when it is applied to the unknown impedance. These two currents, making due allowance for the turns ratio of C and D, can now be balanced in the second transformer either by adjusting the voltage ratio or varying the value of the standard, or a combination of both.

Figure 2 also illustrates another extremely important feature of the bridge. If an impedance (x) is connected across the ratio arm B, that is to say between the voltage side of the unknown and N, the neutral connection of the bridge network, the accuracy of the measurement is virtually unaffected.

Although this impedance loads the transformer and causes a voltage drop, the tight coupling of the windings gives rise to an equivalent voltage drop on the standard side of the bridge, and for all practical purposes, the loading of the circuit does not affect the point at which the network balances. It is, perhaps, sufficient to point out that a similar situation arises in the event of an impedance (y) being connected across the second transformer winding.

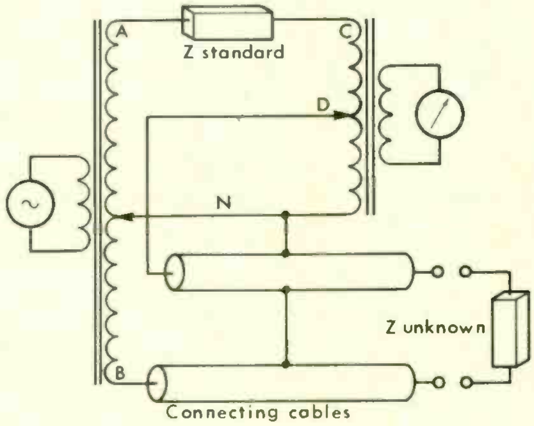

Fig. 3

If the basic circuit of Figure 2 is now re-drawn in the form of Figure 3, it will be seen that the capacitances of the two connecting cables replace the impedances (x) and (y). It now becomes clear that the use of relatively long cables to connect the unknown impedance to the bridge can be tolerated.

To give an example of the advantage of this facility, it is in practice possible to measure accurately a small fraction of one picofarad in the presence of cable capacitances of several hundred picofarads.

Further notes in this series will develop the principles which are explained in this issue, and also their application to a wide range of measurement problems.

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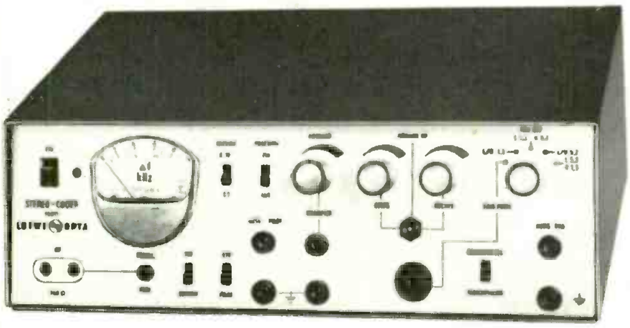

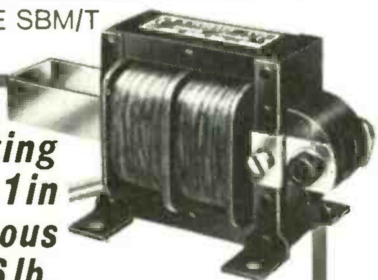


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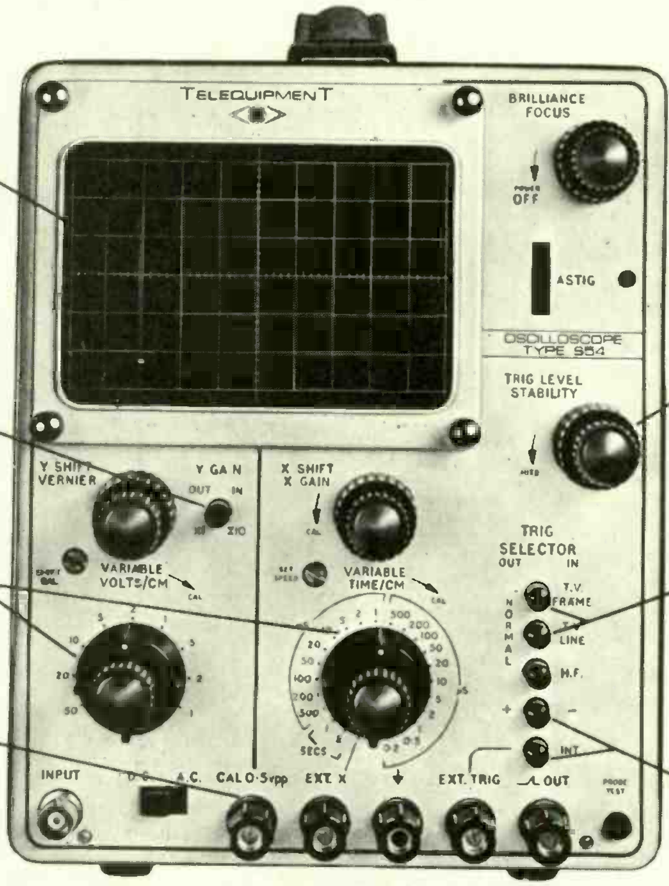

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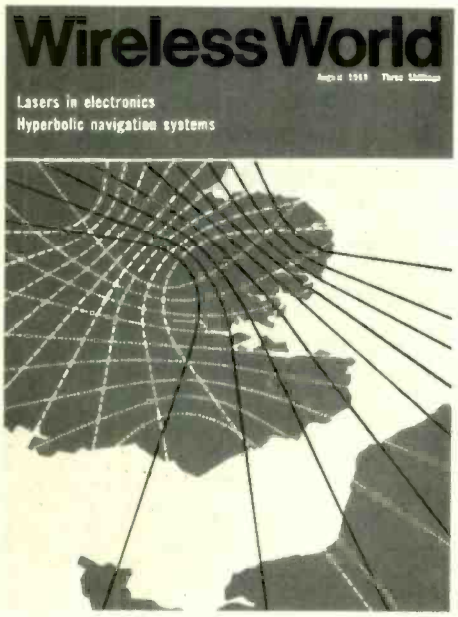

This month's cover. A Decca artist's interpretation of the hyperbolic patterns produced by the south-east England Decca Navigator Chain (see p. 353).

Contents

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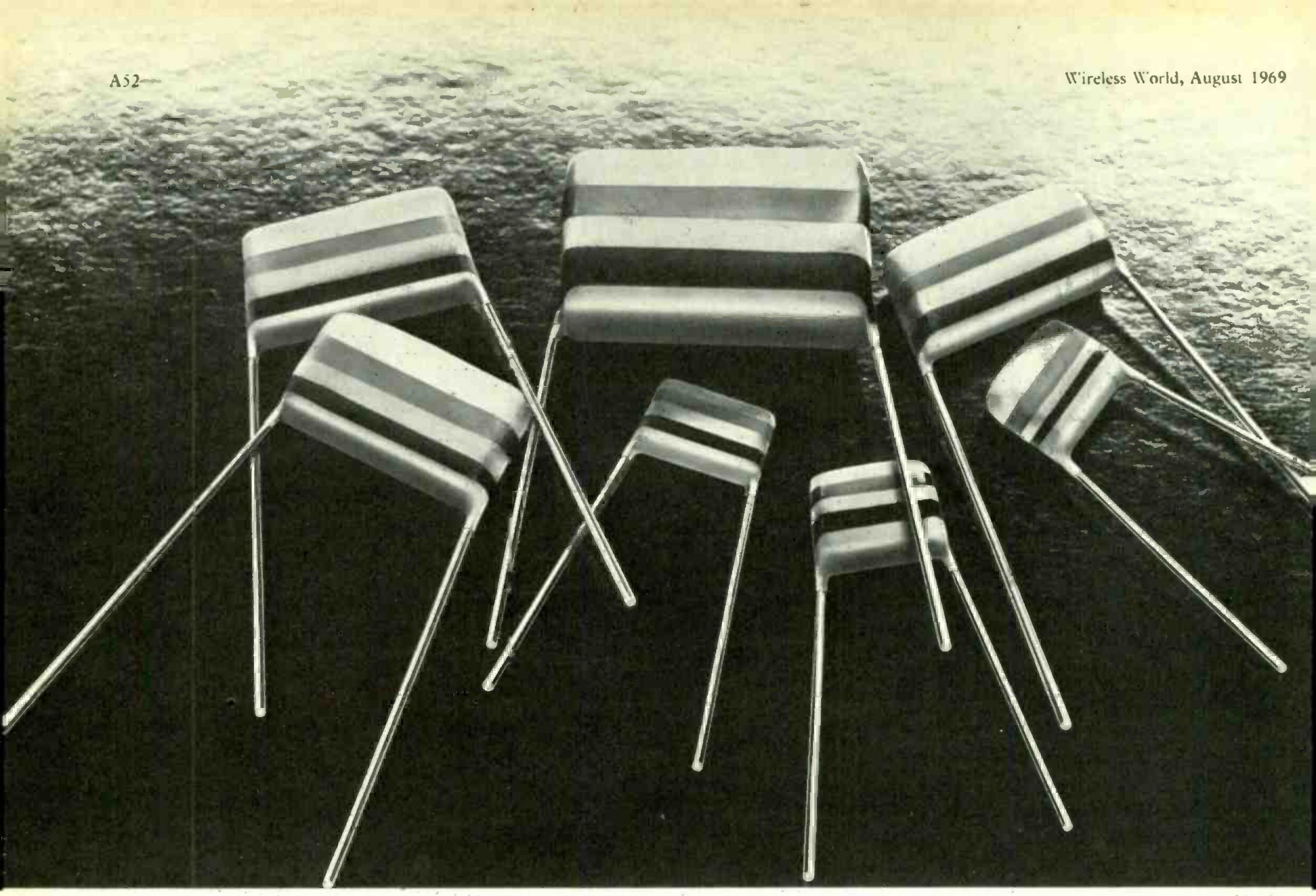

How we set the trend in plastic film capacitors

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New techniques New manufacturing techniques were then introduced in plastic film capacitors, which allowed a metallised layer to be deposited on the film. This reduced our capacitor sizes by up to a further 50%. About this time, the general acceptance of printed circuits created a strong demand for various components in different shapes, with particular dimensions to close tolerances. And because we at Mullard anticipated this trend we now produce the C280 miniature metallised film capacitors. These small devices have radial terminations in the standard I.E.C. 0·1 inch grid spacing, making them the economic answer to the problems of improving packing densities and reducing assembly production times. Due to their distinctive colour coding, small size and wide capacitance range the demand for these capacitors is far in advance of all others. The 400V units have a more recent polyester film (polycarbonate) which reduces losses at frequencies of 20kHz and above. This also applies to the C281 series with their axial leads and moulded encapsulation.

Development Work of course continues, and encouraging results are being achieved with capacitors for a.c. power handling, for example for interference suppression and power factor correction, using polypropylene films.

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Wireless World

Economics of broadcasting channels

When the B.B.C. were deliberating on how to improve the distribution of sound radio transmissions (see "News", page 358) one wonders if anybody gave a passing thought to the more fundamental economics of broadcasting. Economics is not just management of cash, but good utilization of resources, whatever they happen to be. In the case of broadcasting one of the most important resources is channel capacity, a strictly limited commodity. Did anyone, in fact, consider whether our broadcasting channels are being utilized in the most economical way for the material they are required to carry? Probably not, first of all because it wasn't on the agenda and secondly because there is nobody with the right knowledge and authority to deal with such a problem—even if there is anybody who admits that it exists.

The trouble is we have the programme producer on the one hand and the engineer on the other. Each does his job independently of the other, though no doubt with understanding of the other's immediate problems. The overall organizers certainly have a synoptic view, but it cannot go very deep: they are essentially men of affairs. The programme producer is aware that there is only a limited number of channels and he distributes his material among them according to some formula. His idea of economics seems to be to fill up as many hours of broadcasting as possible—leave no silence, no raster unfilled. The engineer, also aware of channel limitation, international frequency allocations etc., sees a broadcasting channel as essentially a communications channel with a maximum information-carrying capacity, à la Shannon, determined by bandwidth and signal/noise ratio. He is apparently unperturbed that this view of information could mean complete absence of information to the programme producer—gibberish, noise, abstract patterns, could all produce high rates of "information" in bits per second. The engineer's idea of economics is largely a matter of saving bandwidth by techniques such as single- and vestigial-sideband working, frequency interleaving and pulse sound: he is not concerned with the economic use of what he has saved.

The utilization questions that seem to have nobody to investigate them are of this kind: If speech intelligence requires a bandwidth of only a few kilohertz, is it economic when an 8-MHz television channel or a 300kHz f.m. sound channel is used for news bulletins and the like? Does "sweet" background music for busy housewives, or pop foreground music for sated juveniles, require as much channel capacity as music with a subtle, complex approach to the emotions and intellect? (This is not a question of taste, but what are the required stimuli and responses in each case and the minimum information rates in bits per second needed to generate them. Some pop music may need higher rates than some classical music.) If the maximum rate at which a single television viewer can take in visual information at any given time corresponds to a 5-MHz video bandwidth, is it economic to operate a system that provides him with several times that information carrying capacity? (This point was raised recently by R. P. Gabriel, of Rediffusion International, as an argument in favour of his "dial back" cable television distribution system.) In short we are looking for an economic matching of communication channels to the human communication requirements at the inputs and outputs of the channels, an equation relating engineers' "information" to semantic information.

At present there are no obvious techniques for remedying any mis-matching that might be admitted to exist. But the continuing demand by society for more and more channels of communication (including broadcasting) might well provide a stimulus for work in this field in the future.

Active Filters

A practical approach on feedback amplifier theory

1. Survey of circuits

by F. E. J. Girling and E. F. Good**

Many works on active filters are written so exclusively for a small circle of specialists that the ordinary circuit designer may easily feel that there is little hope of understanding the subject without first mastering a whole range of new concepts.

It is the aim of this series of articles to show that a comprehensive and practically useful theory of active-filter design can be built up from the theory of linear feedback amplifiers as laid down by Black, Nyquist, Blumlein, and others.

The present article is a survey of the circuits to be discussed. In subsequent articles we shall collect together some of the fundamentals of the theory of both passive and active net-works; then later we shall look in detail at some of the more useful methods of realization.

Throughout we shall endeavour to base the exposition on the simplest and most widely known concepts, not only in order to be intelligible to the non-specialist reader, but also because we believe there is a real danger in taking too narrow a view: too close an inspection of a single tree can easily result in failure to appreciate the existence of the wood.

The dynamics of *CR* and *LCR* circuits

An *LCR* filter is a resonant structure, that is: at least one component of its natural motion or transient response is less than critically damped. This is necessary to obtain a sharp cutoff—as shown, for example, in the low-pass response of Fig. 1. In a passive *CR* circuit, no matter how complicated, dissipation in the resistances dominates and the natural motion is more than critically damped. Passive *CR* networks do not give sharp cutoffs.

(Many readers will be familar with these facts in terms of the positions on the complex plane of the poles of the response functions.)

When, however, *RC* networks are used with gain and feedback (i.e. in an active system) the restriction on the type of natural motion is removed, and consequently on the type of frequency response obtainable. Indeed it has been common knowledge since the publication of the work of Bode and Nyquist that a feedback amplifier containing only *CR* coupling and feedback networks can show a peaky and resonant response and further can be unstable, i.e. oscillate. (Ref. 1). In amplifiers this is to be avoided: in active filters it is put to use.

Related fields

Two areas in which gain, feedback, and *CR* networks are used to obtain virtually any response that may be desired are analogue computers and servo simulators; and it was with some knowledge of these arts that the present authors began designing active filters (low-pass "scratch" filters for reducing surface hiss from 78 r.p.m. shellac discs).

The simplest electronic analogue of a 2nd-order servo system, i.e. one having two integrations in the forward path, is shown in Fig. 2(a). This uses three "operational" amplifiers, and so is rather cumbersome (or was so before silicon integrated amplifiers became available). An alternative circuit using a single amplifier is shown in Fig. 2(b). For both circuits the voltage transfer ratio in conventional transfer function form is (leaving out the minus sign, which is not of importance when discussing the frequency response)

$$\frac{V_{out}}{V_{in}} = \frac{1 + \alpha pT}{1 + \alpha pT + p^2T^2} \qquad (1)$$

where p is the Heaviside differential operator† (signifying the process d/dt), T is the reciprocal of the undamped natural frequency in radians/second (i.e. $T = 1/\omega_c$), and α is a measure of the damping (being equal to 2ζ, where ζ is the conventional damping factor‡). As will be seen later $\alpha = 1/q$, where q is the conventional Q-factor of a tuned circuit, and we shall take

† Some may prefer to write s, the complex-frequency variable. For our purposes it is immaterial which letter is used. The important thing is to understand that p (or s) represents differentiation and that $1/p$ (or $1/s$) represents integration.

‡ This is defined so that critical damping is given by $\zeta = 1$. It should not be confused with the "damping factor" commonly used by audio engineers, which, although concerned with the same basic physical phenomenon—damping of a potentially oscillatory system—is given by loudspeaker impedance divided by amplifier output impedance.

* Royal Radar Establishment.

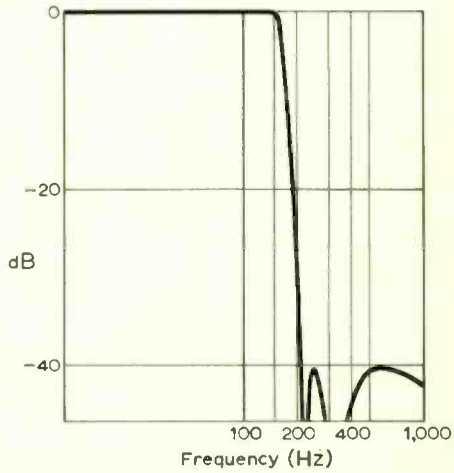


Fig. 1. Low-pass filter, 5th-order Darlington response. The ripples in the pass band do not show on the small scale used.

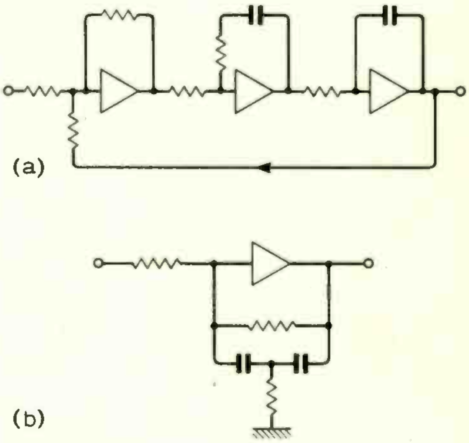


Fig. 2. Two analogues of a basic second-order servo system. All amplifiers are high-gain, sign-inverting.

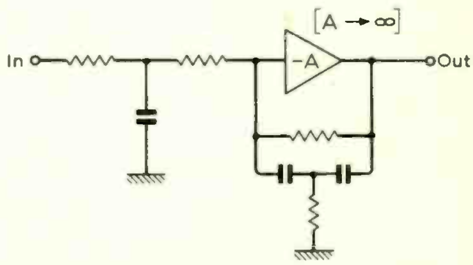


Fig. 3. Low-pass filter derived from an analogue of a second-order servo system.

this relationship as the definition of the Q-factor of any 2nd-order system.

By writing $j\omega$ for p an expression for the frequency response is obtained,

$$\frac{V_{out}}{V_{in}} = \frac{1 + j\alpha\dfrac{\omega}{\omega_c}}{1 + j\alpha\dfrac{\omega}{\omega_c} - \left(\dfrac{\omega}{\omega_c}\right)^2} \quad (2)$$

When $\omega \gg \omega_c$

$$\left|\frac{V_{out}}{V_{in}}\right| \simeq \frac{\alpha\dfrac{\omega}{\omega_c}}{\left(\dfrac{\omega}{\omega_c}\right)^2}$$

i.e.

$$\simeq \frac{\alpha\omega_c}{\omega}$$

Thus in this region there is increasing attenuation as the frequency is raised, but the rate of cut off is not very great as the response is proportional to only $1/\omega$.

If we could remove the second term of the numerator of the voltage transfer ratio we should have better filtering, as the response in the cutoff region would be proportional to $(\omega_c/\omega)^2$ approx. This can be done by multiplying by the factor $1/(1 + j\alpha\omega/\omega_c)$, which means that we must add a simple lag of time constant α/ω_c, i.e. αT. A convenient way of doing this is to split the input resistor into two and add a capacitor as shown in Fig. 3.

We now have a circuit which realises the equation

$$\frac{V_{out}}{V_{in}} = G(\omega) = \frac{1}{1 + j\alpha\dfrac{\omega}{\omega_c} - \left(\dfrac{\omega}{\omega_c}\right)^2} \quad (3)$$

The equation for the amplitude response is therefore

$$|G(\omega)| = \frac{1}{\left\{\left(1 - \dfrac{\omega^2}{\omega_c^2}\right)^2 + \left(\alpha\dfrac{\omega}{\omega_c}\right)^2\right\}^{\frac{1}{2}}}$$

$$= \frac{1}{\left\{1 + (\alpha^2 - 2)\left(\dfrac{\omega}{\omega_c}\right)^2 + \left(\dfrac{\omega}{\omega_c}\right)^4\right\}^{\frac{1}{2}}} \quad (4)$$

And from this, taking $\alpha(= 1/q)$ as parameter, we obtain the family of curves shown in Fig. 4.

If this rate of fall in the cutoff region is sufficient, $|G(\omega)| \propto (\omega_c/\omega)^2$, a curve which is likely to be selected is that for $\alpha = \sqrt{2}$. For this degree of damping (0·707 of critical) the middle term of the denominator of the expression for $|G(\omega)|$ vanishes, leaving

$$|G(\omega)| = \frac{1}{\left\{1 + \left(\dfrac{\omega}{\omega_c}\right)^4\right\}^{\frac{1}{2}}} \quad (5)$$

This is the Butterworth or "maximally flat" response (Refs. 2, 3) for this set of curves, i.e. the response which shows the sharpest turn-over at the corner without crossing the low-frequency asymptote, $|G(\omega)| = 1$, or the high-frequency asymptote, $|G(\omega)| = (\omega_c/\omega)^2$.

If a sharper cut off is required we may select the slightly peaked response, $\alpha = 1$, and add somewhere in the signal path a simple lag of equal corner frequency so that we obtain an overall frequency response

$$|G(\omega)| = \frac{1}{\sqrt{\left\{1 - \left(\dfrac{\omega}{\omega_c}\right)^2 + \left(\dfrac{\omega}{\omega_c}\right)^4\right\}\left\{1 + \left(\dfrac{\omega}{\omega_c}\right)^2\right\}}} \quad (6)$$

$$= \frac{1}{\sqrt{\left\{1 + \left(\dfrac{\omega}{\omega}\right)^6\right\}}} \quad (7)$$

which is Butterworth response, 3rd-order. The shape of this response and of the two factors is shown in Fig. 5 (Ref. 4).

The next step is the appreciation that apart from the factor $\frac{1}{2}$ the above response is identically the same as the response of the conventional low-pass LC filter shown in Fig. 6, for which the voltage transfer ratio is

$$\frac{1}{2(1 + 2pT + 2p^2T^2 + p^3T^3)}$$

$$\equiv \frac{1}{2(1 + pT)(1 + pT + p^2T^2)} \quad (8)$$

This teaches us that we need not look for a new set of responses merely approximating to those of conventional LC filters, but can make RC active filters with responses identically the same as those of conventional LC filters. At one time it seemed that this would be of most use in helping us to understand from a study of their voltage transfer ratios how the responses of conventional LC filters are generated. Now, after the appearance of some important and most useful publications (Refs. 5, 6, 7) the lesson to be drawn is rather that design data prepared for passive filters can be used for active filters.

In the above we have seen in action in simple examples some of the basic notions of active-filter design:—

- The use of feedback techniques to obtain an accurately determined response.
- The value of the transfer-function form in defining the response of a system.
- The choice of a transfer function to give either a known frequency response, or to match that of a known passive filter.
- The realization of an active filter as a cascade of sections, each section realising a factor of the overall transfer function. It is, of course, in an active system easy to arrange the sections in cascade without unwanted interaction. Butterworth (Ref. 2) was the pioneer of this approach.

We may now pass on to the synthesis of active filters as an art in its own right.

Direct synthesis

To synthesize a circuit to realise 2nd-order low-pass response,

$$\frac{V_{out}}{V_{in}} = \frac{1}{1 + \alpha pT + p^2T^2} \quad (9)$$

we may compare this equation with Black's equation for a feedback system (Ref. 8),

$$\frac{V_{out}}{V_{in}} = \frac{\mu}{1 - \mu\beta} \quad (10)$$

in which μ = the forward gain, and β = the feedback factor. When $\beta = -1$, Black's equation reduces to

$$\frac{V_{out}}{V_{in}} = \frac{1}{1 + \dfrac{1}{\mu}} \quad (11)$$

The comparison then gives us

$$\mu = \frac{1}{\alpha pT + p^2T^2}$$

$$= \frac{1}{\alpha pT} \times \frac{1}{1 + p\dfrac{T}{\alpha}} \quad (12)$$

which means that the forward path should consist of an integrator, voltage transfer ratio $1/pT_1$ (where the CR product $T_1 = \alpha T$), and a simple lag, voltage transfer

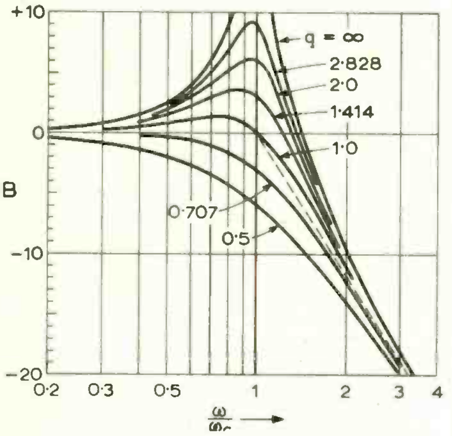


Fig. 4. Amplitude/frequency response of

$$\frac{1}{1 + \frac{1}{q}j\frac{\omega}{\omega_c} - \left(\frac{\omega}{\omega_c}\right)^2}$$

with q as parameter [$q = 1/\alpha$].

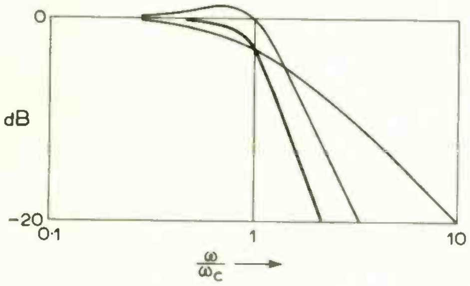


Fig. 5. Amplitude/frequency response of

$$\frac{1}{(1 + pT)(1 + pT + p^2T^2)}$$

and of the factors.

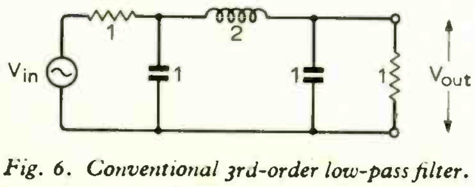


Fig. 6. Conventional 3rd-order low-pass filter.

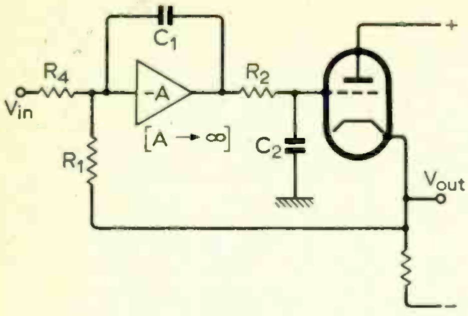


Fig. 7. Basic circuit for integrator-and-lag synthesis of 2nd-order low-pass filter. For $q = 1$, $R_1C_1 = R_2C_2$ (assuming $A = \infty$ and cathode-follower gain = 1).

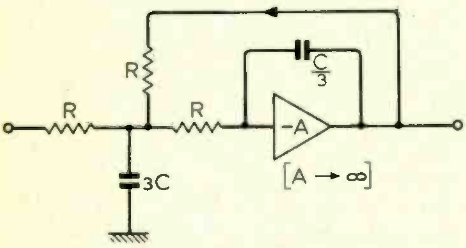


Fig. 8. Another circuit arrangement for a 2nd-order low-pass filter: values shown are for $q = 1$ (assuming $A = \infty$).

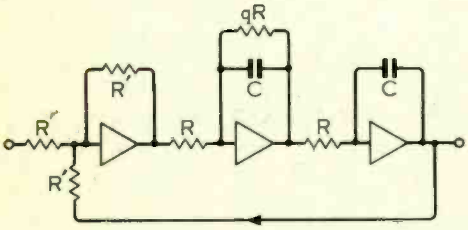


Fig. 9. Two-integrator loop for realizing 2nd-order low-pass response.

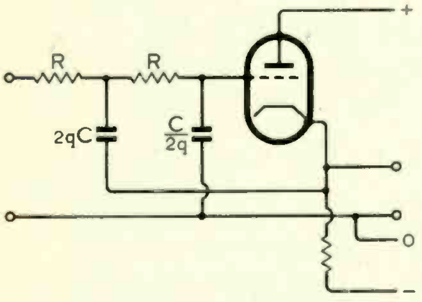


Fig. 10. Sallen and Key low-pass filter. Values shown assume cathode-follower voltage transfer ratio = 1.

ratio $1/(1 + pT_2)$ (where the time constant $T_2 = T/\alpha$), or some equivalent arrangement.

Three methods of realizing this synthesis are shown in Figs. 7, 8, and 9. Normally the design of the amplifiers presents little difficulty: often only one or two valves or transistors are needed per amplifier. [It should be understood that in Fig. 7 and elsewhere a valve is used as a simple and unambiguous symbol for an amplifier or active device, connected as a high-gain amplifier or (as here) as an approximately unity-gain amplifier. See Appendix.] In each circuit the output impedance is automatically low. The response is therefore virtually unaffected by any reasonable load, and any number of second-order sections may be cascaded if a higher-order filter is required.

The Sallen and Key type of circuit

In the well known Sallen and Key circuit, Fig. 10, (Ref. 9) an apparently completely different approach was made, using only a buffer amplifier having a voltage ratio of $\times 1$ (ideally) instead of a high-gain amplifier; and it was natural to compare the performance with what we had learned about a loop containing an integrator and a lag. We found, as we shall prove in a later part, that the circuits are essentially the same, the Sallen and Key circuit being also a loop containing an integrator and a lag, the overall feedback being effected by the cathode follower type of connection. The great apparent difference is due to the choice of a different earthing point.

Importance of high internal gain

We shall also show that in any 2nd-order loop the available gain limits the value of "q" that can be obtained, and that for "q" to be insensitive to changes in available gain there should be a surplus of available gain over the necessary minimum. This is, of course, an example of a general characteristic of feedback systems. Thus, because of the large total available gain, circuits based on three operational amplifiers (e.g. Fig. 9) are to be preferred for anything greater than a modest value of "q". The apparently prodigal use of amplifiers can also often be justified by the great versatility it gives, and by the fact that with the advent of silicon integrated circuits gain is small in size and will be low in cost.

The leapfrog or active-ladder method

From the methods mentioned so far the philosophy arises that the only necessary relationship between an active filter and its passive prototype, if any, is in having the same overall voltage transfer ratio (or, more generally, transfer function, since a filter may have current input and voltage output, or vice versa). The internal workings of the active and passive filters may be expected to show no direct correspondence. If, on the other hand, we set up an analogue of the passive prototype in which the detailed workings of the prototype are reproduced, and in which there is a one-to-one correspondence between voltages or currents in the one and voltages or currents in the other, then there is no need to calculate the two overall transfer functions to see that they are alike, because automatically they will be.

Let us take the example of a ladder low-pass filter (Fig. 11a). A simple method of analysing such a network proceeds as follows. First assume an output voltage, V_{out}, and write down the currents in the load resistance and in the final capacitance. Then add these two currents to give the current through the adjoining inductance, and write down the voltage that the current will cause to appear across the inductance. And so we can go on until we obtain an expression for V_{in}. Each step is either a summation of quantities already found or a differential equation of the simplest kind,

$$i = C\frac{dv}{dt} \quad \text{i.e. } I = pCV \qquad (12)$$

and

$$v = L\frac{di}{dt} \quad \text{i.e. } V = pLI \qquad (13)$$

These operations may be "instrumented" very easily by a system of integrators and sign-changing stages with suitable forward and feedback connections, and the resulting active equivalent or analogue of the chosen example is shown in Fig. 11(b). The structure of the passive filter is no longer evident; but the new structure is a true analogue, since every process in the prototype is reproduced and in particular the voltage at the output of each amplifier represents some voltage or current in the prototype.

Of course the active filter has in addition properties which the prototype does not have. The voltages at the output of each amplifier are available with low source impedance, and so loads may be attached without disturbance. A corollary is that extra forward and feedback links may be connected to these voltages without affecting performance except in the way intended. Similarly the existence of the virtual earths at the input of each (high-gain) amplifier means that the currents flowing in the forward and feedback components are proportional simply to the voltages at the ends remote from the virtual earths. Consequently the scale factor for the voltage at

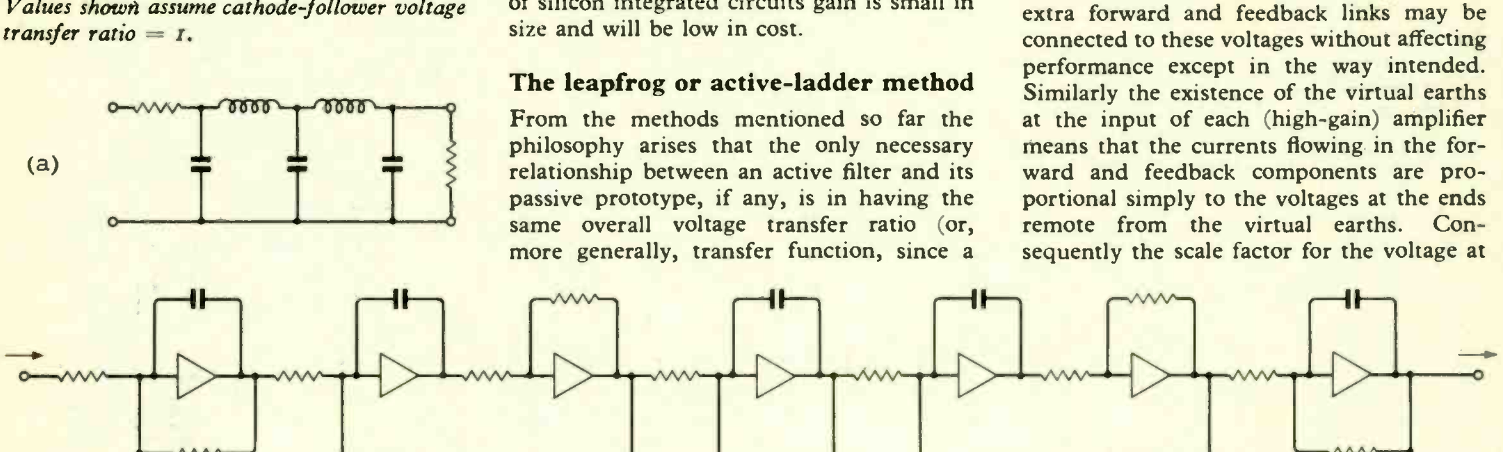


Fig. 11. The leapfrog feedback method of making an equivalent of a low-pass ladder filter.

the output of any amplifier can be varied independently by multiplying all the impedances connected to it by a common factor. This property is especially useful in band-pass filters, where straightforward derivation from the passive prototype often produces a design in which the maximum voltage at the output of some amplifiers is considerably greater than at the output of others. Adjustment to approximately equalize the maximum voltages makes best use of the available gain and maximises dynamic range. The existence of the virtual earths also facilitates the provision of variable tuning, as will be shown.

The capacitor-loaded gyrator method

As a concept, the simplest method of applying the one-to-one correspondence principle is to accept the structure of the passive prototype and replace each inductor with a two-terminal "black box" for which $Z = V/I = pL$. If the black box is not to present an unwanted conductance between the terminals, it must sense the applied voltage with an amplifier or buffer of infinite input resistance. The current which must flow through the black box in response to the applied voltage is given by $I/V = 1/pL$. This shows that the current must be the integral of the voltage divided by the constant L. The input amplifier should therefore pass on the applied voltage to an integrator, which in turn applies its output to a current source, or voltage-to-current converter, the output of which is connected back to the input terminals. This current source should be ideal, i.e. have infinite output resistance, if it too is not to place unwanted conductance between the terminals.

The idea of simulating inductance with an *RC* active black box is not, of course, new. The most familiar example, probably, is the reactance-valve arrangement, Fig. 12, in which the valve is made to pass a current which is almost 90° lagging on the applied voltage. But this simple circuit is too far from ideal to be used in any precisely designed filter. Recently one particular type of realization of the idea has received much attention in the learned journals, and at least one *RC* active filter of remarkably fine performance constructed on these lines has been reported (Ref. 10). However, while we have no wish to get into an argument about the general concept of a gyrator, it does seem to us that when a gyrator is capacitor-loaded to form an inductance which is then tuned with another capacitor to form a resonant circuit, the resultant system can perfectly well be regarded as consisting of two integrators in a feedback loop, though the integrators are not of the usual operational-amplifier type. This was pointed out by a *Wireless World* reader (Ref. 11). Thus, while the gyrator-capacitor method offers another circuit option, which may be an appropriate practical choice in some applications, there is no need for the reader to learn a new theory just because he is confronted with a new name.

This preoccupation with finding common ground between apparently different circuits is a result of a desire to support the analysis of as many different circuits as possible with the minimum number of basic theorems. This is important because when we come to consider the imperfections in practical circuits caused by (for example) finite amplifier gain, it would be unnecessarily laborious to analyse each circuit separately from first principles, when it can be shown that some of the analysis is repeating what has been done already. Assessment of the practicability of a number of circuits for meeting a particular specification is also made easier when it is known that the potentialities of each are bounded by a common set of theorems.

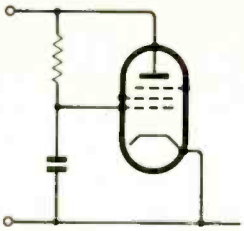


Fig. 12. Simple reactance-valve circuit simulating inductance.

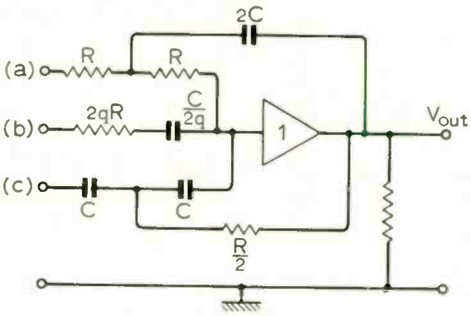


Fig. 13. Filter using parallel-tee to give general 2nd-order transfer function

$$\frac{V_{out}}{V_{in}} = \frac{A + \frac{B}{q}pT + Cp^2T^2}{1 + \frac{1}{q}pT + p^2T^2}, (T = CR)$$

The input voltages at (a), (b), (c) are, respectively, AVin, BVin, CVin.

Negative-impedance converter circuits

We shall not discuss any applications of negative impedance converters, because we believe that nothing can be done with a n.i.c. that cannot be done better some other way. Nor shall we have anything to say about the use of the Wien bridge in a selective amplifier. Both are examples of lag-lead loops. In circuits of this type the method of increasing "q" is by the use of positive feedback acting in the same manner as in the reaction circuit in an old-fashioned t.r.f. receiver. This results in increased sensitivity to changes in loop gain, and it seems reasonable, therefore, to reject such circuits where accurate and stable performance is required. This conclusion must, however, be qualified for certain circuits in which the loop gain is stabilized by feedback, e.g. the Sallen and Key filter shown in Fig. 10.

Parallel-tee circuits

We shall, however, discuss circuits that make use of the selective properties of the well known parallel-T network. These circuits are uneconomical in the number of capacitors they use, and need both *C*s and *R*s of close tolerance if their full potentiality is to be realized. But they can give much higher "q" for a given available gain than the circuits of Figs. 7, 8, and 9. A very useful circuit arrangement is shown in Fig. 13. It is particularly versatile in that it can give the general 2nd-order voltage transfer ratio

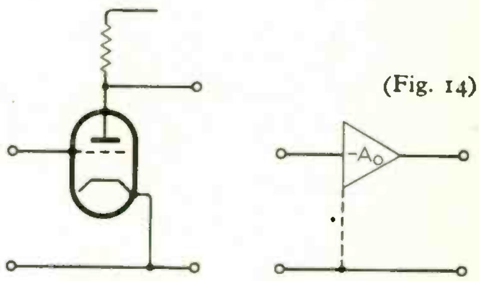
$$\frac{V_{out}}{V_{in}} = \frac{A + \frac{B}{q}pT + Cp^2T^2}{1 + \frac{1}{q}pT + p^2T^2} \quad (14)$$

in which the coefficients A, B, C, can be given the values 1 or 0 by connecting the corresponding input terminals, (a), (b), (c), either to the input voltage or to ground; and values intermediate between 1 and 0 by using attenuators (or potential dividers).

Appendix

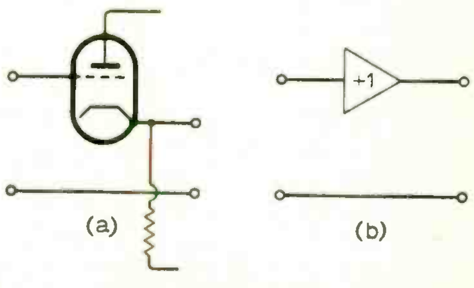
A valve, or vacuum tube, is an example of a simple electronic amplifier. It is a three-terminal device. With grid and cathode as the input terminals, and anode and cathode as the output terminals, Fig. 14 (a), it is characterised to a first approximation by a voltage gain $-A_0$, where A_0 is a positive number. It is thus a primitive example of an operation amplifier, and may be represented by the conventional symbol, Fig. 14(b). Very often the equivalent of the cathode lead, here shown dotted, is omitted—its existence being taken for granted.

If the input is applied between grid and anode, we have the cathode-follower or common-anode connection, Fig. 15(a). As is well known, this gives an approximation to a voltage gain of $+1$, and may therefore be represented by Fig. 15(b). The disadvantage of this symbol is that it does not reveal the close relationship with Fig. 14(b), and indeed seems often to be interpreted as representing a different breed of active device. Fig. 15(a), on the other hand, clearly shows that it uses the same type of device as



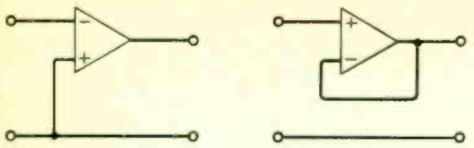
(a) (b)

(Fig. 14)



(a) (b)

(Fig. 15)



(a) (b)

(Fig. 16)

Fig. 14(a), with the same intrinsic or internal properties, and that it is derived from it by connecting the output voltage in series with the input.

To look more up-to-date a bipolar transistor could be substituted for the valve. But then one would often have to imagine an astronomically large current gain, in order to make the input resistance negligibly high, as well as a voltage gain higher than can easily be obtained from a single stage. Very often a direct-coupled complementary pair of transistors is a suitable practical choice of amplifier; but to draw such a combination when discussing the basic theory of circuits might suggest an unintended particularisation. If the use of the valve symbol offends, we ask the reader mentally to substitute an alternative, e.g. Fig. 16(a) when the valve is shown in earthed- (common) cathode connection, and Fig. 16(b) when shown in cathode-follower (common-anode) connection.

REFERENCES

1. "Radio Engineers' Handbook" by F E. Terman. McGraw-Hill, New York (1943), p. 402.

2. "On the Theory of Filter Amplifiers" by S. Butterworth. *Experimental Wireless and Wireless Engineer,* Oct. 1930, Vol. 7, No. 85 pp. 536–541.

3. "Cascade Amplifiers with Maximal Flatness" by V. D. Landon. *R.C.A. Review,* Jan. and April 1941, Vol. 5, No. 3, pp. 347–362, and Vol. 5, No. 4, pp. 481–497.

4. "Gramophone and Microphone Pre-Amplifier" by. P. J. Baxandall. *Wireless World,* Jan. 1955, Vol. 61, No. 1, pp. 8–14.

5. "Design Data for Symmetrical Darlington Filters" by J. K. Skwirzynski and J. Zdunek. *Proc. I.E.E.* Part C, Sept. 1957, Vol. 104C, No. 6, pp. 366–380.

6. "Simplified Modern Filter Design" by P. R. Geffe. Iliffe, London, and Rider, New York, (1963).

7. "Design Theory and Data for Electrical Filters" by J. K. Skwirzynski. Van Nostrand, London (1965).

8. "Stabilized Feedback Amplifiers" by H. S. Black. *Bell System Tech.J.,* Jan. 1934, Vol. 13, No. 1, pp. 1–18.

9. "A Practical Method of Designing RC Active Filters" by R. P. Sallen and E. L. Key. *I.R.E. Transactions on Circuit Theory,* March 1955, Vol. 2, No. 1, pp. 74–85.

10. "Bandpass-Filter Realisation Using Gyrators" by D. F. Sheahan and H. J. Orchard. *Electronics Letters,* Jan. 1967, Vol. 3, No. 1, pp. 40–42.

11. "The Gyrator—Old Wine in a New Bottle?" Letter to the Editor by P. E. K. Donaldson. *Wireless World,* April 1967, Vol. 73, No. 4, p. 194.

Liquid Encapsulation for Crystal Growing

Crystal pulling from the melt by the Czochralski technique is one of the most important methods used for preparing bulk single crystals of semiconductor material for the electronics industry. The technique involves the crystallization of the material in an apparatus which provides a controllable thermal and gaseous environment. The temperature of the material is kept slightly above the melting point whilst a seed crystal, held in a chuck, is dipped into the surface of the melt. The seed crystal is then rotated and withdrawn at a controlled rate and, provided the temperature conditions are suitable, the material will crystallize on the seed and a large crystal will be pulled from the melt.

Difficulty is experienced with this process if the material is volatile, gallium arsenide for instance. A technique called liquid encapsulation which overcomes the volatility problem was demonstrated at a recent "Open Day" at the Royal Radar Establishment. Liquid encapsulation as a concept in its own right can be applied to all crystal growing and has the added virtue of simplicity.

A large number of semiconductor compounds decompose at the melting point. Usually one of the components is volatile and distils from the melt. If the decomposition pressure is high the loss of volatile component is rapid. The transfer of the component is more marked if it can be removed from the gas atmosphere by condensing on cold parts of the equipment.

Liquid encapsulation provides a simple method of preventing the evaporation of volatile components from the melt. An inert liquid layer ("liquid seal or lid") which floats on the melt can suppress vapour loss provided an inert gas at a pressure in excess of the melt dissociation pressure is applied to the surface of the encapsulating liquid. The encapsulating liquid is usually boron trioxide which is a transparent low softening point glass. Crystals can be pulled by the usual method, the seed can be dipped through the encapsulating layer, visual observation can be maintained because boron trioxide is transparent. It has thus been possible to grow single crystals of compounds which generate pressure around 1 atmosphere, e.g. gallium arsenide and indium arsenide, without any modifications to the standard R.R.E. pulling equipment.

There are materials which generate pressures greatly in excess of 1 atmosphere when they decompose. Gallium phosphide (40 atmospheres at 1470°C) and indium phosphide (25 atmospheres at 1060°C) are typical examples. Liquid encapsulation is still a viable technique for growing these crystals, but a pressure vessel is required because of the high inert gas pressure necessary to suppress the decomposition pressure.

The design of a pressurized apparatus could have proved a formidable task but for one important feature of liquid encapsulation. The inert gas which is in contact with the walls of the pressure vessel contains negligible amounts of the volatile component and so the walls can be water cooled.

The R.R.E. designed and built pressure vessel can be pressurized to 200 atmospheres (3000 p.s.i.). It has been designed as an attachment to the standard crystal growth equipment. Both the puller and pressure attachment are now commercially available from two U.K. firms: Metals Research, Melbourn, Nr. Cambridge, and Electroheating Ltd., Lombard Works, Lombard Road, Merton, London, S.W.19.

CORRECTIONS

Book Review. It is regretted that a textural transposition made nonsense of the opening paragraph of P. J. Baxandall's review of Cherry & Hooper's book "Amplifying Devices and Low-Pass Amplifier Design" on page 334 of the July issue. The reviewer wrote "In the opinion of the present reviewer, this book is an outstandingly good one. It is intended primarily, but by no means exclusively, as a text for university electronic engineering students, who are expected to have the necessary theoretical background but who may be rather "green" as far as practical knowledge is concerned. This explains certain features . . ."

In the article **"Distortion Factor Meter"** in the July issue, the meter in Fig.1 is shown as 100mA full-scale. It should be 100μA. Incidentally, the 3-gang potentiometer, RV_2, RV_3 and RV_4, is the Colvern type CLR5022/11 (sections A and B, 59,000 Ω $\pm 2\%$; section C, 25,000Ω $\pm 2\%$).

"Modular Pre-amplifier Design". In the power supply, Fig. 10, the 500μF reservoir capacitor (on the diode side of the smoothing resistor) should have a working voltage of 35V not 25V as shown.

Hyperbolic Radio Navigation Systems

General principles, and a review of systems in use

by F. S. Stringer, B.Sc., F.Inst. Nav.*

Basically there are two main varieties of air and marine navigation technique; they are by dead reckoning or by means of reference to fixed positions on the earth's surface or to heavenly bodies. Dead reckoning demands an initial reference, some knowledge of wind or current and vehicle velocity which then permits the calculation of vehicle heading to make good a desired track. The exercise is completed with apparatus which is self-contained within the craft. A check upon the dead-reckoning system drift and other errors can be made by reference to an externally referenced system. Alternatively, the external system can be used continuously in a manner analogous to visual map reading. As a second alternative the external and the self-contained systems can be combined to form a hybrid.

Ground-based radio navigation aids provide a common frame of reference, hence, despite the advances in dead-reckoning technology, it is likely that radio will play a significant part in the future. The long-term developments may well produce a satellite navigation system which provides a viable fixing facility for civil marine and air navigation available to small as well as large craft. The present point-source systems such as non-directional beacons (NDB) for use with direction finders, visual omni-range beacons (VOR), distance-measuring systems (DME) and ground radar control give assistance to navigation in the form of one or two lines of position. The information is usually available at relatively short distances from the source of radiation because of the high, very-high or ultra-high frequencies employed. For instance, VOR and DME are usable to line of sight distances only.

Area coverage may be achieved either by calculation of a fix from two or more lines of position derived from point sources, or from a circular or hyperbolic lattice derived from a complex of ground transmitters. Such systems are generally designed for operation in the frequency bands 10-14kHz, 70-130kHz, 1-2MHz, and 30-40MHz. Those operating below 130kHz are of particular benefit to both marine and air craft used either independently or as sensors in a hybrid. Since the operational, technical and economic advantages to be gained from the use of circular or of hyperbolic lattice aids can be made available now or in the very near future, they are attractive solutions to the immediate navigation problems and they may provide sufficient facilities to affect the need for satellite systems which have yet to reach a state of development which is viable for general traffic.

Some general characteristics

The principle of the hyperbolic system is illustrated in Fig. 1. If two separated sources of radiation transmit synchronized signals then, assuming a homogenous transmission medium, a receiver positioned at any point along a perpendicular bisector of the baseline will detect no time or phase difference between

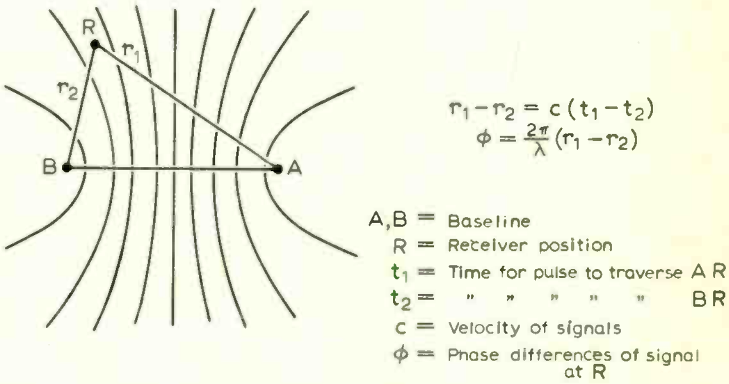


Fig. 1. Single hyperbolic pattern produced by two stations at A and B.

the signals. At a point to either side of this bisector a time difference or phase difference can be detected. The locus of all points with a constant difference is a hyperbola. Families of confocal hyperbolae can be generated with the sources of radiation as the foci. The difference in distance of the receiver from the two radiators is given by $r_1 - r_2 = c\,(t_1 - t_2)$ where the symbols are as defined in the figure.

Thus a single line of position can be generated by the two transmitters. A third transmitter can be synchronized with either of the other two to provide a second hyperbolic lattice as shown in Fig. 2. A further increase in transmitters will provide redundant data. If the signals radiated are in the form of pulses, and if the rise times of the pulses can be defined with adequate precision, the time of arrival of each pulse can be measured at the receiver and $t_1 - t_2$ will allow the identification of the appropriate line of position. It is assumed, of course, that the pulses can be identified from some code such as pulse width, or from a synchronized transmission with some selected delay time at the slave transmitters 2 and 3 after the radiation of a pulse from the master transmitter 1. The Gee and Loran systems operate on this time-difference principle.

Time-difference systems are inherently unambiguous except for the repetition of the lattice on either side of the baseline. An advantage is the higher order of accuracy achievable and they generally provide a maximum of two simultaneously presented lines of position per chain. A fundamental disadvantage of pulsed systems is the wide bandwidth required for the generation of a good pulse shape and the high peak powers required for adequate signal at the transmitter aerial to give a useful coverage.

Continuous-wave systems use the property of measured phase difference between pairs of signals at the receiver instead of the measurement of time difference directly. The signals are synchronous at the transmitters. Since identification of each transmission from the relevant transmitter in a chain must be established, identification is usually arranged by either the

* Royal Aircraft Establishment

radiation of a selected frequency associated with a particular transmitter, this is frequency multiplexing, or by radiation at a single frequency in bursts in an arranged order by time multiplexing. The former method requires some technique to provide for the phase comparison at the receiver by frequency multiplication or division to a common value.

Continuous-wave (c.w.) systems are inherently ambiguous. If a very stable oscillator, such as an atomic standard, is carried in a ship or aircraft and a synthesized signal is obtained from it at the frequency of a radiated signal from the ground, then a frequency comparison between the internally generated and the external signal will provide a line of position which is a circle. As the aircraft distance changes relative to the transmitter, so will there be a change of phase of the difference frequency or phase. After a change of distance of one wavelength λ an ambiguous repetition of the phase will occur. The circles which define these limits of ambiguity are termed lanes. In addition to the ambiguities presented by these distance-distance or "rho-rho" systems, the stability of the internal oscillator will limit the accuracy of the system in a time-dependent manner for long range navigation.

The hyperbolic c.w. systems are also ambiguous, but the lane width is $\lambda/2$ at the common comparison frequency. This can be seen readily if it is realized that as the receiver is moved towards one transmitter of a pair it moves away from the other. Thus twice the number of electrical phase degrees are traversed for an equivalent linear distance traversed by a rho-rho system. A highly stable oscillator is not required, however, and the long-term stability of the system is good although short-term performance will depend upon ambient noise and signal-to-noise ratio. The effect of noise can be limited significantly by a reduction of bandwidth, thus permitting long-distance transmission at acceptable radiated power and poor aerial radiation efficiency.

The accuracy of the fix will depend upon the geometrical angle of cut of the lines of position; two lines will produce a parallelogram or an ellipse of errors which becomes a circle with orthogonal hyperbolae. The hyperbolae will diverge as they recede from the baseline. As the baseline length increases so will the divergence of the lines decrease.

The radio frequencies of most medium- and long-range hyperbolic systems in use today or proposed for the near future are below 130kHz and the signals are affected to a greater or lesser degree by the ionosphere, particularly at night. At frequencies in the band 70-130kHz range is generally limited to that of the groundwave by day and by the interference effects of refracted skywaves by night. At frequencies in the 10-14kHz band ionospheric effects are sufficiently stable to permit the application of corrections to alleviate errors due to modal interference.

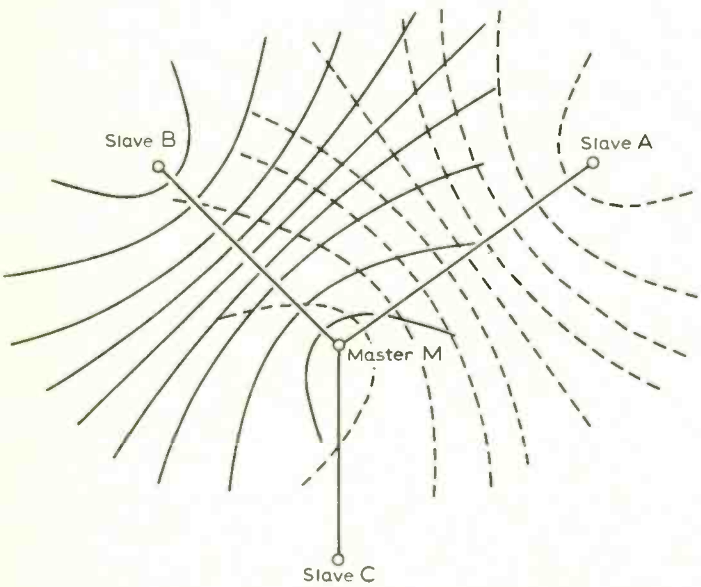


Fig. 2. Typical hyperbolic system chain of four stations. Only two overlapping hyperbolic patterns are shown, one produced by M and A and the other by M and B.

Decca

The Decca Navigator is fundamentally a frequency-multiplex continuous-wave hyperbolic lattice system operating in the frequency band 70-130kHz. The system is displayed in chains comprising a master and three slave transmitters positioned around it at distances of between 50 and 100 miles as shown in Fig. 2. The transmissions are radiated on selected frequencies which are harmonically related to a fundamental f. Each chain has a unique value of f of approximately 14kHz. The slaves are termed green, red and purple radiating $9f$, $8f$ and $5f$ respectively. The master radiates $6f$. The slaves are phase-locked to the master and each master slave pair produces a hyperbolic pattern of stable phase difference position lines over the coverage area. The hyperbolae are printed on charts as coloured position lines which are numbered. The colours correspond to the appropriate slave generating the hyperbolae.

The receivers contain a display comprising three integrating phasemeters known as Decometers which identify the appropriate position line so that a fix can be plotted on the chart manually. Alternatively, a pictorial display or Flight Log/Marine Automatic Plotter is available to provide a track history. Several types of computer are available to drive this variety of displays. A relatively simple unit is associated with displays using "diverse lattice" charts which contain inherent linear distortion, and a complex digital computer "Omnitrac" is available to drive a self-setting flight log which employs conformal charts. The Omnitrac can accept information from sensors other than Decca, can provide waypoint information, data-link encoding, dead-reckoning memory in the event of loss of signal and autopilot coupling.

For phase comparison of the pairs of master-slave signals two techniques are employed depending upon the mark of receiver equipment. Earlier versions multiply the signals to common frequencies of $18f$, $24f$ and $30f$ for green, red and purple respectively. Later versions are superheterodynes and the carrier signals are divided down F (16.2kHz). This is the intermediate frequency corresponding to f. One cycle of phase difference at F represents a "zone". A zone is about 6 miles wide on the baseline. It can be measured to one part in 1,024. The receivers which employ the multiplying technique experience a change of phase representing one "lane" for each phase-difference cycle. A lane is about $\frac{1}{4}$-mile wide on the baseline and can be resolved to one part in 100. Decca is a cw frequency multiplex system and experiences ambiguities. There are 18, 24 and 30 phase ambiguities for each green, red and purple zone respectively. These correspond to lanes in multiplying receivers and the ambiguities are resolved by the integrating action of the Decometers and by independent lane-identification signals radiated from the ground transmitters three times per minute. A separate lane-identification meter assists the resolution. Automatic lane setting is provided in the dividing type of receiver. The phase ambiguities which result from the frequency division are resolved by the effective transmission of a frequency f which forms a phase datum. Frequency f is derived in some marks of receiver by generating a beat between two carriers. Other versions employ a pulse train generated from the summation of the four carriers $5f$, $6f$, $8f$ and $9f$ radiated as a "multipulse" transmission. Zone identification is available on the dividing receivers which use a beat between $8.2f$ and $8.0f$ transmitted from each station to indicate a correct zone within a group of five.

The receivers may select a required chain generally by a key. Although the selection available in transit is limited on earlier models, the latest equipment permits selection of the full 63-chain capacity. The current deployment of Decca chains includes all of western Europe, Newfoundland, the eastern seaboard of the U.S.A., the Persian Gulf and other areas of the world. Accuracy diagrams are published to define the system performance and coverage during various seasons and conditions of daylight. The coverage lines indicate the area at sea level within which 95% of fixes are better than

(a) 4 n.m. by night
(b) 2 n.m. by day (winter season)
(c) ½ n.m. by day (spring to autumn).

Less accurate fixes may be obtained outside this area of coverage which is about 200 n.miles from the master by night. Fixing errors in full daylight within 100 n.miles of the master transmitter are generally less than ¼ n.mile (95%).

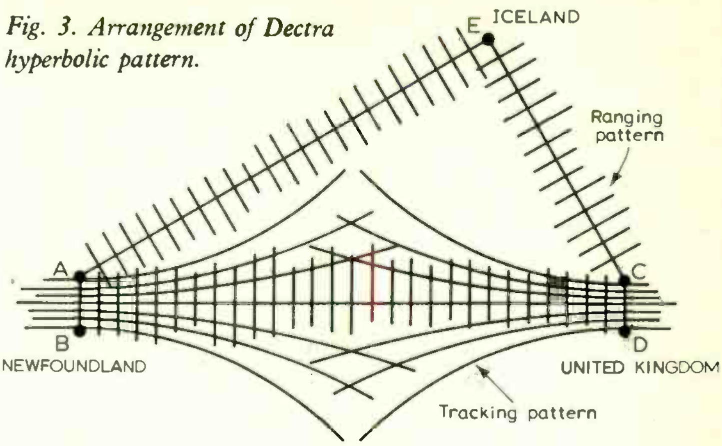


Fig. 3. Arrangement of Dectra hyperbolic pattern.

Dectra

Dectra is a hyperbolic long-range radio-navigation aid which operates in a time frequency multiplex mode at approximately 70kHz. The system has been developed by the Decca Navigator Company and in its latest form is made integral with a Decca receiver system, the Mark 17. Reference to Fig. 3 illustrates the basic principle of the system. Five transmitters are used, two pairs on short baselines of about 60 n.miles baseline length and a ranging station in Iceland. One pair is sited in the north west of the British Isles and the other pair is in Newfoundland. Both pairs are part of existing Decca chains.

Stations A and B in Newfoundland transmit frequency F_f on a time-shared sequence to provide a tracking pattern of hyperbolic position lines. Similarly, stations C and D transmit on F_2 to provide a second tracking lattice. Ranging patterns are provided between stations A and C, also between E, A and C.

The tracking pattern is generated at a spot frequency F_1 near 70kHz as a continuous signal from one transmitter of a pair, except for a brief break every 10 seconds. During this break the other transmitter of the pair radiates F_1. Slave B is phase locked to A. The lanes of the pattern diverge away from the baseline where the lane width is approximately 2,300yds.

The ranging pattern is generated by slave station C in the United Kingdom in conjunction with the master station A. The slave transmission C differs in frequency from A and time sharing is not needed. The difference frequency is roughly 150Hz which is the frequency of comparison in the receiver. The baseline lane width is approximately 2,320 yd wide.

In practice $F_1 = nF_3$

$F_2 = (n+1)\,F_3$ and $n = 459$

Similar ranging patterns are derived between A and E and C and E. The Dectra receiver is operated with a flight log display and an Omnitrac computer. A fix is derived from the intersection of the ranging pattern lines of position. These lines are ambiguous and the integrating qualities of the flight log are used to provide a measure of resolution. If there is a conflict between the fix as defined by separate pairs of ranging pattern position lines reference will be made every 10 seconds to one or both of the tracking patterns which will provide an automatic correction. It will be seen that a substantial degree of dead reckoning is included in the Dectra information. This has been proved essential to mitigate the effects of ionospheric interference, particularly at night.

Dectra is an area coverage system particularly designed for route coverage over areas such as the north Atlantic Ocean.

Loran A

The first practical hyperbolic radio-navigation system was the British Gee system which was operational with the Royal Air Force from 1942 until recently. It was a time-difference system using pulses of radio frequency of 2-10 microseconds duration in synchronism from three or four ground transmitters separated by about 75 miles. The differences in the times of arrival of the pulses at the receiver were measured on a cathode-ray tube indicator by a navigator to determine the position lines corresponding to the aircraft location within the coverage area. The radio frequency was in the band 20-85MHz giving a coverage area some 300 n.miles from the centre of the chain. The accuracy varied from a few hundred yards near the baselines to about 5 miles at maximum range.

The American Loran A system is similar in principle to Gee. It became operational in 1943 and is still available today. Loran A pulses are radiated synchronously in the frequency band 1750-2000kHz from pairs of transmitters spaced two to four hundred n.miles apart. The pulse from a slave transmitter B is delayed until the pulse from the master A has passed the slave location to prevent the A pulses from being mistaken for B pulses. To facilitate the identification of pulses, those from B are delayed by half the time between two pulses from A as received at B. The pulse recurrence rate of B is synchronized by A. The signals from a pair of ground stations are displayed on an oscilloscope with two horizontal traces synchronized with half the recurrence rate assigned to the transmitter. The leading edges of the pulses provide the datum for measurement of the time difference. Several transmitter pairs may have different pulse recurrent frequencies to allow a common radio frequency. The unwanted pulses drift across the traces and the stationary desired pulses without impairing the display.

The Loran A pulse width is 45 microseconds with a rise time of 10 microseconds. There are 96 available channels. The older receivers provided a microsecond scale on the trace to permit the operator to count the time differences between pulses. More modern equipment contains an electronic counter indicating the time difference directly in three decades. An inherent disadvantage of Loran A, common to all pulse systems, is the large frequency spectrum required. This is countered to some extent by the separation possible between groundwave and skywave at the receiver display although skill on the part of the operator is needed to ensure that the groundwave or skywave pulse is indeed being measured. The peak pulse power of the transmitters is about 100kW. The accuracy of Loran A is determined by the geometry of the hyperbolic lattice. The accuracy of measurement is some 1-5 microseconds time difference (standard deviation) between ground-wave components. Use of skywave introduces tolerances due to propagation variations which are dependent upon many factors. The 95% accuracy is generally quoted at 0.2-0.6 per cent of distance from the baseline centre.

The Loran A coverage of the groundwave depends upon the surface conductivity and the noise ambient. The maximum usable groundwave in tropical areas over seawater has been quoted as 400 n.miles whereas 800 n.miles is experienced in arctic regions. Ranges of 700-800 n.miles over sea and 200-500 n.miles over land have also been quoted for daytime operation with an average accuracy of 1.5 n.miles. Corresponding skywave operation at night is recorded as providing a 5 n.mile accuracy to 1400 n.miles over both land and sea.

Position fix information is derived from Loran A charts which display the hyperbolic lattices of the operational chains which are operated by the U.S. Coast Guard. The chains provide groundwave cover over much of the north Atlantic Ocean, the U.S. eastern and western seaboards, part of the Pacific Ocean around the coast of South east Asia and Hawaii.

Loran C

Attempts were made to increase the coverage area of Loran A by employing radio frequencies in the 100-kHz band. The low efficiency of the transmitter aerials, the long transient times of circuits and aerials and the high noise levels in this band presented difficult technical problems. After prolonged experiment and development, however, a long-range Loran system known as Loran C was designed. This operates in the 90-110-kHz frequency band and employs transmitters spaced in pairs with baseline lengths of 600-1,000 n.miles long radiating pulses with peak powers of 60-200kW. The stations are arranged in triads, stars or squares.

Loran C has many similarities to Loran A. Pulses emitted from two transmitters are used for an approximate time difference measurement of equal time difference hyperbolae. A fine measurement is made possible by the phase difference measurement of the carrier frequencies. The 100-kHz carrier provides a 1 n.mile ambiguity along the baseline but this ambiguity is removed by the coarse time difference measurement. The positional accuracy is ten times better than that of Loran A because of the fine phase measurement.

By synchronization of the carriers which are contained within the pulse and by careful control of the pulse rise time it is possible, in addition to resolving the ambiguities, to obtain the fine fix independently of the skywave component of the received pulses. The fine measurement is usually made at the third cycle from the start of the relatively rounded pulse as shown in Fig. 4. The receivers can employ either a visual display such as a cathode-ray tube, similar to the advanced type of Loran A display, or it can be fully automatic providing continuous two-position line data for connection to an automatic chart recorder or a computer for integration with dead-reckoning sensors.

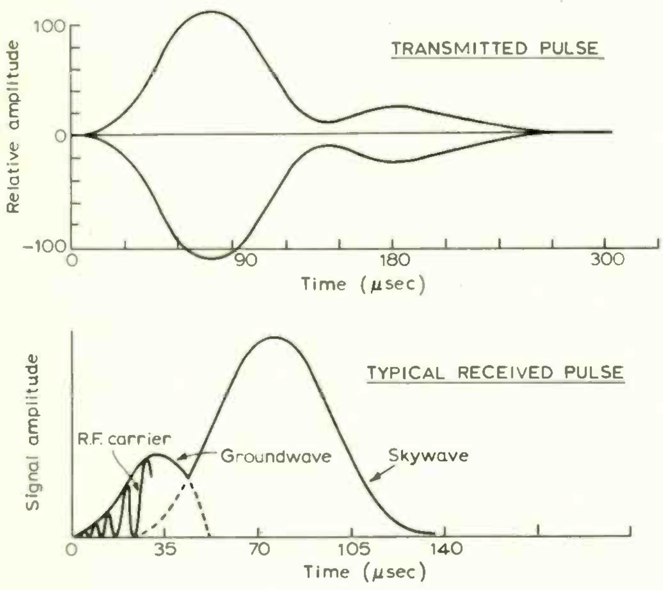


Fig. 4. Transmitted and received pulses of the Loran C system are shown here. A few cycles of the r.f. carrier within the pulse envelope are indicated in the received groundwave pulse.

Each transmitter radiates groups of eight pulses each spaced 1,000 microseconds apart. By storing them in the receiver it is possible to obtain an improved signal-to-noise ratio. Most Loran C repetition rates are compatible with Loran A and for these rates Loran A receivers can be modified to permit reception of the 100-kHz Loran C signals for envelope matching.

The phase of the carrier-frequency signals of individual pulses is kept constant or reversed in phase to a predetermined code for the master and slave transmitters. These coded-carrier oscillations may be compared with a locally generated reference in the receiver to remove a skywave component from the pulses. This is caused by pulse echoes which suffer considerable delay by multiple ionospheric reflection and are received at the time of arrival of the succeeding pulse. The coding also assists in station identification. The pulse rise time from zero to peak amplitude is approximately 75 microseconds. Skywave components of the received pulses are to be expected at less than 35 microseconds. Pulse shaping at the transmitter places the turning point of the rising leading edge at a 30 microsecond position. The pulse-recurrence frequencies are 10, $12\frac{1}{2}$, $16\frac{2}{3}$, 20, 25 and $33\frac{1}{3}$ groups per second.

Loran C operates on one nominal radio frequency only, 100-kHz. The transmitters of a chain are identified by a known shift of the pulse transmissions with respect to time. By employing a variety of pulse groups and pulse-repetition rates and by the pulse-keying technique the relatively extravagant use of the radio-frequency spectrum is limited. 288 channels can be accommodated in this way but only 50 would be needed for world cover. It should be realised however that the cost of such a ground complex would be extremely high. The current coverage area extends over the north Atlantic Ocean, the Mediterranean and parts of the Pacific Ocean.

The overall system accuracy using the ground wave is claimed to be $\pm 0.25\mu s$ for 95 per cent of the time with a baseline of about 500 n.miles length. The limit of accuracy is determined by groundwave propagational errors. The accuracy is extremely high however being in the order of 300 yards (95%) within 650 n.miles from the baseline. The groundwave range over sea varies with season and time of day. Typical values observed are 1,250 n.miles on a summer night and 1,600 n.miles on a winter day.

Omega

It has been known for many years that very low radio frequencies in the band 10-14kHz have qualities attractive to very long range navigation systems. Research in the United Kingdom and the United States over the past decade has provided evidence of low attenuation with distance (approximately 5dB or less per 500 n.miles) and highly predictable propagational characteristics. Measurements have shown that the D layer of the ionosphere and the earth's surface affect the signals in a manner analogous to a spherical waveguide. First, second and higher modes are set up as illustrated in Fig. 5. By day the first mode predominates at distances greater than a few hundred miles from a transmitter. By night the D layer rises and the second mode is more in evidence. The diurnal variation is predictable, however, and changes of phase due to propagational variations can be estimated with much greater precision than is possible at frequencies above 50kHz.

A very low frequency system called Delrac was proposed by the Decca Navigator Company many years ago but it was not developed. The Omega system, proposed *circa* 1962 by the U.S. Navy, has attempted to employ the benefits of the very low frequency propagation to achieve world-wide cover and multiple-position line fixing information. Omega is a hyperbolic lattice time, frequency multiplex system. Eight transmitters should provide effective world cover. Four are transmitting at the present time providing a service of two position lines over about a quarter of the earth's surface. Negotiations are proceeding for the implementation of the remaining four.

The principle of operation can be realised by reference to Fig. 6. A burst of continuous radiation at a frequency of 10.2kHz is radiated from station A in Norway for a period of about one second. A phase-locked synchronous burst of radiation is then transmitted for one second from transmitter B in Trinidad. This is followed by a similar burst from C in Hawaii and another from D at Forestport in New York State.

A remote receiver within the coverage area receives the four bursts of radiation and gates them into separate receiver channels. The gated signals are used to synchronize phase-locked loops which effectively provide continuous waves locked to the appropriate signals from each transmitter respectively. Phase comparison of pairs of signals in the receiver provides lines of position which are hyperbolic and characteristic of other systems. Due to the extremely long baselines, however, they have very little divergence relative to each other. The hyperbolae are ambiguous every 8 minutes along the baseline, this is of little significance to marine navigation but of importance to aircraft.

One method of resolving the ambiguities has been attempted by the radiation of two further carrier frequencies as shown in the illustrated format of Fig. 6. After each 10.2-kHz signal another is radiated at 13.6kHz. This is followed by a third at 11.33kHz. A second hyperbolic lattice derived from the 13.6kHz signals would be coincident with the 10.2-kHZ lattice every 24 n.miles along the baseline. Thus an equivalent to a 3.4-kHz lattice can be derived. Similarly the 11.33-kHz signals are coincident with those of 10.2-kHz at 72 n.miles. Thus resolution to within 72 n.miles can be effected.

Experiment has shown that there may be propagational anomalies caused by second modal interference by night which could reduce the reliability of the beat-frequency ambiguity-resolving method. Alternatives have been investigated and it has been shown that since the aircraft or ship is likely to be within system coverage throughout its journey, only signal outage time, due to noise or interference for example, need cause concern. The application of data derived from the self-contained navigation aids or even air data over the period of the outage can be used to identify the appropriate 10.2-kHz lane upon resumption of reception. Redundancy can be applied to increase reliability by measuring the incremental lane change on all three carrier frequencies for selected periods, say 5 minutes. Reduction of the 13.6-kHz and 11.33-kHz increments to 10.2-kHz equivalent increments by the Omega or a general-purpose computer can provide a constant cross check upon lane slip or lane loss.

The long range of the Omega signals should be capable of providing a multiple position line fix. The 95% accuracy is expected to be about 5 n.miles. The application of correction tables, however, removes some of the propagation errors and improves the accuracy of the fix to better than 2 n.miles.

An attraction of Omega is the possible use of this long-range system over the medium-range distances near airfield terminal areas or harbours where navigation accuracy needs to be an order better than in the en route phase. By application of the Differential Omega or Corrected Omega techniques, experiment has shown that these requirements may be met. The improvement is gained by the removal of most of the short-term propagational errors by the use of monitor receivers positioned at known co-ordinates on the ground. Errors between the measured and datum co-ordinates are broadcast over a data link to airborne or marine users as corrections. Application of the corrections has been shown to give improvements over sixty miles from the monitor which would give a system performance to match the local navigation requirements. Experiments are continuing.

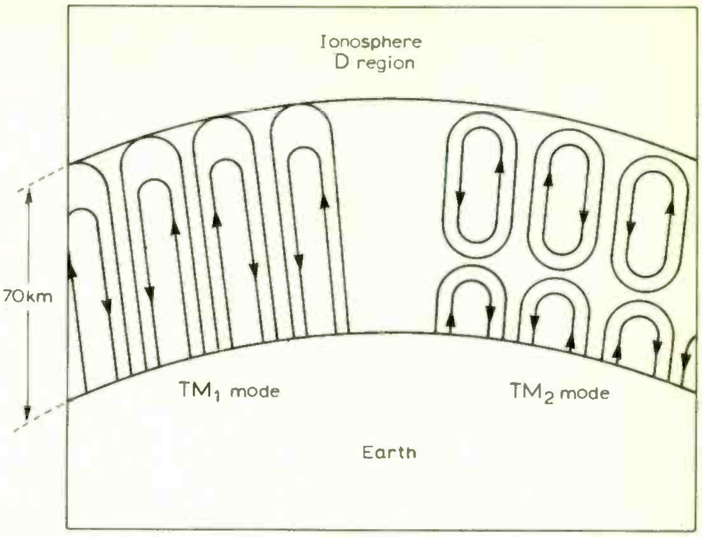


Fig. 5. In the Omega system transmission is at v.l.f. and in waveguide modes between the earth and the ionosphere. Two modes are shown here.

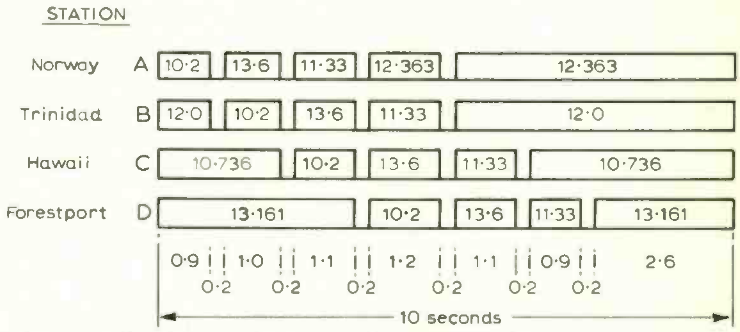


Fig. 6. This diagram indicates the format of the existing stations of the Omega system, together with frequencies involved in proposed methods of resolving ambiguities.

Future trends

Pulse systems are generally extravagant in their use of the radio-frequency spectrum, usually provide only one or two lines of position at a time, are limited in range and often require long signal acquisition times, particularly when automatic. Their inherent advantages are that the systems can be entered at any time since they are unambiguous and they are very accurate. For the price of whole cycle ambiguity, higher accuracy can be achieved by the use of continuous-wave techniques.

Continuous-wave systems are economical in spectrum and capable of operation in a high noise environment due to the narrow bandwidths employed. Lower frequencies may be used with consequent increase in available range. Although the transmitters and aerials may be expensive, they are relatively few and world cover would be cheaper overall. The c.w. systems can provide multiple position lines and therefore better reliability although with less accuracy at long range.

The problem of ambiguity resolution of c.w. systems has been a continual and only partially solved issue for many years. The advent of the v.l.f. navigation with world-wide cover could remove this difficulty since outage time would be the only cause for concern. The application of dead reckoning or of short-range radio-system information to resolve lanes at the termination of the outage should provide a powerful means of ensuring complete reliability. So far, hyperbolic systems have been designed to be completely independent, having their own computers, ambiguity-resolving systems and displays. The future may well see a trend towards the integration of the dead-reckoning and the externally generated systems with the accent upon sensor simplicity.

News of the Month

Broadcasting in the seventies

The B.B.C's plans to rationalize and reshape the sound broadcasting services in the U.K. were announced on July 10th and outlined in a booklet entitled "Broadcasting in the Seventies" and have been submitted to the P.M.G. for approval. Basically there are planned four services to be provided by the national network: Radio 1 (pop music), medium wave only; Radio 2 (light music), long wave and v.h.f.; Radio 3 (classical music, plays, etc.), v.h.f. with possibly some m.w. support in daytime initially; and Radio 4 (largely speech and light entertainment), m.w. and v.h.f. In addition it is proposed that local radio will be extended on v.h.f. with some daytime medium-wave support.

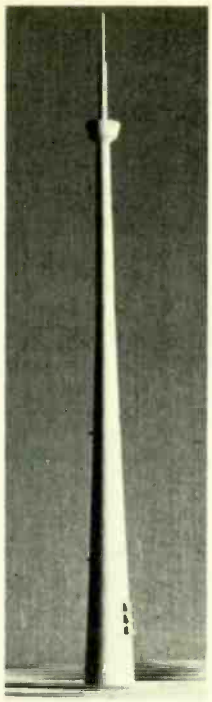
To implement these proposals and to provide maximum coverage it will be necessary to redeploy the B.B.C. medium-wave and v.h.f. channels allocated under the Copenhagen and Stockholm Plans respectively and to build some additional transmitters.

As a high priority the B.B.C. plans to improve the medium-wave coverage of Radios 1 and 4. At present Radio 1 serves 86% of the population by day and 33% by night and Radio 4 serves 98% and 70%. The improvement can be achieved by using the medium-wave channels released by discontinuing regional and Radio 3 medium-wave transmissions. Radio 1 will have one more transmitter in the North (100kW), and the two frequencies used will be 908 and 1214kHz. Radio 4 will operate on three more frequencies, 647, 1052 and 1088kHz.

A proposal has been put to the P.M.G. for expanding the present experimental group of eight v.h.f. local broadcasting stations to about 40 to reach nearly 90% of the population of England. Additional Band II v.h.f. channels will be needed for this number of stations and the 95-97.6MHz part of the band at present occupied by non-broadcasting services is in the process of being cleared for broadcasting. The band 97.6-100MHz will be used for an educational network.

The increase of music programmes on Radio 3 in the evenings will encourage the extension of stereophonic transmissions in this network and this, together with the addition of stereo on local radio and possibly Radio 2, will be added attractions to the v.h.f. services.

It is to be hoped that set manufacturers will not drag their feet.



A model of the new Emley Moor mast

New mast for Emley Moor

The Independent Television Authority is to construct a new mast on the Emley Moor site to replace the one that collapsed. The new mast will be made of reinforced concrete and at 1080ft will probably be the third tallest structure of its type in the world. Similar, higher, structures exist in Moscow and in East Berlin.

It is hoped that the new mast, which will be used by both the I.T.A. and the B.B.C., will be in operation by the end of 1970. Work on the foundations is to start almost at once even though negotiations with the builders have not yet been finalized. Estimated cost for the project, including all aerials and associated equipment, is between £400,000 and £500,000. On completion of the concrete tower the 670ft Swedish mast, which was erected as an interim measure, will be dismantled.

The concrete tower, which will weigh a total of 14,000 tons, will be 80ft in diameter at the base tapering approximately exponentially to 20ft diameter at the 900ft level. A room built at this height will be equipped as a microwave link station for outside broadcast use. Above this a 100ft long, 12ft diameter glass fibre cylinder supported by a steel lattice structure will house the v.h.f. aerials. Above this another similarly supported glass fibre cylinder, 5ft diameter and 80ft long, will contain the u.h.f. aerials, bringing the total height to 1080ft.

German radio show

The biennial German radio show, to be held this year in Stuttgart from 29th August to 7th September, will be the last national show—the next is to be international and is planned for Berlin.

The show is given substantial support by the broadcasting organizations and the Bundespost who will provide a large display showing the wide variety of radio services it operates. Nearly 50% of all telephone calls made in the Federal Republic are handled via radio links. The scheme to utilize the 12-GHz band for television broadcasting (mentioned in our report of the Montreux Television Symposium—July issue) will also be demonstrated. The 12-GHz signal from a transmitter at the exhibition will be received on standard television sets fitted with converters designed by the Bundespost. A 60-cm metalized plastic parabolic aerial is used.

Among the many other exhibits in the 15 halls occupied by the exhibition will be a demonstration by radio amateurs.

Licence evasion

In answer to a question in the House of Commons on July 3rd the Postmaster General announced that the Post Office was increasing its detector vans by 18 to 38. The estimated annual loss of revenue to the B.B.C. due to tax dodging by owners of television recievers is £7.5m. The widespread evasion of the payment of car radio licences is also causing concern. The P.M.G. stated "my estimate shows that there are about three million sets in use and that there are about two million evaders". He referred to the anomaly that a licence fee does not have to be paid for a battery operated set used in a car whereas a set installed in a car must have a licence. He said he was "examining the position". One M.P. suggested that motorists with car radios should display a disc indicating that an up-to-date radio licence has been obtained; but what good would that do?

Aid to big ship berthing

Following a series of trials and experiments at Milford Haven and on the Mersey, the Marconi International Marine Co. Ltd. is now in production with a new doppler Speed of Approach Measurement Indicator (SAMI) developed in conjunction with the Ministry of Technology's Royal Radar Establishment at Malvern to meet the requirements of the Marine Department of the Esso Petroleum Co. Ltd. Esso have now ordered an installation for their Milford Haven terminal jetty.

The velocity of first impact of a ship on a jetty is very critical. The momentum of a large loaded ship is immense, even at very slow speeds measured, not in knots, but in feet per minute. A final jetty approach at 30 feet per minute could result in substantial and costly impact damage to both ship and jetty.

Using the doppler effect, SAMI beams a microwave signal at an approaching vessel and, by measuring the change in frequency which is directly related to any movement of the vessel along the radar beam, shows the speed of such movement in feet per minute, or in knots. This is shown as on a meter reading and is simultaneously recorded in graph form on a chart from which any change in velocity, and the rate of any such change, is immediately apparent.

With SAMI installed ashore on the jetty, the operator or observer passes all velocity information to the pilot of the incoming vessel by radiotelephone. It might, as an alternative, be installed on board the ship itself so that the pilot could read off the information for himself, although in very large vessels this might entail a dual installation to provide early warning of a bow or stern swing not immediately apparent to the pilot's eye.

The SAMI device is completely solid-state, including a Gunn diode microwave generator, and operates from low-voltage batteries or from a mains supply. Four speed ranges measure 0-50 feet/min, 0-100 feet/min, 0-5 knots, and 0-10 knots. The graph recorded during observation, besides displaying an absolute measurement of velocity, also shows whether the vessel is approaching or receding. When a dual installation is used, with one unit beamed on each end of the berthing vessel, any tendency to swing can be observed, advised to the pilot, and corrected.

Medical electronics technicians salaries too low?

Our hospitals will never be staffed with the best electronics and engineering technicians and development engineers while salaries remain so low—with the possible exception of those who regard their work as a calling and who are willing to put up with the low return.

An electronics engineer recently admitted to a large hospital with a suspected heart complaint came to the conclusion that the electronic equipment used by the staff to diagnose his complaint was sicker than he was! He was sorely tempted to jump out of bed and ask for a multimeter and soldering iron.

To illustrate the present state of affairs we print below an advertisement recently received by the journal *"Hearing"* and brought to our attention by the Royal National Institute for the Deaf

"Audiology technician, Grade I, required at H.M. Prison, Wormwood Scrubs, for up to two sessions per week. The fee for a three hour session is £1 8s 6d."

Laser to measure earth/moon distance

Shortly after the Apollo 11 astronauts land on the moon's surface, a "pancake" of laser light two and half miles across and ten feet thick will strike their landing area and bounce off a special reflector erected by them in a scientific experiment designed to measure the precise distance to the moon.

The "pancake" will represent a 10ns pulse of high-power laser light fired from a range-finder/telescope, built by the Hughes Aircraft Company of America, on an Arizona mountain top. The rangefinder, one of the most precise ever built, will be able to measure the relative earth-moon distance to within one and a half metres, a precision far greater than previously possible.

The light segment will remain its original length as it travels toward the moon but will gradually spread, just as a continuous beam would, attaining a diameter of about two and a half miles on the moon.

A tiny portion of the light will strike a two square foot reflector and will be bounced back to the telescope. By measuring the precise travel time of the laser pulse, using a ceasium beam timing system, (approximately 2.4 seconds) the distance between the reflector and telescope can be accurately computed.

International apprentice competition

Between the 6th and the 16th of July 23 young apprentices, all under 21 years old, from Britain were competing in the international apprentice competition which was held in Brussels. At the time of going to press the results were not known.

The competition—which covers the engineering, building, iron and steel, electrical, electronics, and radio and television industries—attracts entrants from West Germany, Japan, Italy, Switzerland, Holland and Belgium.

The British entrants in the categories that are of interest to *Wireless World* were as follows: in the industrial electronics section—Philip Robert Gutteridge (age 19) from Mintech and in the radio and television repair section—Roger Pheasant (age 20) who is at present working for Alex Owen Ltd., of Beeston, Notts. Next year the competition will be held in Japan.

Interplanetary billiards

After Mars and Venus come Jupiter, Saturn, Uranus, Neptune and Pluto in one of the most far-reaching space missions yet conceived by man.

Plans for two, three-planet grand tours in the late 1970s are being developed by the National Aeronautics and Space Administration's Jet Propulsion Laboratory, Pasadena, Calif. One such mission would fly by Jupiter, Saturn and Pluto, the other would go to Jupiter, Uranus and Neptune.

The eight-to-eleven-year missions to the other planets are detailed by James E. Long of J.P.L.'s Advanced Studies Office in the June issue of *Astronautics and Aeronautics*. Mr. Long points out that, "The best outer planet alignment in 179 years, occurring in the 1976 to 1980 time period, opens the outer planets to exploration in an effective and timely manner." The infrequency of such favourable alignment is due to the slow movement of the outer planets about the Sun.

Mr. Long proposes the use of either conventional or solar-electric propelled spacecraft, with a nuclear isotope power source to operate spacecraft equipment. From Jupiter on, a grand tour spacecraft would employ the gravitational attraction of each planet to spin on to the next.

Television cameras and other scientific instruments aboard the unmanned spacecraft could study the planets, their atmosphere, magnetic fields and satellites, he suggests. Of special interest are Jupiter's red spot and radiation belts and Saturn's rings.

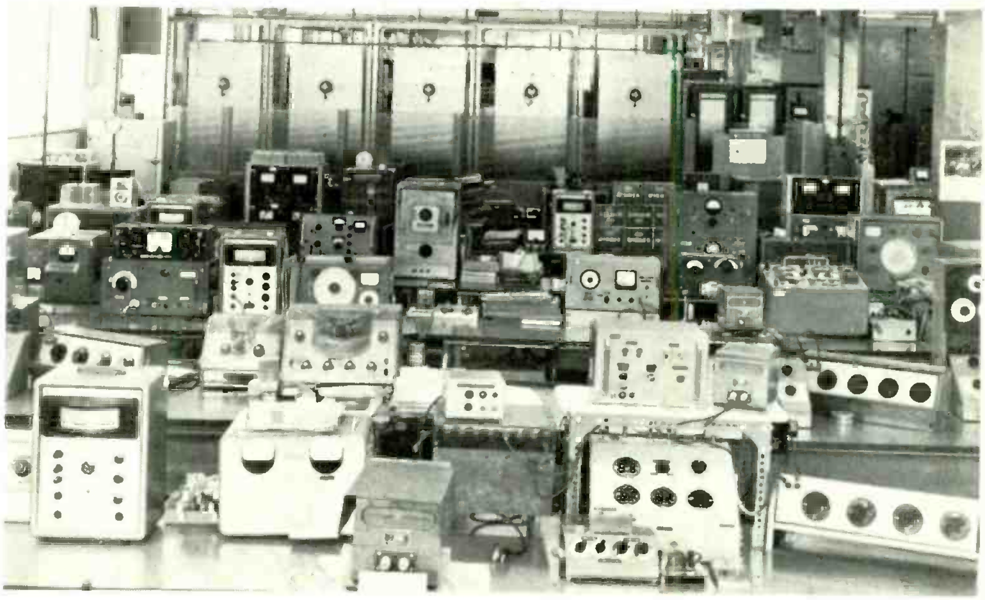
Long pinpoints 1977 through 1979 as the best years for launching grand tours. That period, he says, will afford "the best combination of the planets' closest approach altitude, flight time and launch energy requirements."

Computer course for £5

A computer appreciation course cheap enough to attract school-leavers, is to be run as an experiment by I.C.L., at its London training centre. The course—two evenings a week for five weeks began on July 1st—cost only £5.

The course, which was open to anyone, provided a comprehensive introduction to computers. It has been designed to give each trainee a general understanding of electronic data processing, its history and applications; and also to describe the job opportunities available in the field. The object of the course is to

The photograph shows the Quality Assurance Laboratory at the Erie Company's plant at Great Yarmouth, Norfolk. The laboratory has received approval under the BS9000 scheme (No. 1001/m).



help overcome the shortage of staff that is apparent throughout the industry. Those interested in future courses should contact: I.C.L. Training Centre, South Ealing, London.

I.E.E.E. New York exhibition

The Electronic Engineering Association is again to sponsor participation by British companies in the Institute of Electrical and Electronics Engineers' international convention and exhibition to be held in New York from the 23rd to the 26th March, 1970.

U.K. companies exhibiting under E.E.A's sponsorship will qualify for financial assistance under the Board of Trade's Joint Venture Scheme. Already ten companies who took part this year have applied for space in the 1970 event.

Companies requiring further details should contact the E.E.A. Information Office, Berkeley Square House, Berkeley Square, London, W.1.

I.E.E.T.E. membership increases

The membership of the Institution of Electrical and Electronics Technician Engineers in the year ended 31st March, 1969, increased by 1,623 to 10,816.

The Institution was successful in its application for registration under the 1960 Charities Act and secured the licence of the Board of Trade to omit the word Limited from its title.

New resistor group

A Resistor Manufacturers Group has been formed recently within the Radio and Electronic Component Manufacturers Federation, and comprises all leading British firms producing fixed and variable resistors, and potentiometers. This follows the emergence of other groups representing relay, capacitor and connector manufacturers.

The object is to provide not only a forum for promoting the interests of resistor manufacturers, but to serve the electronics industry in general, in particular by endeavouring to provide a better service for all resistor users.

At the inaugural meeting, J. Thomson (Morganite Resistors Ltd) was elected as the Group's chairman, and E.W. Embleton (Welwyn Electric Ltd) as vice-chairman. Enquiries should be made to the secretary, P. Costley, R.E.C.M.F., Mappin House, 4 Winsley Street, Oxford Street, London W1N ODT.

Detecting overhead hiss

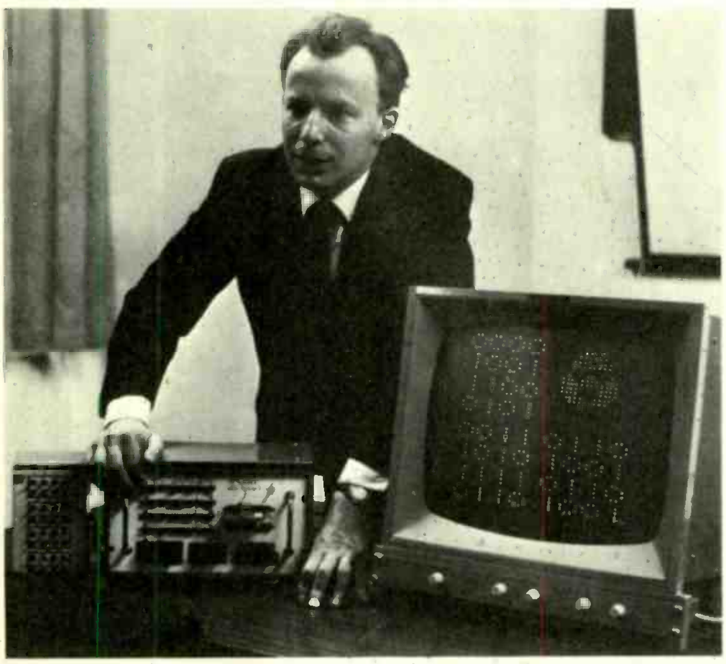
Many old style overhead telephone cables still in use employ paper insulated conductors which are pressurized with dry air to prevent damage should the protective sheath be punctured.

Such punctures generate ultrasonic noise as the air escapes and Bell Labs of America have built a simple device that enables such leaks to be detected from ground level. An ultrasonic detector is contained within a small Cassegrain type reflector (a 45mm hyperbolic reflector located at the focus of a 254mm paraboloid). The output of the detector is amplified and used to indicate the presence of a leak.

The reason for devoting so much space in news this month to what on the face of it may be considered to be an almost frivolous item is quite simple.

Many readers will work in plant or laboratories which employ gas and air lines where a leak would put a system out of action. The normal method of leak detection is to split the piping system into sections and to test each section individually by pressurizing the line and using some form of aneroid instrument to detect the presence of a leak. This method is expensive and time consuming and does not give the exact position of the leak but only the section in which it lies. The writer knows this only too well after spending hour upon hour tracing leaks in aircraft pitot and static instrument air systems.

The Bell Labs equipment would appear to solve this problem once and for all and many firms will find that it would be worth the time and trouble involved in building a similar system.



At the invitation of the British Computer Society, Brian Crank, the designer, described the "Wireless World" Logic Display Aid at a meeting of the Logic Design Group on July 9th: a 19-inch oscilloscope made by Lan Electronics was used for the demonstration.

Automatic measurement of airfield visual range

Five major British civil airports are to use an electronic system which will automatically provide air traffic control with a continuous report of a pilot's visual range along a runway as he lands his aircraft.

The I.V.R. system has been developed at the GEC-AEI's Leicester laboratories and is based upon photo-electric measurements of the atmospheric transmission of light at three points alongside the runway, one at each end, and one in the centre.

Measurements taken by instruments at these points are digitized and transmitted over telephone lines to the I.V.R. computer housed in the airfield's telecommunications equipment room.

The computer then performs the computation of runway visual range, assures the calibration and integrity checking, and controls the logging and formatting of data. The runway visual range is then displayed by digital readout on a six-inch square panel in the airport's operational control centre.

Landing system to be produced by Plessey

The responsibility for developing the correlation protected instrument landing system* originally conceived at the Royal Aircraft Establishment has been placed with Plessey Radar under a Mintech contract.

Unlike the traditional i.l.s. the new system is unaffected by interference or by changes in the strength of received signals. One of the main advantages of c.p.i.l.s. is that it is fully compatible with existing i.l.s., the only changes in the aircraft necessary being the addition of a smaller aerial and a minor modification to the i.l.s. receiver.

Scout tape recording contest becomes annual

Final judging took place at Baden Powell House on Whit Saturday of the first national Scout tape recording competition, sponsored by Philips Electrical Ltd. The panel of five judges made their selections before an invited audience of about 150, including a number of entrants.

Twenty of the winners will spend a 4-day holiday in Holland in August. Other prizes included cassette recorders and visits to recording studios.

* *Wireless World*, May 1967, p. 218.

More and more the demand is for the consistency, high quality and reliability of Electrosil glass-tin-oxide resistors in instruments, telephone exchanges, computers, automation, missiles and, in fact, in every type of electronic equipment. Over and over again glass-tin-oxide proves its superiority. For example, recent independent tests by a major equipment manufacturer showed that Electrosil 100 p.p.m. C5 resistors gave a more consistent performance on load and temperature stability than metal film resistors by six competing suppliers.

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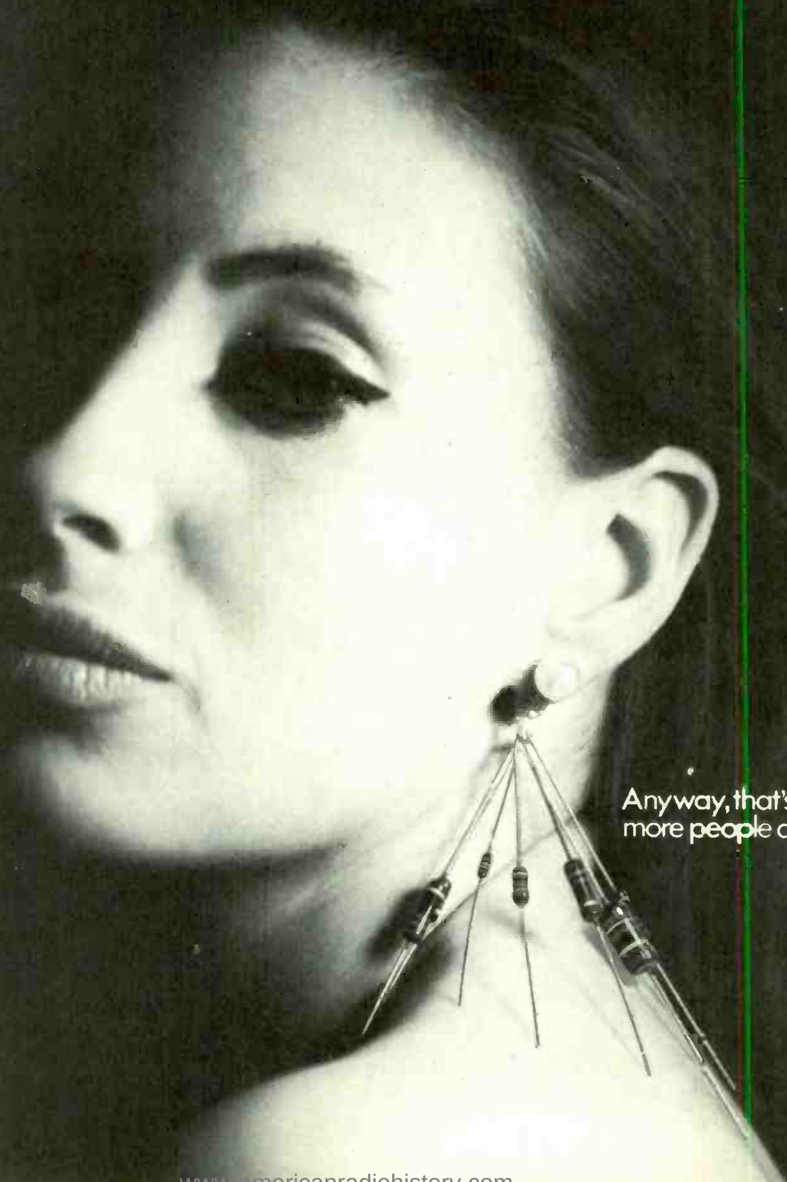

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WW—297 FOR FURTHER DETAILS

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V_{a2}	50 to 150	75 to 225	V
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Amateur Communications Receiver

2: i.f. amplifier, b.f.o., product detector and a.f. amplifier

by *D. R. Bowman*, A.M.Inst. E., G3LUB

This month sees the start of the description of the final design and construction of the receiver. Inevitably there will be quite a few loose ends that will be tidied-up later.

All the coil winding details are given although much of the circuitry does not appear in this issue.

Table one gives the complete frequency coverage and it will be noticed that this does not include the last section of 10 metres, however this can be added by incorporating an extra crystal if required.

TABLE ONE

Amateur bands		Rx. coverage
m	MHz	MHz
80m	3·5 — 3·8	3·5 — 4·0
40m	7·0 — 7·1	7·0 — 7·5
20m	14·0 — 14·35	14·0 — 14·5
15m	21·0 — 21·45	21·0 — 21·5
10m	28·0 — 29·7	28·0 — 28·5 28·5 — 29·0 29·0 — 29·5

Component considerations

Throughout the various components lists given in this article the values are as used by the author and it is strongly recommended that new components only be employed. The resistors, except where stated, are 0·25W carbon $\pm$ 5% types, but $\pm$ 10% types could equally well be used. In almost all cases where silver mica capacitors are specified they must be used. In the case of the larger values of disc ceramics, Mullard C280 miniature foil capacitors could be substituted. Again wherever Philips concentric air dielectric trimming capacitors are specified other types of trimmers could be substituted.

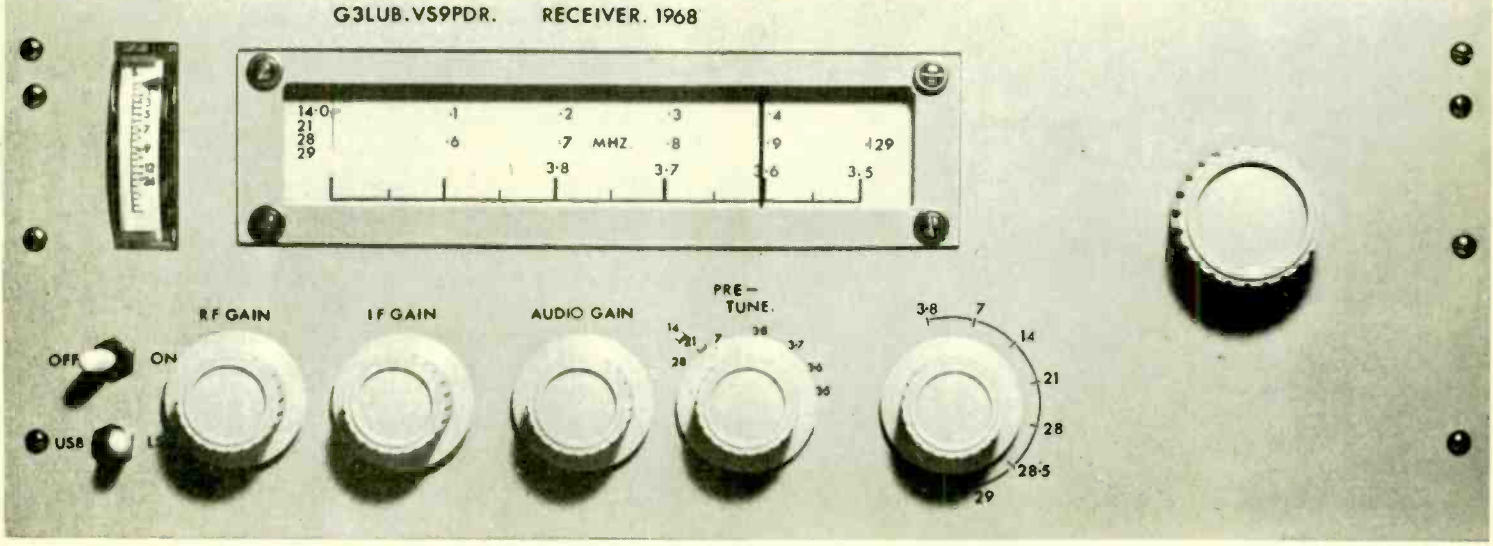
With two exceptions coils are wound on Radiospares core formers which can be obtained from Home Radio (Components) Ltd., Mitcham, Surrey, under catalogue number CR2. The iron dust cores can be obtained from the same address (catalogue number CR5).

Whilst on the subject of coil winding the author found the simplest method of anchoring the wire to the former was to wrap a number of turns of sewing cotton over the wire end and round the former. The only exceptions are L_{10} and L_3 and L_{11}. L_{10} should be wound on a CR12 former with a screening can No. CR13. These are small $\frac{3}{4}$in. × $\frac{3}{4}$ in. i.f. transformer cans. L_3 and L_{11} are $\frac{1}{3}$ in dia. CR9 formers. The crystal filter used is the K.V.G. No. XF-9B which can be obtained from Lowe Electronics, 50/52 Wellington Street, Matlock, Derby. There are a number of alternative filters, but details are not included as this filter has by far the best performance and value for money. The various tuning capacitors can be supplied by Jackson Brothers (London) Ltd. C_{12} and C_{11} type are U102 6-75pF, 2 gang (front end tuning) and C_1 is type U101 6-75pF, single gang (v.f.o. tuning).

The dual ratio ball-drive type 4511/DRF can also be supplied by Jackson Bros. The odd r.f.c. is a standard valve type 2·5mH radio frequency choke.

Now we come to the transistor types. There are a number of devices which could be expected to perform equally well as an alternative to type 2N706. The following are a few 2N706A, 2N708, BSY38, BF115, C111, 2N2926. The BC107 can be

Fig. 10. Front view of the prototype showing the marking of the various controls.



replaced by any silicon n–p–n high-gain transistor with an h_{fe} in excess of 150. The h.f. crystal oscillator uses a 2N918 for which any of the following devices could be used as an alternative 2N4292, BFY90, TIS48. The audio output pair ACY17 and a BFY50 are very cheap and unless a matched complementary pair are available the author would advise no change.

Since starting, a substitute for the 3N140 dual gate f.e.t. has come on the market which is strongly recommended since it incorporates built-in gate protection. The new device is the MEM564C and is available from: S.D.S. (Portsmouth) Ltd, Gunstone Road, Hilsea Industrial Estate, Portsmouth, Hants.

The diodes used in the power supply can be almost any types with at least a 50V p.i.v. rating. Zener diodes used can again be replaced by alternative types. (The 9 volt device has a power rating of 1 watt and the 5·6V zener a rating of 0·25 watt). All coils were wound using wire which can be obtained from Post Radio Supplies, 22 Bourne Gardens, London E.4. The h.f. oscillator crystals used were purchased from Cathodeon Ltd, who it should be noted have a minimum charge of £3. These crystals are for series, fundamental or third overtone mode operation, as noted in the crystal list. The particular types used in this receiver were of HC/6U construction.

Physical construction

Figs. 10, 11 and 12 show the layout of the original receiver built by the author. The dial drum used was home made, but an alternative would be Jackson Bros. Part No. 5035 3·5 in drum.

The i.f. amplifier and particularly the b.f.o. and product detector must be completely screened, as must the h.f. crystal oscillator and synthesizer mixer (the screening covers were removed for photography). It is also advantageous to screen the i.f. break-through filter from the r.f. amplifier.

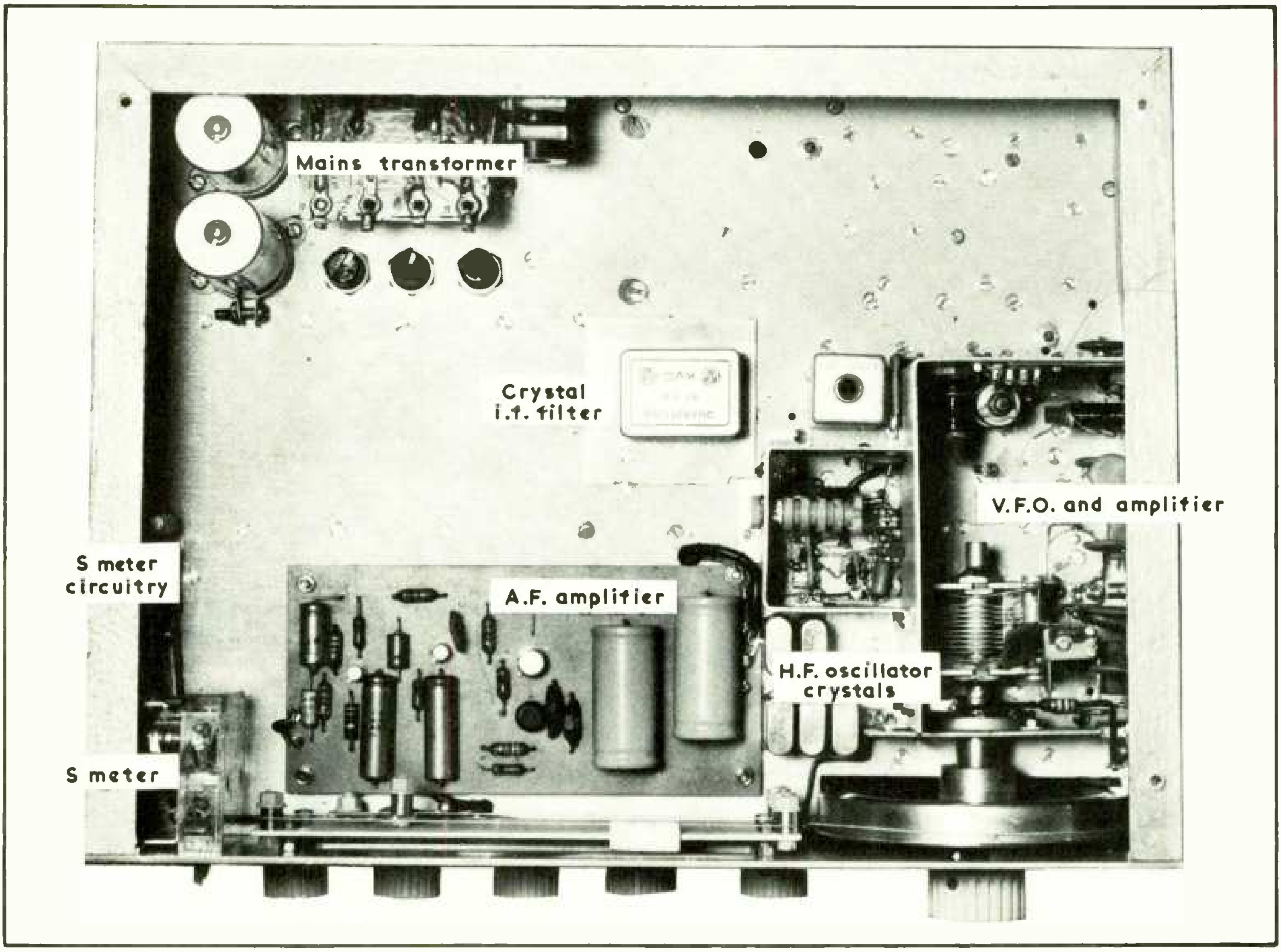
With the exception of the r.f. stage the various circuits can be laid out on individual printed circuit boards. As can be seen from the photographs the author used boards only for the following circuits: i.f. amplifier, a.f. amplifier, product detector, b.f.o. and the S meter. The other stages were built using conventional wiring techniques for convenience during circuit development.

The i.f. amplifier

The i.f. amplifier is constructed on a $5\frac{1}{8}$ in. × 3 in. piece of copper clad printed circuit board. The layout drawing is shown in Fig. 13 and the circuit in Fig. 14. The holes should be drilled using a 0·03 in. drill. The components, with the exception of R_3, R_{10}, and the transistors can be mounted as shown in the diagram and soldered into place. The small aluminium screens should be attached and the mounting screws firmly soldered to the copper earth mat to complete the construction of the board.

The constructor is advised to purchase twenty-five 2N706 transistors which should be graded according to gain, say, 20, 40, 60 and over 60, using the simple transistor tester shown in Fig. 15. Any meter with a 10mA range can be used in the circuit. With the range switch set to R_1 the meter will give a full scale deflection when the gain is 100 and 250 when set to R_2. The switch S_2 has

Fig. 11. A view of the upper side of the chassis.



o be pressed to make these measurements. The two ranges may not quite agree, due to the transistor's gain dependency upon collector current, however, the discrepancy is unimportant. From he 25 transistors choose three pairs with similar gain figures. The uthor's devices were within the range 40 to 50. Solder these into he i.f. amplifier board, together with a transistor with a gain of 0 to 80 in the Tr_7 position. Temporarily connect two 120kΩ esistors into the board, at positions R_3 and R_{10}, connecting only the base ends at this stage. The other two ends are tied together and connected to the h.t. supply. After careful circuit checking connect he amplifier to a 9V supply and measure the potential at the collectors of Tr_2 and Tr_4 using either a valve voltmeter or a sensitive multimeter. This potential should be between 4 and 6V and can be varied by adjusting the value of the temporary h.t. to base esistors. Having found the appropriate resistance value the esistance of R_3 and R_{10} can be found as follows:

$$R_3 \text{ and } R_{10} = (R_{\text{(h.t. to base)}}/2) - R_{23}$$

f for example the resistor from the h.t. supply to the base of Tr_1 vas 120kΩ, then:

$$R_3 = [(120 \times 10^3)/2] - (33 \times 10^3) = 27\text{k}\Omega$$

Resistors of the calculated value should be soldered into circuit n the R_3 and R_{10} positions in place of the two temporary 120kΩ esistors. The next step is to reconnect the 9V supply, and a high value potentiometer of about 100kΩ between the point on the board marked X and the h.t. supply. Using a valve voltmeter the potential on terminal F should be monitored. It will be found hat with potentiometer set to maximum resistance and no signal nput, the potential should be between 5-6 volts.

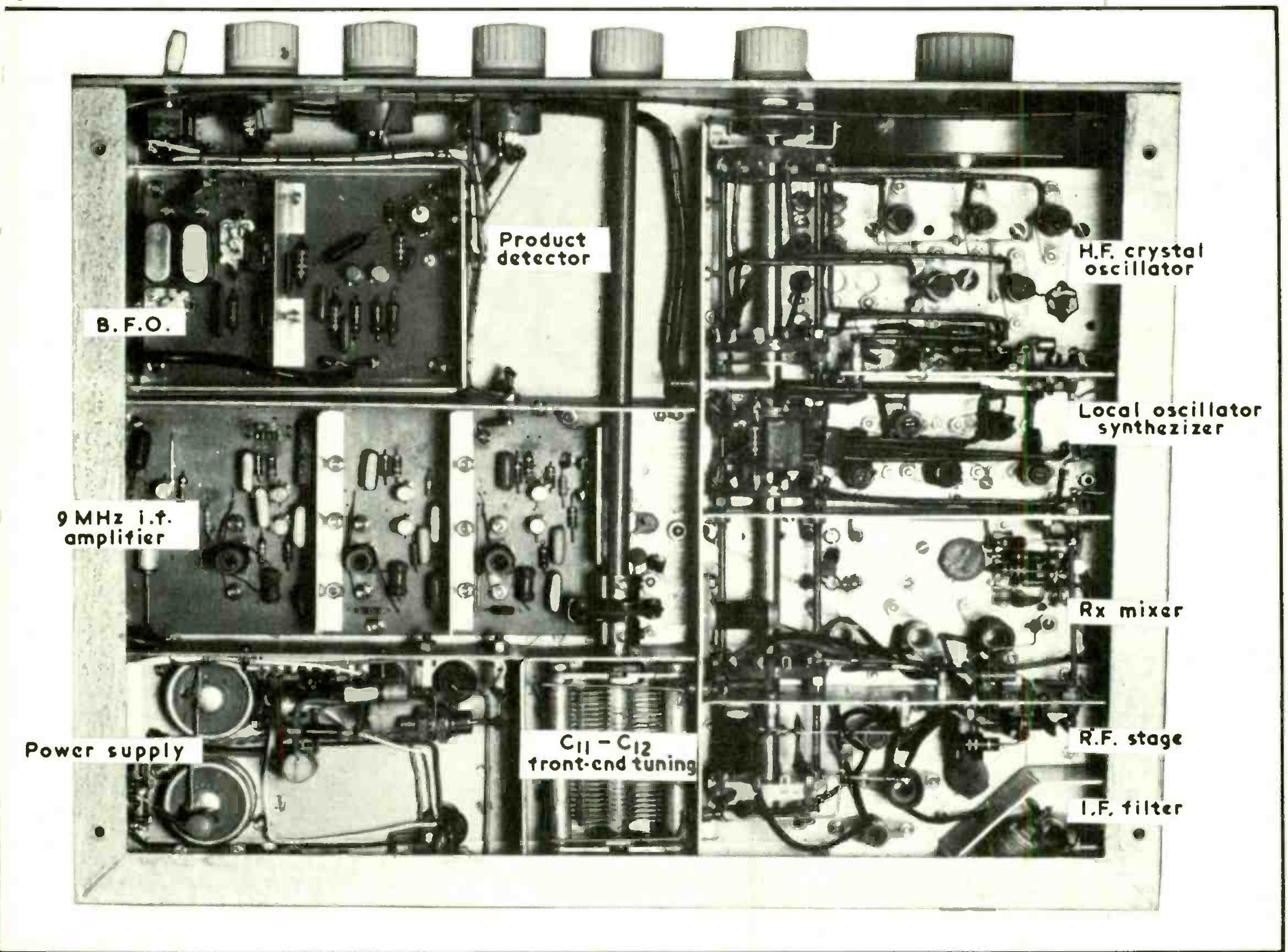
A source of 9MHz r.f. voltage is injected into terminal D (from a grid dip oscillator, signal generator or simple test oscillator) and the i.f. transformer cores of T_1, T_2 and T_3 are adjusted until the potential at F dips to a minimum. It will be necessary to progressively reduce the 9MHz drive, as this process continues. It is strongly advised that the amplifier be well screened during these tests and that all signal leads to and from the amplifier be made as short as possible. If the amplifier should show signs of instability, increasing the values of R_6, R_9 and R_{19} should cure the trouble. R_4, R_{11}, and R_{17} also can be increased if necessary. It will be found that the amplifier has more gain than is required and it will be unconditionally stable when incorporated as part of the receiver. A photograph of the i.f. amplifier is given in Fig. 16.

The b.f.o. and product detector

It is essential that these sections be constructed in a well screened aluminium box. The b.f.o. (Fig. 17) is required to generate either one of two frequencies, positioned on either side of the i.f. filter characteristic (Fig. 2). It is generally accepted that an audio frequency response covering the range 300Hz to 2·6kHz is the minimum for acceptable communication quality. This entails setting the b.f.o. frequencies about 20dB down either side of the filter characteristic. The particular filter used in this receiver is supplied with the appropriate b.f.o. crystals.

The author would advise any prospective constructor to purchase new crystals and not attempt to use war surplus which are now at least 25 years old. The b.f.o. uses a circuit configuration

Fig. 12. A view of the underside of the chassis. Certain screening covers have been removed for clarity.



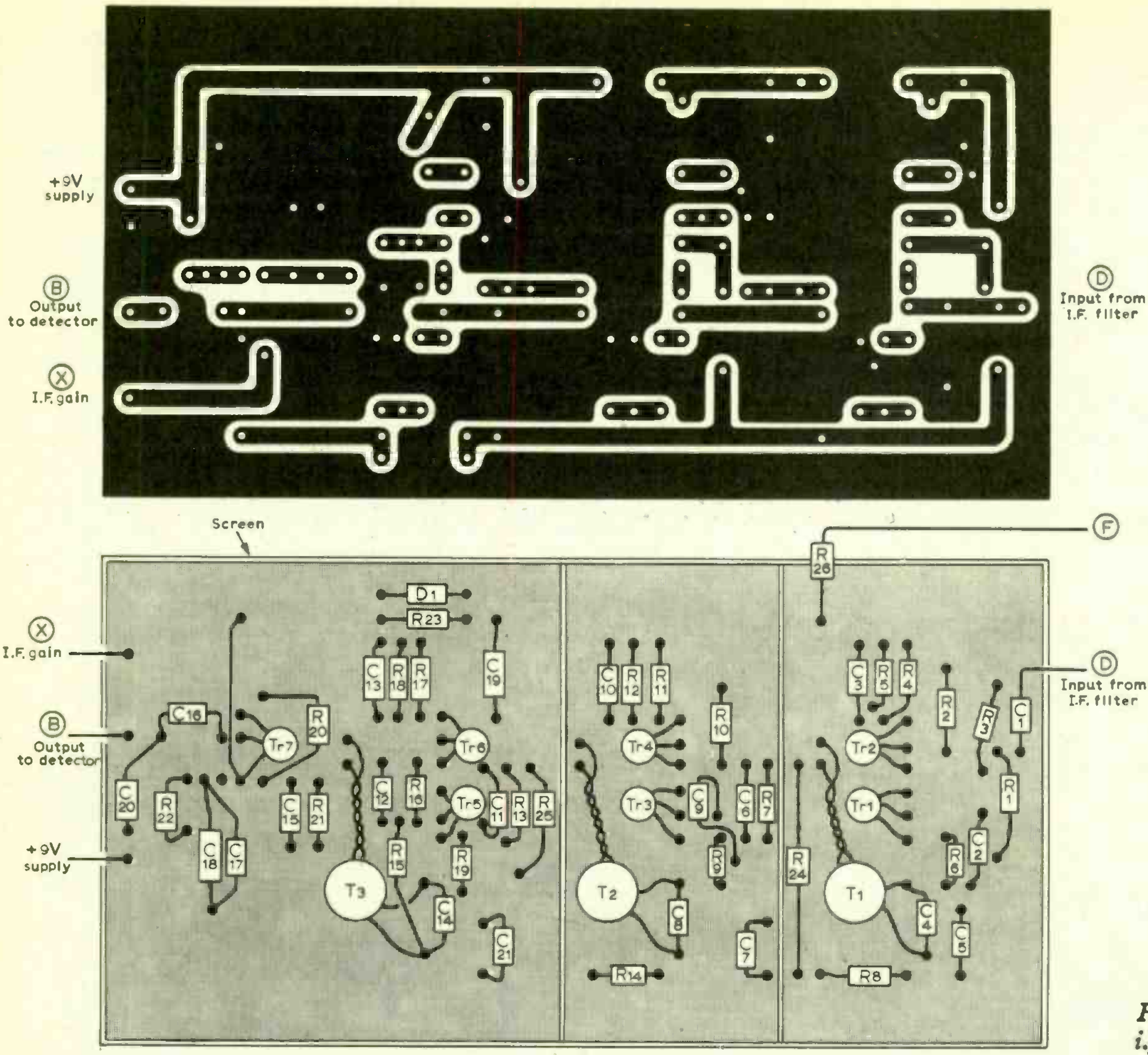


Fig. 13. Construction of the i.f. amplifier.

which should be familiar to many readers, as it is very similar to the valve Pierce oscillator. An interesting point is the method of changing the b.f.o. crystals. This uses diode switching which allows the sideband selection control to be positioned conveniently on the front panel and remote from the oscillator box. This eases the problem of keeping stray b.f.o. voltages out of the i.f. amplifier as none of the leads external to the b.f.o. compartment carries r.f.

The product detector requires the very low oscillator drive of

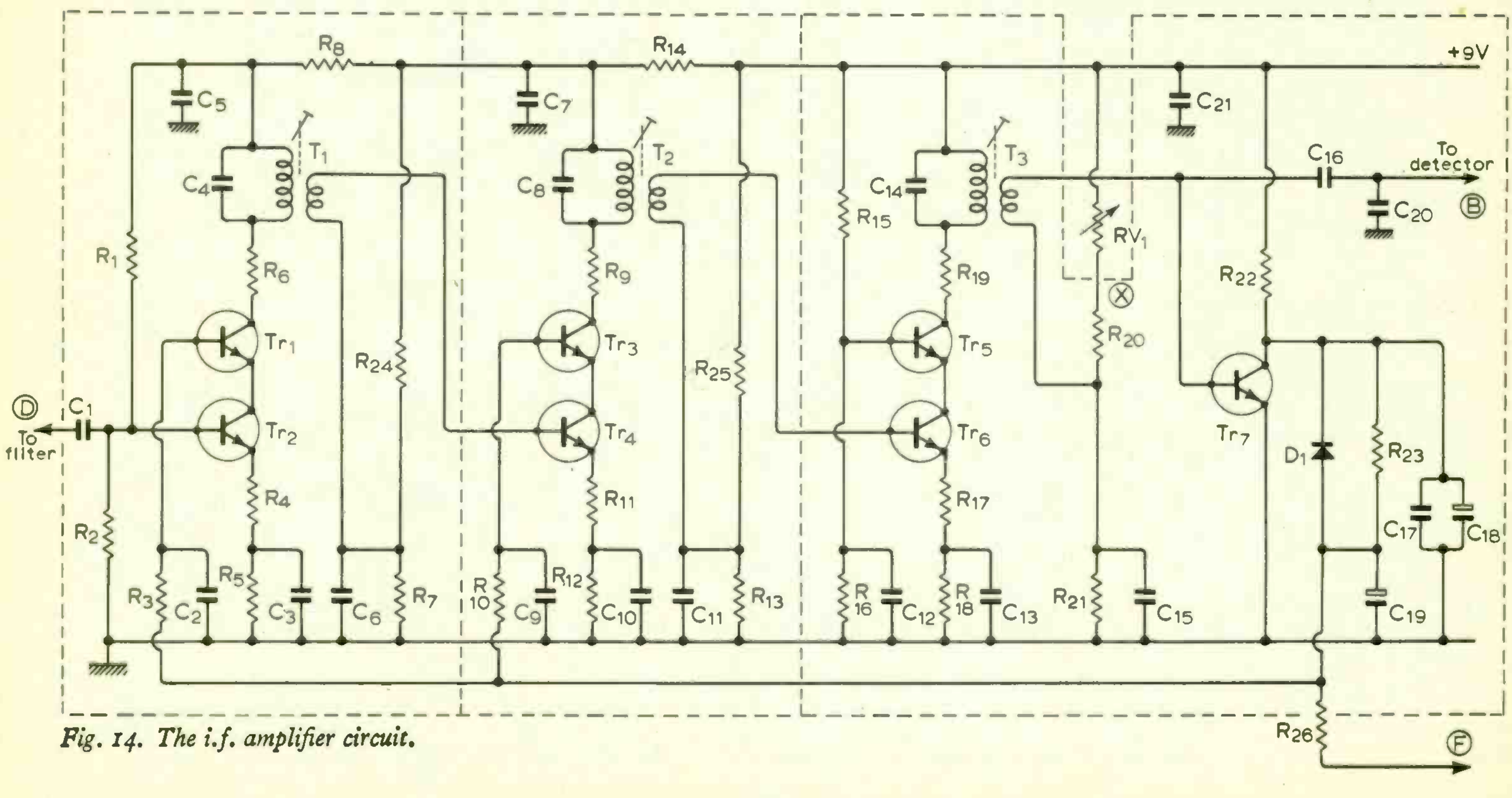


Fig. 14. The i.f. amplifier circuit.

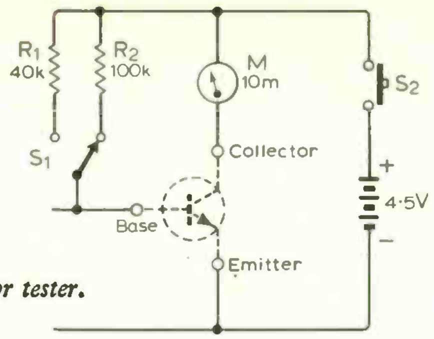


Fig. 15. A simple transistor tester.

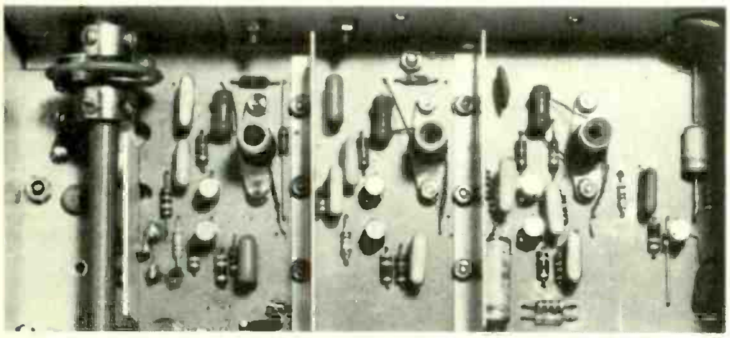


Fig. 16. The finished i.f. amplifier.

not more than 100mV which means a small value of coupling capacitance (5pF) between the oscillator and detector. The process of product detection is analogous to normal mixer action with the output being in the audio frequency spectrum. It is recommended that a pair of 2N706 transistors ($Tr_{2\,\&\,3}$ Fig. 17) with similar current gains should be used in the circuit. The signal requirement is modest at 10mV, and the capacitive potential divider ($C_{16\,\&\,20}$ Fig. 14) on the output of the i.f. amplifier serves the dual purpose of reducing the i.f. amplifier voltage to suit the detector and reducing the reverse transfer of stray b.f.o. voltage back into the i.f. amplifier.

The presence of unwanted b.f.o. signals in the final receiver can be checked by removing one b.f.o. crystal from the circuit and adjusting the receiver to a clear channel. The S meter reading should be identical when the sideband switch is operated. In other words the application of b.f.o. voltage to the detector should not affect the S meter zero reading. The r.f. filter in the detector collector circuit makes use of a 10μH r.f.c. which is easily constructed by close winding 30 turns of 34 s.w.g. enamel covered copper wire on a Radiospares coil former which is fitted with an iron dust core and adjusted to produce maximum inductance. This filter is used to eliminate the 9MHz component present in the audio signal at the output of the detector. The finished b.f.o. and product detector is shown in Fig. 18.

The a.f. amplifier

The audio amplifier is of conventional transformerless design (Fig. 19) consisting of two common emitter-connected stages driving a complementary output pair which drive the 3Ω loudspeaker. Considerable negative feedback is applied over the last two stages which tends to stabilize the d.c. operating point as well as reducing output non-linearity. It is essential that the following procedure is carried out to set-up bias levels otherwise the output stages transfer characteristic will include considerable cross-over distortion.

In the audio output circuit this bias voltage is determined by the values of the resistor chain R_7 and R_8. First connect the audio amplifier to a 12V supply and a 3Ω loudspeaker to the output terminals. Connect an audio signal generator with an output of about 30mV to the amplifier input. A general multimeter or milliammeter set to 50mA full scale deflection should be connected in

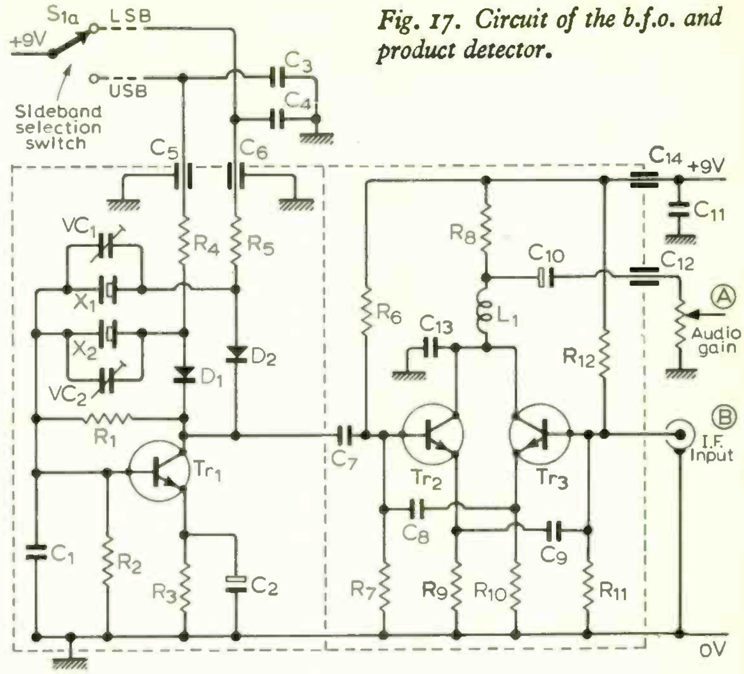


Fig. 17. Circuit of the b.f.o. and product detector.

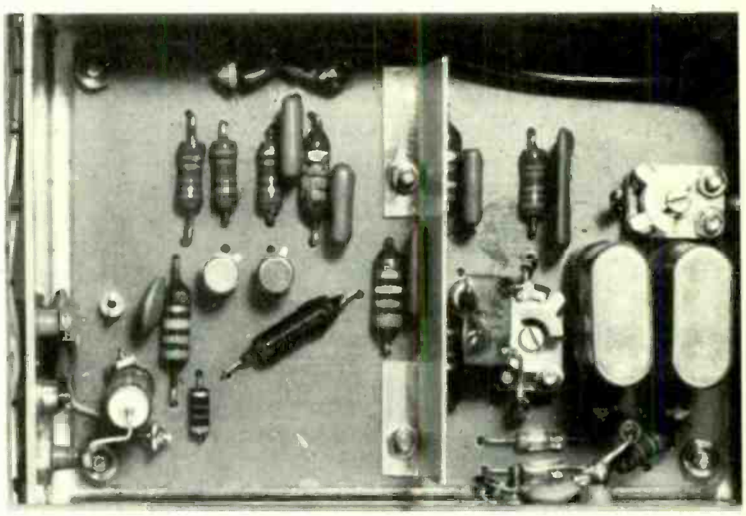


Fig. 18. Finished b.f.o. and product detector.

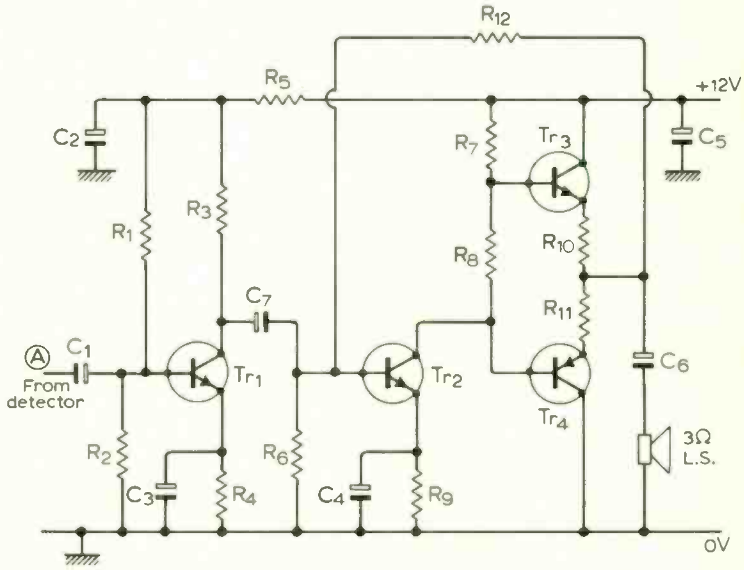


Fig. 19. The a.f. amplifier circuit.

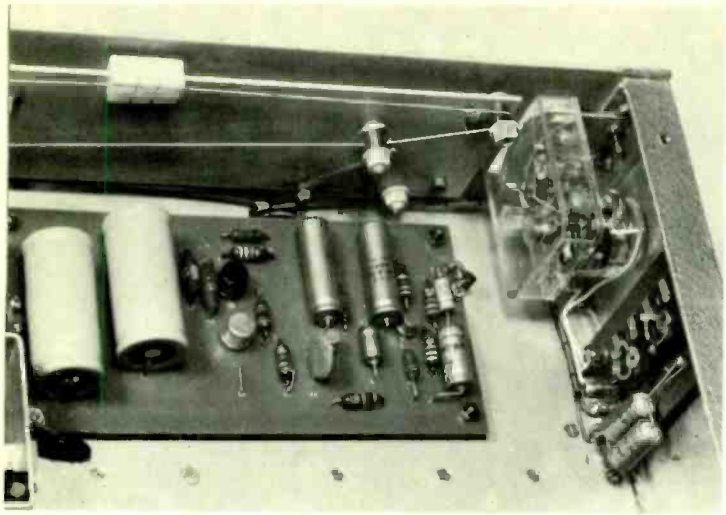


Fig. 20. On the left the a.f. amplifier and on the right the S meter and associated circuitry.

series with the 12V supply to the amplifier. With no input signal the current taken from the supply should be noted. The value of resistor R_8 should be progressively increased until the previously noted current begins to increase. The final value for R_8 will be that value which produces an increase in current from 1 to 3mA.

It is most important not to make the value of this resistor too large as this may cause thermal runaway in the output transistors. The complementary pair consist of one silicon n–p–n BFY50 and a germanium p–n–p ACY17 transistor. It is generally bad practice to mix silicon and germanium devices in a complementary circuit, but the continued high price and supply difficulties forced the author to consider their use. In practice it will be found that the performance of this amplifier is far better than is required for a communications receiver. By careful adjustment the cross-over distortion can be reduced to a very low level. The finished a.f. amplifier is shown in Fig. 20. In the photograph the not yet discussed S meter and associated circuitry can also be seen.

This description ends this month with components lists for the circuits described so far and all the data on coil winding for the complete receiver. Next month more design and constructional information will be given.

COMPONENTS LIST

i.f. amplifier

R_1	.. 33kΩ	R_8	.. 150Ω	R_{15}	.. 22kΩ	R_{22}	.. 5·6kΩ
R_2	.. 10kΩ	R_9	.. 560Ω	R_{16}	.. 33kΩ	R_{23}	.. 33kΩ
R_3	.. •	R_{10}	.. •	R_{17}	.. 33Ω	R_{24}	.. 3kΩ
R_4	.. 33Ω	R_{11}	.. 33Ω	R_{18}	.. 560Ω	R_{25}	.. 33kΩ
R_5	.. 560Ω	R_{12}	.. 560Ω	R_{19}	.. 560Ω	R_{26}	.. 1kΩ
R_6	.. 560Ω	R_{13}	.. 10kΩ	R_{20}	.. 10kΩ		—
R_7	.. 10kΩ	R_{14}	.. 100Ω	R_{21}	.. 3·6kΩ		—

• adjusted as described in the text.

C_1	.. 0·01μF†	C_8	.. 50pF•	C_{15}	.. 0·1μF†
C_2	.. 0·1μF†	C_9	.. 0·1μF†	C_{16}	.. 68pF†
C_3	.. 0·1μF†	C_{10}	.. 0·1μF†	C_{17}	.. 0·1μF†
C_4	.. 50pF•	C_{11}	.. 0·1μF†	C_{18}	.. 6·8μF§
C_5	.. 0·1μF†	C_{12}	.. 0·1μF†	C_{19}	.. •†
C_6	.. 0·1μF†	C_{13}	.. 0·1μF†	C_{20}	.. 0·0001μF•
C_7	.. 0·1μF†	C_{14}	.. 50pF•	C_{21}	.. 0·1μF

† disc ceramic. • silver mica. § 10V working.
•† adjust to give a.g.c. time constant required.

All transistors type 2N706 selected as described in the text.
D_1 .. germanium diode type CV448, OA91 or similar.
RV_1 .. 25kΩ, i.f. gain.

a.f. amplifier

R_1	.. 33kΩ	R_4	.. 430Ω	R_7	.. 620Ω	R_{10}	.. 1Ω•
R_2	.. 6·8kΩ	R_5	.. 2·2kΩ	R_8	.. •†	R_{11}	.. 1Ω•
R_3	.. 2·2kΩ	R_6	.. 1kΩ	R_9	.. 100Ω	R_{12}	.. 3·3kΩ

•† see text. • wire wound.

C_1	.. 2·5μF•	C_4	.. 125μF†	C_7	.. 25μF•
C_2	.. 50μF•	C_5	.. 1000μF§		—
C_3	.. 125μF†	C_6	.. 1000μF§		—

•20V working. † 6V working. § 15V working.

Tr_{1-2} .. 2N2706 Tr_3 .. BFY50 Tr_4 .. ACY17
3Ω Loudspeaker.

b.f.o. and detector

R_1	.. 47kΩ	R_4	.. 2·2kΩ	R_7	.. 2·2kΩ	R_{10}	.. 1kΩ
R_2	.. 22kΩ	R_5	.. 2·2kΩ	R_8	.. 6·8kΩ	R_{11}	.. 2·2kΩ
R_3	.. 220Ω	R_6	.. 22kΩ	R_9	.. 1kΩ	R_{12}	.. 22kΩ

C_1	.. 150pF•	C_6	.. 0·001μF△	C_{11}	.. 0·01μF†
C_2	.. 0·01μF†	C_7	.. 5pF•	C_{12}	.. 0·001μF△
C_3	.. 0·01μF†	C_8	.. 0·01μF†	C_{13}	.. 0·001μF†
C_4	.. 0·01μF†	C_9	.. 0·01μF†	C_{14}	.. 0·001μF△
C_5	.. 0·001μF△	C_{10}	.. 25μF§		—

• silver mica. † disc ceramic. § 20V working. △ feed-through.

All transistors type 2N706.

D_{1-2} .. germanium diodes type CV448 or OA91
VC_{1-2} .. 3 to 30 pF trimmers
X_{1-2} .. b.f.o. crystals supplied with crystal filter
L_1 .. 10μH r.f. choke
VR_1 .. 5kΩ logarithmic, a.f. gain

COIL WINDING DETAILS

function	frequency or band	winding details	coil no.
signal frequency gate 1	40m	Wound on 0·3in diameter former type CR9. 55 turns of 30 s.w.g. wire close wound. Primary winding four turns wound over the earthy end of the previous winding.	L_3
	20 m	33 turns of 34 s.w.g. wire close wound.	L_4
	15 m	20 turns of 30 s.w.g. wire close wound	L_5
	10 m	19 turns of 22 s.w.g. wire close wound	L_6
signal frequency drain	40 m	Wound on 0·3in diameter former type CR9. 55 turns of 30 s.w.g. wire tapped at 22 turns from the h.t. end	L_{11}
	20 m	33 turns of 34 s.w.g. wire close wound	L_7
	15 m	20 turns of 30 s.w.g. wire close wound	L_8
	10 m	19 turns of 22 s.w.g. wire close wound	L_9
9MHz i.f. transformer	9MHz	Wound on 0·25in screened former cat. No. CR12 can No. CR13. Primary 40 turns of 30 s.w.g. wire close wound. Secondary wound over earthy end of primary. 6 turns also of 30 s.w.g.	L_{10}
v.f.o. base coil	5 to 5·5MHz	30 turns of 30 s.w.g. wire close wound	L_1
v.f.o. amplifier	wideband coupler 5 to 5·5MHz	Two coils each wound with 50 turns of 34 s.w.g. wire close wound. In addition L_2 has a secondary consisting of 4 turns close wound over the primary	L_2 L_3
h.f. crystal oscillator	11MHz	30 turns of 34 s.w.g. wire close wound.	L_1
	25MHz	22 turns of 28 s.w.g. copper wire close wound	L_2
	32MHz 32·5MHz 33MHz	9 turns of 26 s.w.g. wire spread to a winding length of 0·5in.	L_3 L_4 L_5
oscillator mixer	5·25MHz	25 turns of 28 s.w.g. wire close wound and tuned by a parallel capacitor of 200pF	L_6
	16.25MHz	20 turns of 28 s.w.g. wire close wound and tuned with a parallel capacitance of 15pF	L_7
	30·25MHz	12 turns of 22 s.w.g. copper wire close wound and tuned with a parallel capacitance of 5pF	L_8
	37·25MHz 37·75MHz 38·25MHz	11 turns of 36 s.w.g. wire spread to a winding length of 0·5in tuned with a parallel capacitance of 5pF	L_9 L_{10} L_{11}
9MHz i.f. amplifier	9MHz	Primary winding 35 turns of 30 s.w.g. wire close wound with the secondary consisting of 8 turns wound over the h.t. end of primary	
product detector	r.f.c. 10μH	30 turns of 34 s.w.g. wire close wound with an iron dust core	L_1
i.f. trap	9MHz	12 turns of 34 s.w.g. close wound	L_1
	9MHz	46 turns of 34 s.w.g. wire close wound	L_2

With the exceptions noted above, all coils are wound on Radiospares coil formers obtainable from Home Radio, Cat. No. CR2. Iron dust cores are used in all coils with the exception of the signal frequency and i.f. trap coil L_2. See later for signal frequency coil tuning adjustment. Home Radio also supply iron dust cores under the catalogue number CR5. The author found that a satisfactory method of anchoring the wire ends to the former was to wind several turns of ordinary sewing cotton over the wire To complete the job a small quantity of shellac can be applied to the cotton. Enamelled copper wire is used in all cases.

Laser Applications in Electronics

A review of the most significant fields of use of laser radiation

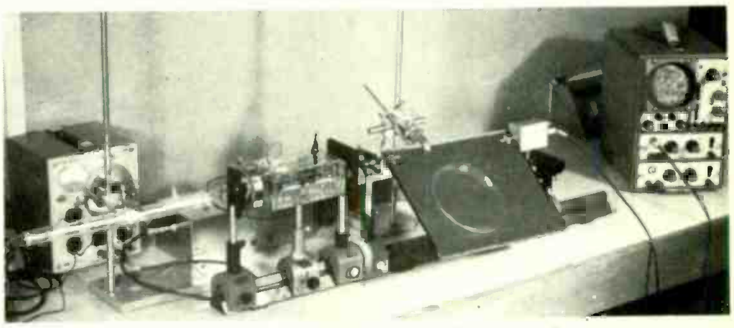
by W. A. Gambling D.Sc., Ph.D., F.I.E.R.E., F.I.E.E. and R. C. Smith*, B.Sc., Ph.D.*

Electronic technology at the present time is based largely on semiconductor junction devices which, although developed to a high degree of sophistication, are continuing to improve with the evolution of new types and techniques. However, all components which involve interaction of charge carriers with electric fields at a junction become progressively more limited in their power-handling ability at high frequencies because of transit time and capacitance effects. Until recently therefore electronic techniques were limited to frequencies below 100GHz. Any significant improvement was clearly dependent on the development of a radically new technique, which, in all probability, would involve some kind of amplification process throughout the bulk of a material rather than at a junction. In fact this new technological revolution was hinted at by the invention of the maser in 1954 but really began to gather momentum in the early 1960s with the emergence, in rapid succession, of lasers[1], acousto-electric interaction in semiconductors[2] and the transferred electron or Gunn effect[3], also in semiconductors. Each of these processes is of very great interest but this article is concerned only with the first of them. The basic properties of lasers are outlined in the Appendix, while typical present-day practical achievements are listed in Table 1.

The applications of lasers arise from the properties of coherent radiation at optical frequencies as compared with incoherent radiation, and the main ones are that it can be collimated and focused to a degree limited only by diffraction and it can give rise to interference and diffraction phenomena. A light beam of wavelength λ and diameter D can be focused to a spot or area of approximately λ^2 so that a laser output of as little as 1mW can produce a power density of about 10^5W/cm^2. A beam of diameter D can be produced with a spreading half-angle of approximately λ/D so that a transmitting aperture of diameter 1m will give a patch of light on the moon of diameter only 600m.

Table 1 Properties of some typical lasers

Type	*material*	*wavelength*	*power*	*operation*
gas	helium-neon	0·63μm	1-100mW	continuous
	argon	0·49, 0·51μm	1-50mW	continuous
	carbon dioxide	10·6μm	100W-10kW	continuous
solid	neodymium: glass	1·06μm	10-100,000MW, 1-10,000J,	10ns 10ms
	neodymium: YAG	1·06μm	1·1W	continuous
	plus SHG	0·54μm	1·1W	continuous
semiconductor	gallium arsenide	0·84-0·9μm	10W,	100ns
parametric	lithium niobate	0·68-2·4μm	5kW,	10ns



Experimental glass fibre communication link at Southampton University. A beam from a helium-neon laser (left) is modulated by the unit in the rectangular plastic box (left of centre) before it is passed through a coiled cladded glass fibre (on the rectangular flat plate, right of centre). The signal is shown on the c.r.o.

Communications

Because of their high operating frequency lasers are potentially communications sources of enormous bandwidth, if suitable modulators and demodulators can be designed, but they are inherently more noisy than microwave and lower frequency sources. For example a power level of 1mW at a frequency of 10GHz corresponds to a flux of about 10^{10} photons per cycle whereas a similar power at optical frequencies corresponds to about 10 photons per cycle so that in the last-mentioned case the granular nature of the signal is much more evident. Thus even though thermal noise is negligible the best noise figure possible at visible light frequencies is no better than 10dB. This may be compared with the noise figure of a maser receiver of $<$1dB. This is the penalty to be paid for the increased bandwidth.

Unshielded systems. Because of turbulence and temperature gradients in the atmosphere point-to-point communication in unshielded systems at optical frequencies is unlikely to be feasible over any appreciable distance even in clear weather. For example, large regions of different refractive index in a propagating beam can cause the beam to be deflected and small regions cause a breaking up of the beam. Since the atmosphere is seldom quiet the variations occur randomly and quite rapidly.

The magnitude of the problem can be judged from the fact that a collimated beam of 5cm diameter at visible wavelengths will be deflected by a transverse temperature gradient of only a few thousandths of a degree, over a distance of 1·5km, through a distance equal to its own diameter[4]. On the other hand for short distances and inconvenient locations such as building sites and rough country, and where high security is required, there are possible applications and hand-held sets using light-emitting diodes and semiconductor lasers operating at room temperature have already been produced.

Space communication. Outside the earth's atmosphere the situation is rather different because, with diffraction as the only limiting factor, the efficiency of transmission for given transmitting and receiving apertures increases as the square of the frequency. Above about 10^{13}Hz the photon noise level increases linearly with frequency so that the signal/noise ratio also increases linearly with

* University of Southampton. This article is a slightly modified version of a paper published in our associated journal *Optics Technology*, Vol. 1, No. 3.

frequency. Thus in situations where size and weight are at a premium, such as on an artificial satellite, optical communications may eventually have an important application. The low operating efficiency of lasers may not be quite such a disadvantage since sunlight can be used as pumping radiation in certain optically-pumped lasers.

Calculations show that with a perfect 5m telescope and using existing lasers it should be possible to set up a communications link over a distance of 10 light years with a signal/noise ratio of 10^4, although the delay in receiving any reply would tend to make the exercise one of only marginal interest. However, apart from the fact that a real need for transmitting over vast distances in space does not yet exist, there are still many problems to be overcome such as aiming with the required degree of accuracy, and improving the efficiency of modulators, detectors and, of course, lasers.

Guided systems. On the surface of the earth an optical beam can be protected from the weather by enclosing it in a pipe. Even with highly-reflecting coatings, reflection from the walls must be prevented to avoid high loss and dispersion, and the pipe must therefore be optically straight. Transverse thermal gradients must be avoided either by evacuating the pipe or by burying it underground. To keep the diameter within practicable limits the spreading of the beam due to diffraction can be counteracted by using a periodic sequence of weakly converging lenses[4,5] as shown schematically in Fig.1 . The high loss due to reflection at each lens surface can be avoided by using anti-reflection coatings but these will not be entirely lossless.

Another possibility is to use a radial temperature gradient in a gas to produce a variation in refractive index and such thermal gas lenses are remarkably effective[6]. The transmission loss is negligible but obviously the rest of the system cannot be evacuated without introducing further surfaces and uncontrolled temperature gradients elsewhere can be every bit as troublesome as with an unshielded beam. There are many other difficulties such as the effect of skew or lateral displacement of the lenses. If these, and other, problems can be overcome a beam guiding system of enormous bandwidth may be possible but at best it will be very costly to install and maintain.

Yet another possibility is to use a transmission line structure of some kind. At optical frequencies metals are very lossy and only dielectric materials can be considered. For single-mode propagation, essential for broad-band communications, a surface-wave on a dielectric rod can be used. If the rod diameter is about equal to the wavelength of the carrier then only the HE_{11} mode can propagate but since at optical wavelengths λ is approximately $1\mu m$ the rod, or fibre, would be fragile and difficult to support without causing reflections of the electromagnetic field which is carried mainly in the space surrounding the fibre. The transmission loss would, of course, be very small.

By cladding the fibre with a material of lower dielectric constant a number of advantages are obtained[7]. Firstly the combined structure is mechanically more robust, and secondly, as long as the cladding is sufficiently thick (say about 50λ) that the surface wave fields are extremely small at its outer surface, there is no difficulty in supporting the cladded fibre. Furthermore if the dielectric constant of the cladding ϵ_1 is only slightly less than that of the core ϵ_2 so that $(\epsilon_2 - \epsilon_1) \ll \epsilon_2$ then single mode operation can be achieved with a core diameter of perhaps four or five wavelengths, so that the manufacturing problem is eased somewhat. However the surface wave propagates largely in the cladding and it is essential that a low-loss material is used. Unfortunately the best glass available at the present time has a loss coefficient equivalent to several hundred dB/km and the success of the fibre-optic system depends on the development of a material with about an order of magnitude improvement.

Calculations show that if this can be achieved then a bandwidth of perhaps 1GHz can be obtained in a transmission system which is inherently very cheap and small. Even though the permissible bending radius is several thousand wavelengths, since λ is small the fibre is very flexible and is compatible with the existing cable duct telephone system. Each fibre would have a bandwidth of roughly ten times that of a coaxial cable and with an overall fibre diameter of $100\mu m$ several hundred could be combined in parallel in a cross-section of appreciably less than $1cm^2$, providing a much greater line bandwidth with a high degree of redundancy to compensate for breaks in individual fibres. The required reduction in glass attenuation by a factor of ten should be possible with present-day technology and already there are encouraging signs of an appreciable improvement.

This attempt at using lasers for communications is much less

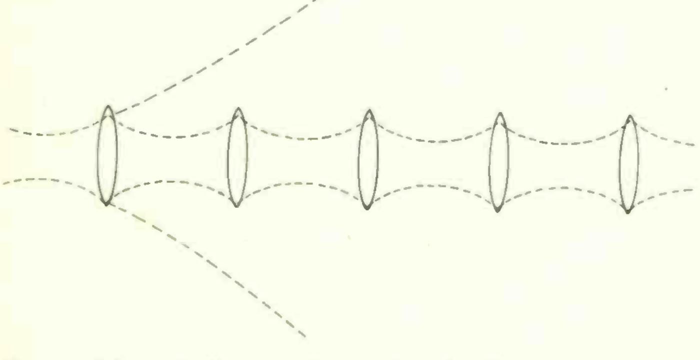


Fig. 1. *Schematic diagram of correction of diffraction spread using a periodic system of converging lenses.*

Table 2 Comparison of optical guiding systems

Type of guide	*attenuation in db/km*	*band-width per channel*	*dia-meter*	*flexibility*	*cost*	*remarks*
Beam waveguide	very low	very large	2-100cm	zero	very high	sensitive to earth movement
Reflecting pipe (overmoded)	10-100 (or more depends on precision)	100MHz	5cm	low	high	performance very dependent on quality of surface
Cladded optical fibre (multi-mode)	20-100	10MHz	<1mm	excellent	low	low-loss glass required
Cladded optical fibre (single-mode)	20-100	more than 1GHz	<1mm	excellent	low	low-loss glass required

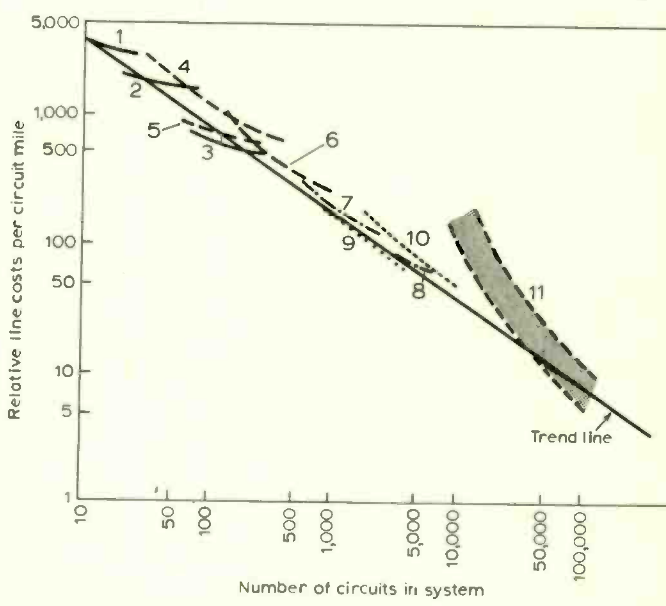


Fig. 2. *Variation of relative line cost per circuit mile with the number of circuits in a system. Curves 1, 2, 3, types of open wire system; 4, 5, 6, cable systems; 7 and 8, coaxial cable systems; 9 and 10, microwave relay systems; and 11, circular waveguide. (Courtesy Professor A. E. Karbowiak.)*

ambitious than the beam guiding system, which is being investigated by Bell Telephone Laboratories in the U.S.A., and there is a reasonable chance of achieving a practicable system by the mid-1970s. The cable system itself will be relatively cheap to produce and the installation costs using existing cable ducts will be relatively small. An obviously attractive type of source is a room-temperature injection laser but it seems unlikely that one can be developed to operate at the required pulse rate. A more reasonable possibility, or so it seems to the authors, would be to use the mode-locking technique (see Appendix) to produce a train of pulses from a laser[8] which can then be deflection-modulated onto the core of the fibre to give a pulse-code-modulated signal. On the other hand it may be worthwhile trying to develop the three-terminal gallium arsenide device[9] into a suitable modulator. Work on fibre-optic communications originated at Standard Telecommunication Laboratories and is being continued there and at the Post Office Research Station. The Signals Research & Development Establishment and the Department of Electronics, University of Southampton are collaborating in the development of a narrow-bandwidth glass fibre system for short distance links (see photo).

A comparison of various types of optical guiding structures is given in Table 2 while Fig. 2 shows how the cost per circuit mile has fallen with systems of increasing bandwidth. If this trend continues at optical frequencies then the prospect is a truly exciting one.

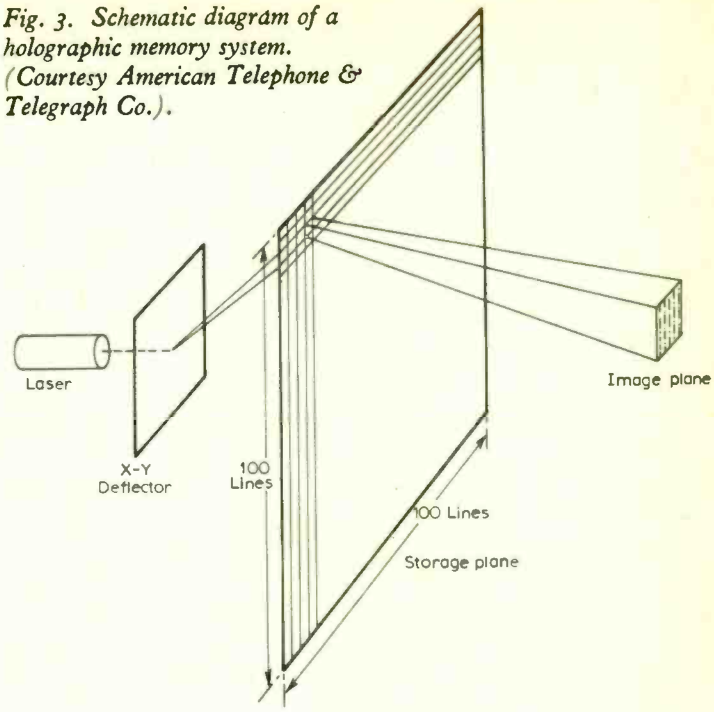
Holographic image recording

In conventional photography only information about the amplitude of light reflected from an object is recorded on a photographic plate and light from a point on the object is stored at a corresponding specific point on the recording plate. However by using the holographic technique in which both the object and the recording plate are illuminated with light from a coherent source such as a laser, and scattered light from the object is also allowed to fall on the plate, then an interference pattern is recorded which is characteristic of the object. Thus both amplitude and phase information is stored. A further consequence is that light from any point on the object is scattered and hence stored over the whole of the image plane, and therefore dust, blemishes or breakages do not render any of the stored information inaccessible. The original object or scene can be reproduced in true three dimensions by illuminating the recording plate with the same, or another, laser. The requirement on the laser radiation is that it must be coherent, which means in practice that the coherence length must be greater than (i) the depth of scene to be recorded and (ii) the path-length difference between laser-object-photographic plate and laser-photographic plate, i.e. between the object and reference beams.

There are several possible applications of this technique and one of the more interesting ones is in the optical storage of information. Accurately collimated light beams are now easy to produce and if they can be deflected with precision then one can envisage digital information stored on a photographic plate in the forms of ones and zeros represented by transparent and opaque areas, and a very high density of information storage is possible. High-speed deflection of a laser beam can be produced by the electro-optic or acousto-optic effects although it is to be hoped that development of improved materials will make the technique an easier one than it is at the present time. Nevertheless addressing rates of 10^6 per second can be achieved with existing technology. However a simple photographic store of this kind can be badly affected by dust and imperfections and an improved method[10] is illustrated in Fig. 3.

Using a suitable deflector a laser beam is scanned to any one of an array of perhaps 100×100 small holograms in the storage plane. These are so oriented that each one produces a real image on an array of photodiodes which converts the optical signals into electrical ones. In the matrix each photodiode corresponds to one element of the image in which the presence or absence of light can correspond to a binary one or zero. An array of 100×100 diodes is possible giving a store of 10^4 bits per hologram and a total capacity of 10^8 bits. With present-day technology an addressing rate in the storage plane of 10^6 hologram per second is probably just feasible but even with the easily achieved rate of $10^4 s^{-1}$ this method of 'page-storing' gives a net rate approaching 10^6 instructions per second.

Fig. 3. Schematic diagram of a holographic memory system. (Courtesy American Telephone & Telegraph Co.).



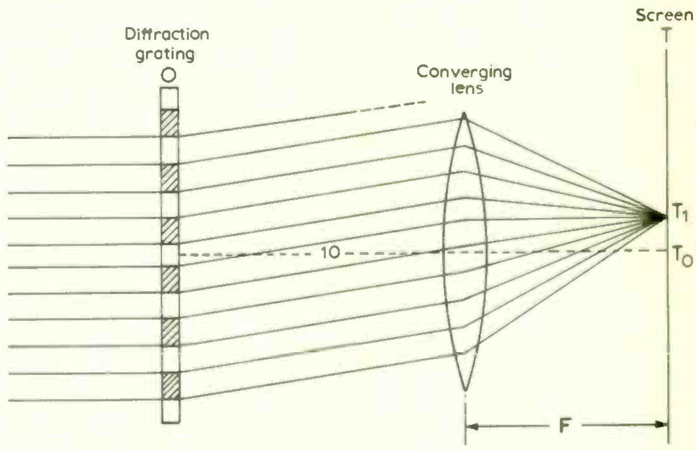


Fig. 4. Insertion of a diffraction grating in object plane O deflects the spot of light in plane T, which is at the focus of the lens, from T_0 to T_1.

Using the holographic technique the only effect of dust is to reduce the signal/noise ratio for all the bits in one hologram and the exact positioning of the holograms is not critical. The angular orientation of the hologram in the storage plane is important but the required precision of 0·1% is not difficult to achieve. The main difficulties lie in the preparation of holograms, although it appears possible to store 10^4 bits on each hologram and to contain the 10^4 holograms in a space 5cm × 5cm. Techniques for making photodiode arrays are being rapidly improved and a 100×100 array with associated read-out circuitry should soon be practicable. A semi-permanent memory of this kind, with high-speed random-access capability, could prove invaluable as a store for base programmes in the increasingly complex computers of the future.

Pattern recognition

Elementary optics shows that if a diffraction grating, which consists of an array of closely-spaced parallel slits, is illuminated by a perpendicular coherent beam of light then the transmitted light is contained in a number of beams which are deflected through various angles. The angle of diffraction of the first-order beam is λ/s where λ is the wavelength of the light and s the spacing of the slits so that θ depends linearly on the reciprocal of the spacing or spatial frequency of the slits. If a converging lens, of focal length F, is placed in the deflected beam, as in Fig. 4, then a spot of light is focused on a screen at T_1, distance F from the lens. With the diffraction grating removed the incident beam is brought to a focus at T_0. In general with a grating of spatial frequency s_1^{-1} a spot of light is formed at T_1 which is at a distance $F\theta = (\lambda F/s_1)$ from T_0. Thus the position of the spot T is a measure of the spatial frequency of the grating. Note that the position of the object transparency (the diffraction grating in the above example) is immaterial, the only requirement being that it must be perpendicular to the axis of the system. A similar argument applies in the transverse direction perpendicular to that of the paper and the result may be expressed mathematically by the theory of diffraction optics

$$E_2(x_2y_2) = (i/\lambda F) \int E_1(x_1y_1)$$
$$\exp(2\pi i/\lambda F)(x_1x_2 + y_1y_2)\, dxdy$$

where $E(xy)$ is the two-dimensional, complex, electric field amplitude distribution in the transverse co-ordinates x, y and the suffixes 1 and 2 refer to the planes of the diffraction grating and screen respectively.

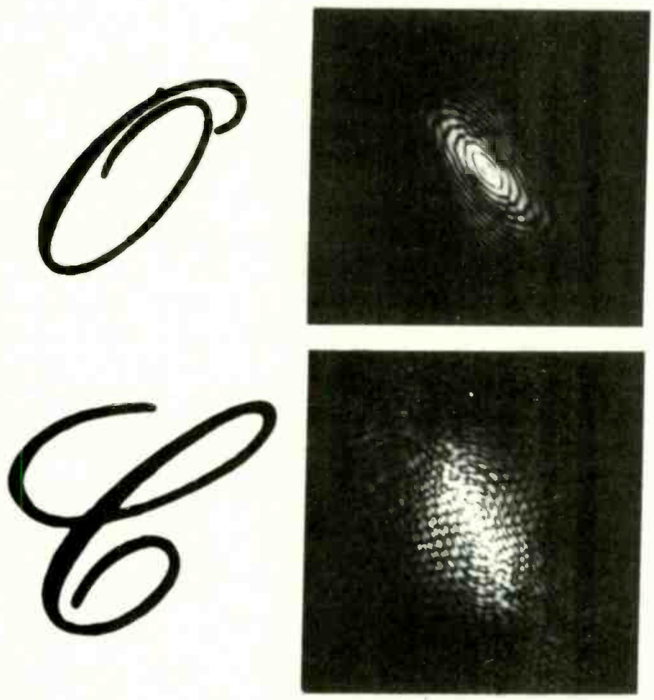


Fig. 5. Optical spatial transforms of two simple figures. (Courtesy A.W.R.E.)

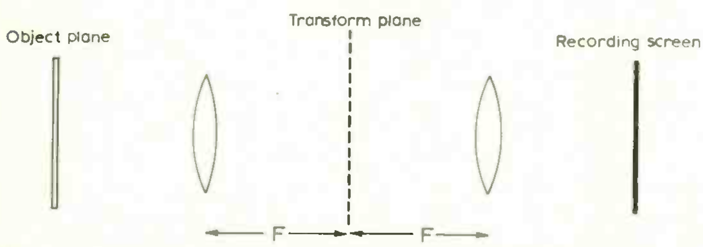


Fig. 6. The spatial Fourier transform of an object is produced in the plane shown by the central dotted line and the original object is reproduced from the Fourier components in the plane on the right. The transform plane is equidistant from two identical lenses of focal length F.

It can be seen that this equation is exactly analogous to that fc the Fourier transform of a time-varying signal. Examples of tł optical spatial transforms obtained with some simple shapes aı shown in Fig. 5.

An optically spatially-varying signal (or pattern) can be syr thesized from its spatial-frequency components simply by adding second lens of focal length F at a distance F from the transforı plane and by moving the recording screen to the position as show in Fig. 6. The spatial Fourier transform of a transparency in th object plane is thus generated in the transform plane and th original object is reproduced in the recording plane. It is nov possible to operate on the transform of the signal. For example i the object transparency lacks detail perhaps due to graininess (i.e noise) an opaque disc placed on the longitudinal axis in the trans form plane removes the low spatial frequency components anc noise, thus accentuating the high-frequency components. Edge and lines in the reproduced image in the recording plane are thu made much clearer than in the original. The disc acts, in fact, as a high-pass filter. A low-pass filter consisting of an opaque shee with a hole centred on the axis of the system removes high-frequency components and can be used, for instance, to remove wrinkles from the face of an aging actress. An opaque annular disc behaves as a band-pass filter.

The technique can be greatly extended[11] and it is possible tc operate on data either in the transform or the image and object planes and effect multiplication, correlation, convolution, an improvement in signal/noise ratio, etc. Spatial processing has the great advantage over electrical methods of signal processing that large quantities of information can be processed in parallel. A typical application might be in the simultaneous processing of the signals from all the inputs of a multi-element aerial array.

If a transparency of a page of print is placed in the object plane then the spatial frequency distribution of each letter and word on the page is produced in the transform plane. Suppose now that a transform is made of the letter T and that a negative of the transform is placed in the transform plane. Then the only light passing through the transform negative, i.e. spatial filter, is that corresponding to the letter T. Thus the only images appearing in the recording plane will be those letters T in the page of print and thus we have a pattern recognition system. The method can be modified slightly to produce spots of light rather than specific letters and one example that has been demonstrated is filtering an integral sign from a page of mathematics. This is potentially a very useful tool in the field of pattern recognition, especially where complex patterns are involved, and one application which is being actively pursued is in the searching of fingerprint files which is at present a very tedious and time-consuming task.

Acknowledgements. The authors wish to make grateful acknowledgement to Professor A. E. Karbowiak of the University of New South Wales, Dr. F. M. Smits and Dr. L E. Gallaher of the Bell Telephone Laboratories and Mr. C. D. Reid of the Atomic Weapons Research Establishment for permission to reproduce figures as indicated in the captions.

Appendix

Basic properties of lasers

In Fig. 7, a population inversion is maintained between two energy levels of the appropriate separation in a laser amplifying medium and the medium is placed in a resonant cavity consisting of two mirrors. If the cavity has a resonance at the frequency at which the active medium behaves as an amplifier, and if the round-trip gain exceeds the total loss, than an output may be obtained if one of the mirrors, M_2 in Fig. 7, partially transmits. Ideally the output is coherent, i.e. it consists of a single-frequency component having a phase front which is coherent in both space and time. The intensity variation across the wavefront is Gaussian and the spreading angle θ of the beam is limited only by diffraction to a value $\theta \approx \lambda/D$ where λ is the wavelength and D the spot diameter at

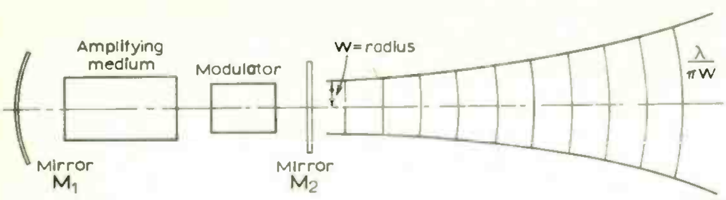


Fig. 7. Schematic diagram of laser with mirrors M_1, M_2 between which are placed amplifying medium and modulator. Output beam is of radius W at M_2 and has beam spread angle of $\lambda/\pi W$.

the output mirror. In practice many factors operate to degrade the output.

Firstly the gain curve of the active material may embrace many cavity resonances so that if, as is usually the case, there is no coupling between the various frequency components of the fluorescence line then multi-mode operation occurs. Secondly the active material, particularly in solid-state and liquid lasers, may be spatially inhomogeneous, resulting in a distortion of the wavefront. Thirdly, in most optically-pumped lasers the rate of stimulated emission is greater than the rate at which energy can be supplied so that operation is intermittent and relaxation oscillations occur. In addition there may be imperfections in the mirrors and windows, non-uniform pumping and so on.

Nevertheless surprisingly good results may be obtained. For example the dominant transverse mode of the cavity can be selected by suitable resonator design or by using an aperture, and by replacing a single mirror with a two-mirror reflector all the available energy may be channelled into a single axial mode. Components can now be made to a high degree of excellence and by stabilising the frequency[13] using solid mountings and perhaps servo-control of the resonator length, gas lasers can produce remarkably pure outputs. A line-width of only a few hertz has been measured and coherence lengths of hundreds of metres are typical. Beam spreads are close to the limit set by diffraction and the ideal coherent beam is approached quite closely.

In solid-state lasers using good quality material inhomogeneity is mainly due to heating because of the high pumping energies normally used but by carefully shaping the laser rod, and with a well-designed resonator, thermal effects can be effectively cancelled out[14]. The high rate at which stimulated emission occurs in solid-state, optically-pumped lasers, which usually prevents satisfactory continuous operation, can be used to produce short, high-power pulses by suitable internal modulation. In what is called Q-switching the cavity Q is made low during the pumping period by reducing the effective reflectivity of one of the mirrors. Then when a large population inversion has been produced the reflectivity is suddenly restored and a pulse lasting for about 20ns results at power levels up to 1GW[15].

A second technique is that of mode locking[16] and it may be applied to any kind of multi-mode laser. Briefly, the phases of the various resonator modes can be locked together so that the output consists of a continuous train of ultra-short pulses. The process is a kind of inverse Fourier analysis in which the various frequency components are generated and then locked in the appropriate phase to give a time-domain picture of a pulse train. For typical solid-state lasers the pulse width is approximately 10^{-12}s so that a new dimension of time scale has been introduced into electronics, and completely novel techniques must be used for measuring pulse lengths as short as this. Such a wave train contains only about 500 cycles of oscillation and occupies a length of only a few tenths of a millimetre. Power levels of 10^{12}W have been produced although the total energy is not large of course. By a combination of Q-switching and mode locking[17], single pulses of this type, and of higher power and energy, can be obtained. Under the high coherent optical fields available from lasers many optical materials become non-linear in response[18]. Second (and higher)-harmonic generation of laser light is a well-established technique which can be carried out at high efficiency and only recently (July 1968) the radiation of a neodymium laser at 10,600Å has been doubled in frequency to 5,300Å with 100% efficiency[19]. This is a remarkable result. Furthermore recent work on parametric interactions has produced optical amplifiers and oscillators which can be tuned[20] over ranges of an octave or more. At present the technique is not an easy one but further developments may be expected in the near future. Recent results with dye lasers have shown that they too can be tuned[21], over a wavelength range of several hundred angstrom units, at quite high power levels.

REFERENCES

1. "The laser" by A. Yariv and J. P. Gordon. *Proc.IEEE,* vol. 51, 1963, p. 4.
2. "Electronic signal amplification in the u.h.f. range with the ultrasonic travelling wave amplifier" by John E. May. *Proc.IEEE,* vol. 53, 1965, p. 1465.
3. "Closing the frequency gap—some recent developments in submillimetre-wave generation" by W. A. Gambling. *Jnl.IEE,* vol. 13, 1967, p. 413.
4. "Optical transmission research", by S. E. Miller and L. C. Tillotson. *Proc.IEE,* vol. 54, 1966, p. 1300. "Optical communications systems—a survey" by J. Lytolis. *Optics Technology,* vol. 1, 1968, p. 1.
5. "Some aspects of beam waveguides for long-distance transmissions at optical frequencies" by G. Goubau and J. R. Christian. *IEEE Trans. Microwave Theory and Devices,* vol. MTT-12, 1964, p. 212.
6. "Gas mixture lens measurements" by A. C. Beck. *Bell System Technical Journal,* vol. 43, 1964, p. 1821.
7. "Dielectric-fibre surface waveguides for optical frequencies" by K. C. Kao and G. A. Hockham. *Proc.IEE,* vol. 113, 1966, p. 1151.
8. "Terminals for a high-speed optical pulse code modulation system" by R. T. Denton and T. S. Kinsel. *Proc.IEEE,* vol. 56, 1968, p. 140. Unpublished report by W. A. Gambling.
9. "Three-terminal GaAs light emitter-modulator device" by F. P. Califano and M. C. Steele. *Electronics Letters,* vol. 4, 1968, p. 411.
10. "Design considerations for a semipermanent optical memory" by F. M. Smits and L. E. Gallaher. *Bell System Technical Journal,* vol. 46, 1967, p. 1267.
11. "Optical and electro-optical processing of information" by J. T. Tippett et al. (Editors), 1965. "A review of optical data-processing techniques" by A. Vander Lugt. *Optica Acta,* vol. 15, 1968, p. 1.
12. "Optical processing of information" by D. K. Pollack et al. 1963.
13. "Frequency stabilization of gas lasers" by A. D. White. *IEEE Journal Quantum Electronics,* vol. QE-1, 1965, p. 349.
14. "Laser brightness gain and mode control by compensation for thermal distortion" by C. Martin Stickley. *IEEE Journal Quantum Electronics,* vol. QE-2, 1966, p. 511.
15. "Q modulation of lasers" by R. W. Hellwarth. *Advances in lasers,* vol. 1, 1966, p. 253.
16. "Ultrashort light pulses" by A. J. DeMaria, D. A. Stretser and W. H. Glenn. *Science,* 1967, p. 1557.
17. "Laser cavity dumping using time variable reflection" by W. R. Hook, R. H. Dishington and R. P. Hilberg. *Appl.Phys. Letters,* vol. 9, 1966, p. 125.
18. "Non-linear optics and problems of coherent radiation frequency conversion" by S. A. Akhmanov and R. V. Khokhlov. *Radio Engineering and Electronic Physics,* vol. 12, 1967, p. 1895.
19. "Continuous 0·532μ solid-state source using $Ba_2NaNb_5O_{15}$" by J. E. Geusic, H. J. Levinstein, S. Singh, R. G. Smith and L. G. Van Uitert. *Appl.Phys.Letters,* vol. 9, 1968, p. 306.
20. "Continuous optical parametric oscillation in $Ba_2NaNb_5O_{15}$" by R. G. Smith, J. E. Geusic, H. J. Levinstein, J. J. Rubin, S. Singh and L. G. Van Uitert. *Appl.Phys.Letters,* vol. 12, 1968, p. 308. "Optical parametric oscillation in the visible spectrum" by J. A. Giordmaine and R. C. Miller. *Appl.Phys.Letters,* vol. 9, 1966, p. 298.
21. "Continuously tunable narrow-band organic dye lasers" by B. H. Soffer and B. B. McFarland. *Appl.Phys.Letters,* vol. 10, 1967, p. 266.

Wireless World Logic Display Aid

4: Character positioning. Forming the output variables

*designed by B. S. Crank**

Last month, amongst other things, we saw how the characters could be formed within the sub-matrices and it was mentioned that the character generators operated under the control of two signals, called W_0 and W_1. It is worth while re-iterating at this point that during the course of construction the battery power supplies will have to be replaced with suitable bench power supplies as the amount of current taken from the 4.5V supply is considerable.

Forming the W_1 and W_0 signals

The W_0 and W_1 signals, as we have seen, control the character generators and determine when an 0 and when a 1 is to be written on the tube face. We can deduce, from what has gone before, that these signals are only used during the Karnaugh and Truth modes of operation.

For the Karnaugh map the derivation of the W_0 and W_1 signals is simplicity itself as they rely entirely on the mysterious variable Z introduced earlier. All that need be said is when Z is true a 1 is required on the map and when $\overline{Z}$ is true an 0 is required. The Karnaugh mode is represented in equations by the letter K. The W_0, W_1, equations for the Karnaugh mode are therefore:

$$W_0 = K\,\overline{Z} \tag{7}$$

$$W_1 = K\,Z \tag{8}$$

The situation for Truth table presentation is rather more complex. A Truth table is divided into four separate columns. One column each for the variables A, B, C and one column for the result. In this article, for signal generation purposes, columns A and B are treated as a single entity and are represented by the symbol T_{AB}. In a similar way T_C represents the C variable column and T_R represents the result column.

The method of displaying a Truth table in this instrument is shown in Fig. 49. The first table (a) is for a two variable function only, (b) is for a three variable function where C = 0 and (c) is as (b) when C = 1. Some facts immediately come to light on examining these tables: T_{AB} never alters, T_C can either be nothing at all or all 0s or all 1s as dictated by the logic function being illustrated.

We now know what the requirements are, but how can signals be obtained to put all the characters in their proper places?

Examine Fig. 50 in conjunction with Fig. 42. Each square in Fig. 50 represents one of the sub-matrices and if looked at in terms of the variables C, D, H and G it can be seen that the whole thing forms yet another Karnaugh map. Clearly each sub-matrix can be individually addressed in terms of C, D, H and G so that these variables can be used to derive the W_0 and W_1 signals for Truth table display.

Firstly we will derive the expression for positioning the 0s in columns T_{AB}. The Karnaugh map for this is shown in Fig. 51. The 0s in T_{AB} have been ringed because it is the position of these that we require. Proceeding with the simplification in the normal way:

loop 1: $\overline{C}\,\overline{D}\,\overline{G}\,\overline{H}$

$\overline{C}\,D\,\overline{G}\,\overline{H} = \overline{C}\,\overline{G}\,\overline{H}$

loop 2: $\overline{C}\,\overline{D}\,\overline{G}\,\overline{H}$

$\overline{C}\,\overline{D}\,G\,\overline{H} = \overline{C}\,\overline{D}\,\overline{H}$

loop 3: $\overline{C}\,\overline{D}\,G\,\overline{H}$

$C\,\overline{D}\,G\,\overline{H} = \overline{D}\,G\,\overline{H}$

therefore:

$$W_0\,(T_{AB}) = \overline{C}\,\overline{G}\,\overline{H} + \overline{C}\,\overline{D}\,\overline{H} + \overline{D}\,G\,\overline{H}$$
$$= \overline{H}\,(\overline{C}\,\overline{G} + \overline{C}\,\overline{D} + \overline{D}\,G) \tag{9}$$

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T_{AB}		T_C	T_R
0	0		?
1	0		?
1	1		?
0	1		?

(a)

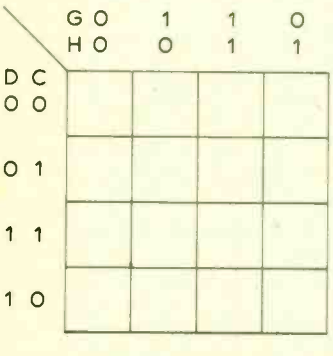
T_{AB}		T_C	T_R
0	0	0	?
1	0	0	?
1	1	0	?
0	1	0	?

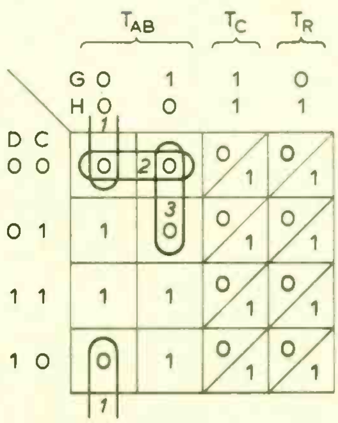
(b)

T_{AB}		T_C	T_R
0	0	1	?
1	0	1	?
1	1	1	?
0	1	1	?

(c)

Fig. 49 Truth table presentation





(left)Fig. 50 The sub-matrices form a Karnaugh map
(right)Fig. 51 Deriving the expression for W_0

What is displayed in column T_C depends on the position of a panel mounted switch. By inspection of Fig. 51 it can be seen that column T_C can be defined by G H. For the time being it will be stated that when G H exists 1s have to be written in T_C and when $\overline{G\,H}$ exists 0s have to be written in T_C. For the record:

$$W_0\ (T_C) = \overline{G\,H} \qquad (10)$$

Turning to column T_R. The as yet unexplained variable Z decides whether a 1 or an 0 is to be displayed in any particular position in column T_R. T_R itself can be defined, by inspection of Fig. 51, as $\overline{G}$ H. Therefore:

$$W_0\ (T_R) = \overline{Z}\,\overline{G}\,H \qquad (11)$$

The complete W_0 equation can now be assembled from equations (7), (9), (10) and (11):

$$W_0 = T[\overline{H}(C\,\overline{G} + \overline{C}\,\overline{D} + \overline{D}\,G) + \text{"}\overline{G\,H}\text{"} + \overline{Z}\,\overline{G}\,H] + K\,\overline{Z} \qquad (12)$$

Notice that the Truth table (T) control signal has been introduced into this equation.

It can be shown, using exactly the same methods as above, that the equations for W_1 are as follows (their derivation being left as an excercise for the reader):

$$W_1\ (T_{AB}) = \overline{H}\ (C\,D + C\,\overline{G} + D\,G) \qquad (13)$$

$$W_1\ (T_C) = \text{"}G\,H\text{"} \qquad (14)$$

$$W_1\ (T_R) = Z\,\overline{G}\,H \qquad (15)$$

therefore:

$$W_1 = T[\overline{H}(C\,D + C\,\overline{G} + D\,G) + \text{"}G\,H\text{"} + Z\,\overline{G}\,H] + K\,Z \qquad (16)$$

The circuit that will produce the discussed W_0 and W_1 functions is shown in Fig. 52 and may now be constructed on board five. The following points regarding this circuit are brought to the reader's attention. The circuit does not produce either the Karnaugh or the T_C terms of the W_0 and W_1 equations. These are produced as another board and fed in on P17/B5 and P18/B5 (see Fig. 46).

The wiring on this board is a little tricky because of the large number of wires; however, as long as great care is taken, no real trouble should be experienced. Some of the board socket pins have been duplicated to avoid having many crossing wires confusing the drawing. As before the white letters in black circles refer to the equations above. After the board wiring has been completed the inter-socket wiring is carried out as indicated.

Testing the W_0 and W_1 generating circuits

Temporarily connect P16/B5 to P17/B5 (coupling the W_0 signal to the 0 character generator) and P18/B5 to P19/B5 (coupling the W_1 signal to the 1 character generator). Also connect a length of wire to P15/B5; this could be terminated in a crocodile clip, the other end of which is attached to the 0V line (simulating $\overline{Z}$).

Switch everything on. Columns T_{AB} should display the pattern of 0s and 1s shown in Fig. 51. Column T_C should remain blank and column T_R should contain all 0s. Disconnect the lead to P15/B5 from earth (simulating Z). Column T_R should now contain all 1s. This test assumed that the probe had not been disconnected from P23/B5.

Again, in the event of trouble, use the probe to trace back through the circuit. There is so much wiring to be done in this instrument that the constructor can really congratulate himself if he gets through it without a mistake; the writer didn't! A wiring mistake can give very peculiar results, or, of course, nothing at all. Leave all temporary connections as they stand as the same wiring will be required for tests after the next stage in the construction.

Adding the T_C signal

The circuit for providing the T_C part of the W_0 and W_1 equations is shown in Fig. 53 and is built on board six. A single-pole three-way test-switch is used to select all 0s, all 1s or nothing at all for column T_C. The reason for placing the G H and $\overline{G\,H}$ terms in earlier equations in inverted commas can now be seen as in reality they are not strictly correct. T_C functions are provided by switching $\overline{G\,H}$ between the 1 and 0 character generators.

After all necessary wiring has been done the circuit should be checked. This is done using the same test circuit as before and ensuring that the switch will produce all 1s, all 0s or nothing in column T_C.

Disconnect the temporary links between P16/B5 and P17/B5, and P18/B5 and P19/B5, leave the rest of the circuit as it is.

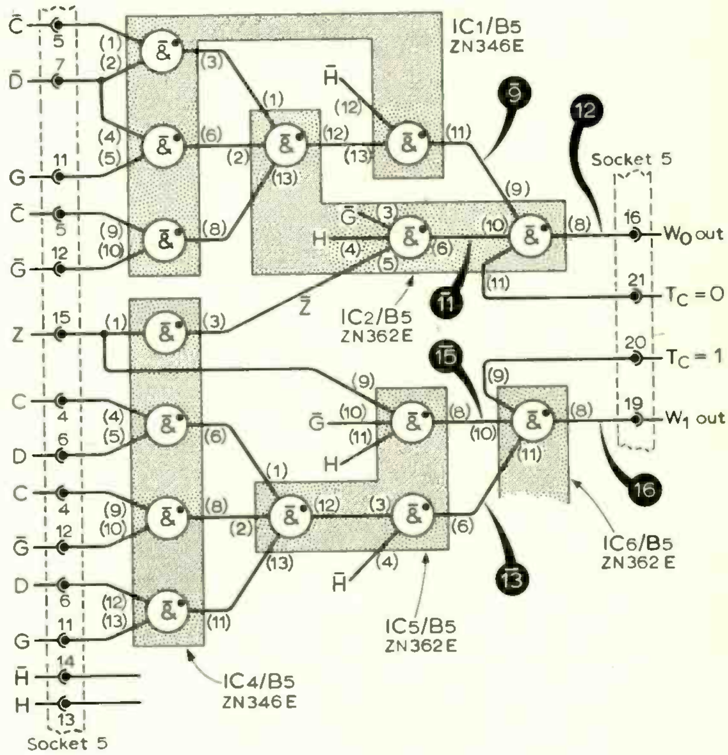


Fig. 52 The circuit for obtaining the Truth table part of the W_0 equation

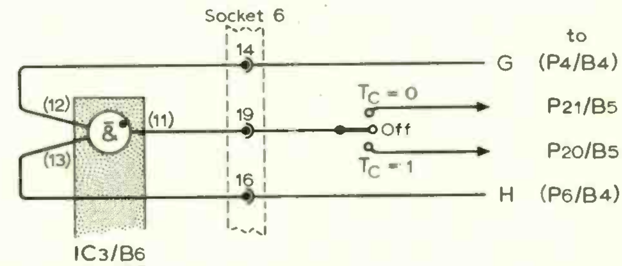


Fig. 53 The circuit for addressing column T_C

Adding control signals

The next stage is to add the missing Karnaugh term to the W_0 and W_1 equations and the Venn term to the video equation. At the same time the V, K and Z control signals are added.

The additional circuits are shown in Fig. 54. The W_0out signal from board five is only the Truth table section of the W_0 equation so this is gated with the Truth table control signal T. This is OR gated with $K\,\overline{Z}$ (equation ⟨7⟩) to form the complete write 0 equation (W_0in) at P21/B6. In the same way the Karnaugh term K Z (equation ⟨8⟩) and the Truth table and Karnaugh control signals are combined to form the composite W_1 signal available at P22/B6. The V Z term from the video equation is also produced in this circuit and is available at P23/B8.

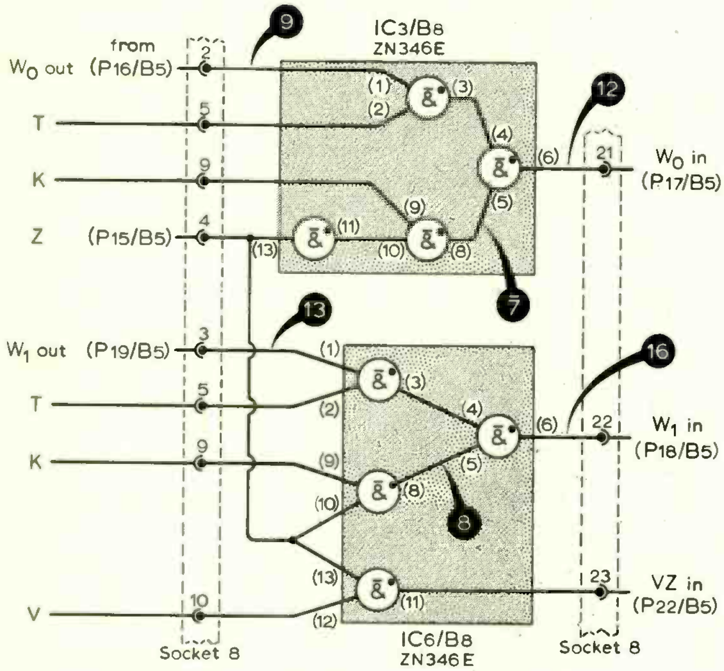
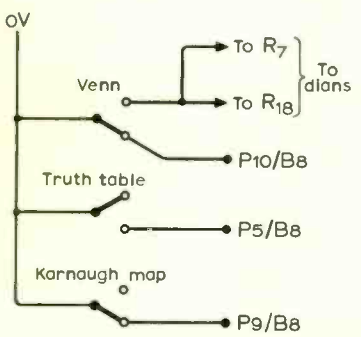
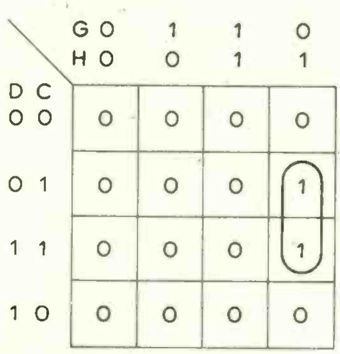


Fig. 54 Adding the control signals





(left) Fig. 55 Control signal switching
(right) Fig. 57 Deriving the expression for A_T

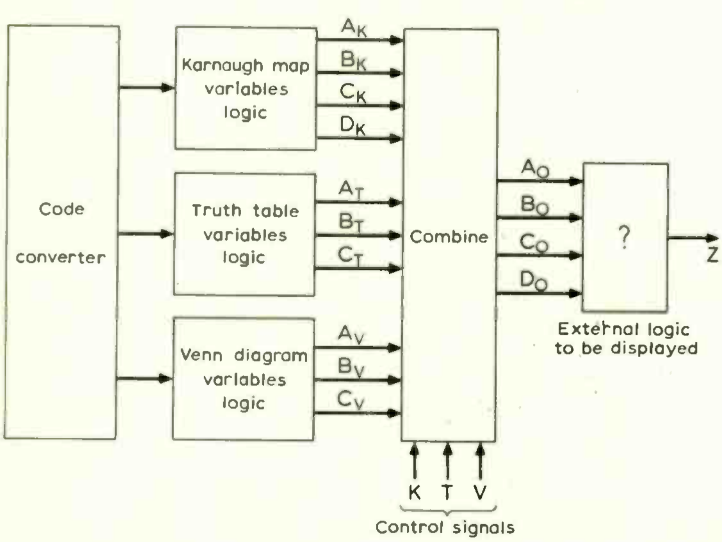


Fig. 56 Showing how the output variables are formed

To test this circuit three single-pole change-over switches are required to provide the control signals. One of these switches also performs the function of the Venn switch that has been used in the circuit so far. The switching circuit is shown in Fig. 55. With the switches in the positions shown the instrument would be operating in the Truth table mode because the K and V signals are at earth potential. Note that one switch controls the dians as well as producing the V control signal.

Complete the wiring shown and when interconnecting P15/B5 with P4/B8 (Z) provide a flying lead terminated in a crocodile clip to either of these pins. Connect the clip to 0V. Place the control switches in the positions shown in Fig. 55 and switch-on the various power supplies.

A Truth table should be displayed with the T_R column displaying all 0s. Disconnect the crocodile clip from earth; the T_R column should now contain all 1s; reconnect the clip to 0V. Check the operation of the switch controlling column T_C and ensure that this operates as before. Operate the Truth table control switch to connect T to earth and open the Karnaugh switch. A pattern of sixteen 0s should be displayed. Disconnect the crocodile clip from 0V and now the display should contain all 1s. At this stage there is no point in operating the Venn switch as the Venn circuits are still incomplete.

It can now be seen that the whole nature of the display hinges on the presence or absence of the as yet unexplained signal Z.

Most readers who have followed this series of articles carefully will have deduced where Z comes from. Fig. 56 tells the story. The signal Z is the output of the external logic to be displayed which can be any logic circuit or even a single gate. The inputs to the external logic circuit are the output variables of the display aid which are called A_O, B_O, C_O and D_O.

In the Karnaugh mode the Karnaugh variables, designated A_K, B_K, C_K and D_K, are decoded from the code converter outputs and become the output variables (A_O, B_O, C_O and D_O) under the influence of the control signal K. In the same way the Truth table variables, A_T, B_T and C_T, and the Venn variables A_V, B_V and C_V are decoded from the code converter outputs and used as output variables under control of the T and V control signals.

With this knowledge we can write the equations for the output variables:

$$A_O = KA_K + TA_T + VA_V \qquad (17)$$

$$B_O = KB_K + TB_K + VB_V \qquad (18)$$

$$C_O = KC_K + TC_T + VC_V \qquad (19)$$

$$D_O = D_K \qquad (20)$$

Forming A_O

Referring to Fig. 10(a) it can be seen that the area occupied by A_K is a horizontal section across the centre of the map. Examining Fig. 42 will show that this area of the map can be addressed by C. C is true for this whole area and is not true for all other areas, therefore:

$$A_K = C \qquad (21)$$

This can be demonstrated on the circuits that have been constructed so far. With the instrument in the Karnaugh mode the flying lead that was connected last month to P15/B5 and P4/B8 can be connected to the code converter output C on P4/B3. Under these conditions the first horizontal row of the map should contain all 0s, the next two rows should contain all 1s and the last row should contain all 0s. The 1s show the area of the map where A_K is true. Disconnecting the flying lead from C and reconnecting it to $\bar{C}$ on P3/B3 will reverse all 0s and 1s on the display showing the area where $\bar{A}_K$ exists, because $\bar{C} = \bar{A}_K$.

No additional logic was required for form A_K, this applies to all the Karnaugh variables. This is to be expected as our matrix-raster is really Karnaugh map.

The next term in the A_O equation (17) is the Truth table variable A (A_T). It will be recalled, in fact it can be demonstrated on the circuits built so far by switching to the Truth table mode, that the display in the first three columns; T_A, T_B and T_C; is fixed and that we only require the variable Z in the result or T_R column. Because of this it is only necessary to allocate areas for the variables in the T_R column. It should be remembered also that the T_R column was addressed by $\bar{G}H$, a fact that can be verified by examining Fig. 51. It would also be true to say that A_T exists in T_R in any position that corresponds to a 1 in T_A. A Karnaugh map for the solution of A_T is shown in Fig. 57. The 1s are placed in the same position in column T_R as the 1s appear in column T_A of the Truth table; compare Figs. 51 and 57 to see this.

As the two 1s fall in adjacent squares the terms can be combined to give:

$$A_T = C\bar{G}H \qquad (22)$$

The most difficult variables to produce are those for the Venn diagram. The position of A_V on the matrix raster is shown in Fig. 58. Various areas of this circle have been looped so that the expressions can be derived in a similar manner to that of a Karnaugh map. Because the output of the code converter was only given a unit distance property over pairs of outputs, in Fig. 58, adjacent 1s will not necessarily combine.

Taking loop 1 first. In the Y axis it can be seen that this corresponds to $C\bar{D}$ and in the X axis to G. Therefore:

$$A_V(\text{loop 1}) = C\bar{D}G \qquad (23)$$

Loop 2 is in two sections with a common X address but with separate Y addresses. In the X axis four terms are involved:

$EFG\bar{H}$

$\bar{E}FG\bar{H}$

$\bar{E}\bar{F}GH$

$E\bar{F}GH$

These four terms can be combined in pairs as each pair only differs by one variable, these are shown looped in Fig. 58. In the X direction then:

$$A_V(\text{loop 2. X}) = FG\bar{H} + \bar{F}GH$$

The Y terms, for loop 2, again there are four of them, can be combined in pairs in the same way to give:

$$A_V(\text{loop 2. Y}) = B\bar{C}\bar{D} + \bar{B}CD$$

The composite equation for loop 2 can now be written as the AND of the X and Y terms in the normal way:

$$A_V(\text{loop 2}) = (B\bar{C}\bar{D} + \bar{B}CD)(FG\bar{H} + \bar{F}GH) \qquad (24)$$

Loop 3 encompasses four points in the matrix-raster which can be addressed by two Y terms and two X terms, no simplification is possible. Therefore:

$$A_V(\text{loop 3}) = (\bar{A}B\bar{C}\bar{D} + \bar{A}\bar{B}CD)(EFG\bar{H} + EFGH) \qquad (25)$$

The complete solution for A_V is the OR of the terms for the three loops, i.e. (23) + (24) + (25):

$$A_V = C\bar{D}G + (B\bar{C}\bar{D} + \bar{B}CD)(FG\bar{H} + \bar{F}GH) + (\bar{A}B\bar{C}\bar{D} + \bar{A}\bar{B}CD)(EFG\bar{H} + EFGH) \qquad (26)$$

We now have enough information to form the complete equation for A_O. This is done by substituting equations (21), (22) and (26) into the A_O equation (17):

$$A_O = KC + TC\bar{G}H + V[C\bar{D}G + (B\bar{C}\bar{D} + \bar{B}CD)(FG\bar{H} + \bar{F}GH) + (\bar{A}B\bar{C}\bar{D} + \bar{A}\bar{B}CD)(EFG\bar{H} + EFGH)] \qquad (27)$$

Forming B_O

The explanation for forming A_O applies equally to B_O only the equations are different. For the Karnaugh variable B_K compare Figs. 10(b) and 42. From this it can be seen that:

$$B_K = D \qquad (28)$$

For the Truth table, B_T, the area covered in T_R corresponds to the positions of the 1s in T_B. Examination of Fig. 51 will show that:

$$B_T = D\bar{G}H \qquad (29)$$

The position of Venn circle B on the matrix raster is shown in Fig. 59. The whole section through the centre of

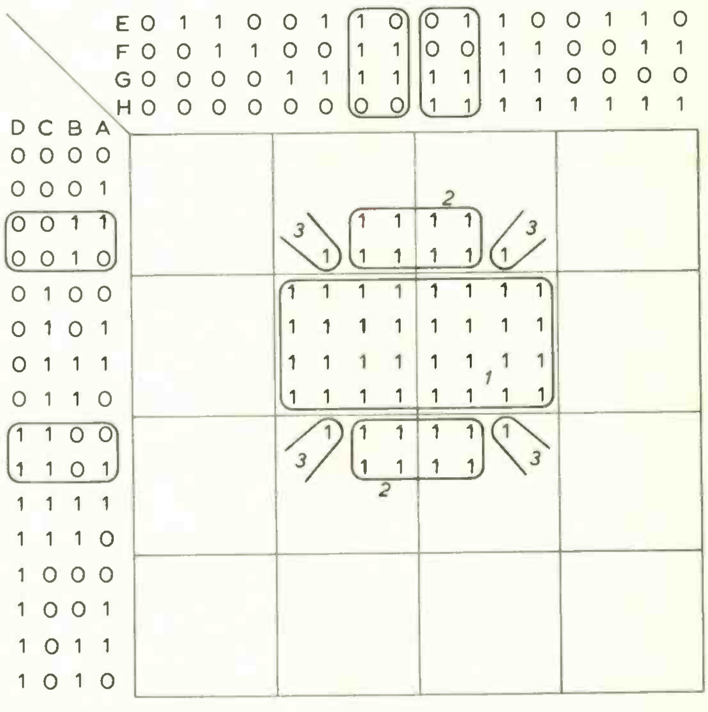


Fig. 58 Deriving the expression for A_V

this circle (loops 1 and 2) is covered by a single Y address. The X address of loops 1 and 2 can be combined into three terms as shown in Fig. 59:

$$B_V(\text{loops 1 and 2. Y}) = CD$$

and:

$$B_V(\text{loops 1 and 2. X}) = F\bar{G}\bar{H} + G\bar{H} + \bar{F}GH \qquad (30)$$

Loop 3, which has two parts, is covered by a single X address and a two Y addresses, as follows:

$$B_V(\text{loop 3}) = G\bar{H}(BC\bar{D} + \bar{B}\bar{C}D) \qquad (31)$$

The remaining loop, 4, requires two Y terms and two X terms:

$$B_V(\text{loop 4}) = (\bar{A}BC\bar{D} + \bar{A}\bar{B}\bar{C}D)(\bar{E}F\bar{G}\bar{H} + \bar{E}\bar{F}GH) \qquad (32)$$

The complete B_V equation is formed by the OR of the four loops:

$$B_V = CD(F\bar{G}\bar{H} + \bar{F}GH) + G\bar{H}(BC\bar{D} + \bar{B}\bar{C}D + CD) + (\bar{A}BC\bar{D} + \bar{A}\bar{B}\bar{C}D)(\bar{E}F\bar{G}\bar{H} + \bar{E}\bar{F}GH) \qquad (33)$$

The final equation for B_O becomes:

$$B_O = KD + TD\bar{G}H + V[CD(F\bar{G}\bar{H} + \bar{F}GH) + G\bar{H}(BC\bar{D} + \bar{B}\bar{C}D + CD) + (\bar{A}BC\bar{D} + \bar{A}\bar{B}\bar{C}D)(\bar{E}F\bar{G}\bar{H} + \bar{E}\bar{F}GH)] \qquad (34)$$

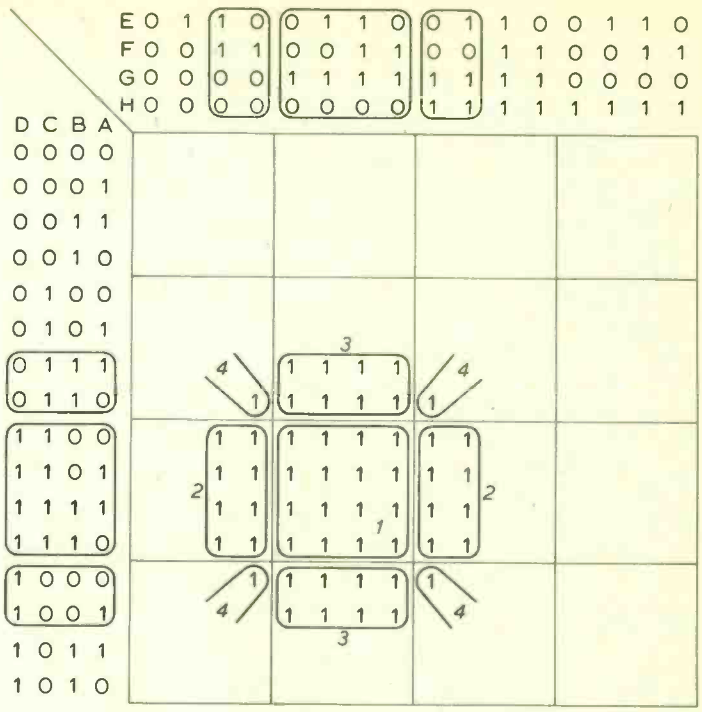


Fig. 59 Deriving the expression for B_V

Forming C_O and D_O

The output variable C_O is formed in exactly the same way and it can be shown that:

$$C_K = G \qquad (35)$$

$$C_T = \bar{G}H \qquad (36)$$

and that (referring to Fig. 60):

$$C_V(\text{loops 1 and 2}) = CD(FG\bar{H} + GH + \bar{F}\bar{G}H) \qquad (37)$$

$$C_V(\text{loop 3}) = GH(BC\bar{D} + \bar{B}\bar{C}D) \qquad (38)$$

$$C_V(\text{loop 4}) = (\bar{A}BC\bar{D} + \bar{A}\bar{B}\bar{C}D)(\bar{E}FG\bar{H} + \bar{E}\bar{F}\bar{G}H) \qquad (39)$$

therefore:

$$C_V = CD(FG\bar{H} + \bar{F}\bar{G}H) + GH(BC\bar{D} + \bar{B}\bar{C}D + CD) + (\bar{A}BC\bar{D} + \bar{A}\bar{B}\bar{C}D)(\bar{E}FG\bar{H} + \bar{E}\bar{F}\bar{G}H) \qquad (40)$$

The final C_O equation becomes:

$$C_O = KG + T\bar{G}H + V[CD(FG\bar{H} + GH + \bar{F}\bar{G}H) + GH(BC\bar{D} + \bar{B}\bar{C}D) + (\bar{A}BC\bar{D} + \bar{A}\bar{B}\bar{C}D)(\bar{E}FG\bar{H} + \bar{E}\bar{F}\bar{G}H)] \qquad (41)$$

It is important to note that the Y terms in the B_V equation are identical to those in the C_V equation—a fact that is made use of in the circuit design.

Finally by inspection of Figs. 10(d) and 42 it can be shown that:

$$D_O = D_K = H \qquad (42)$$

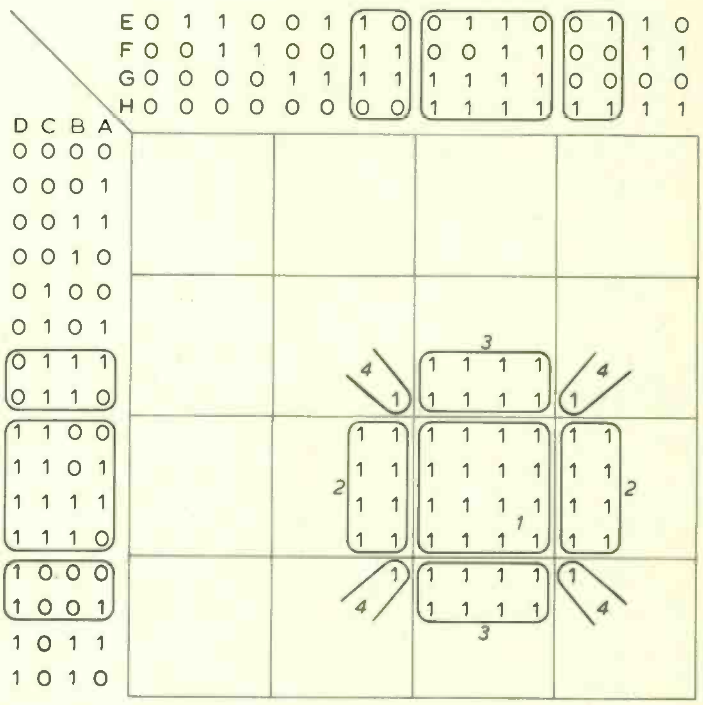


Fig. 60 Deriving the expression for C_V

Figs. 61, 62, 63 and 64 show the logic diagrams for forming the Truth table and Venn output variables which may now be built on the boards indicated and the appropriate inter-board wiring can be carried out. The Karnaugh variables are, of course, direct connections to the code and converter and are not made at this stage.

Next month: Testing the variable forming circuits; more control logic.

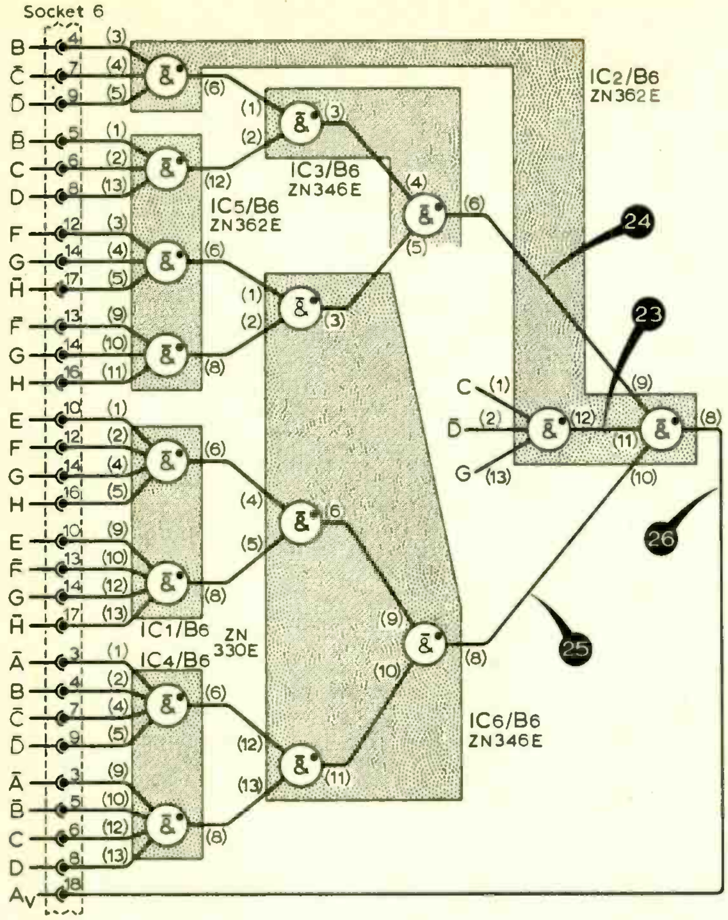


Fig. 61 The circuit to produce A_V

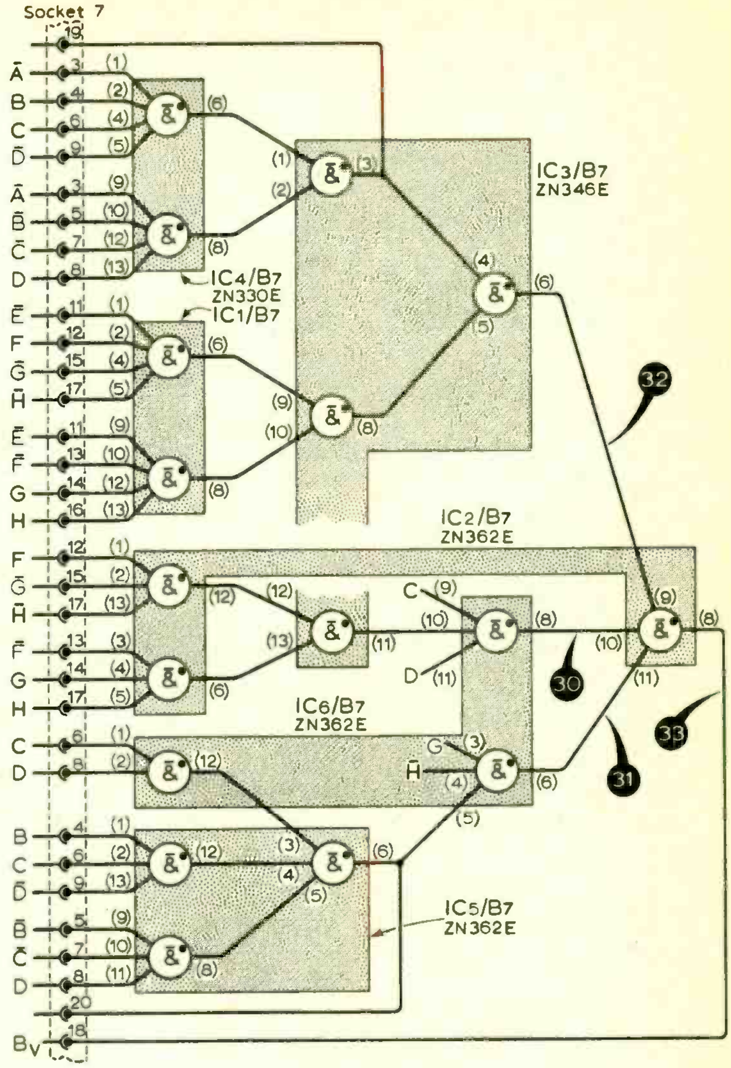


Fig. 62 The circuit which produces B_V

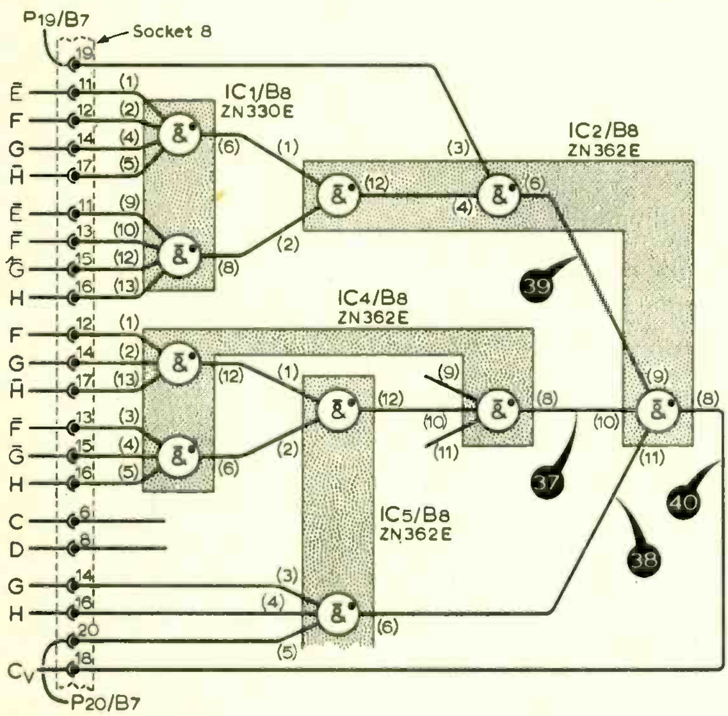


Fig. 63 The circuit which produces C_V

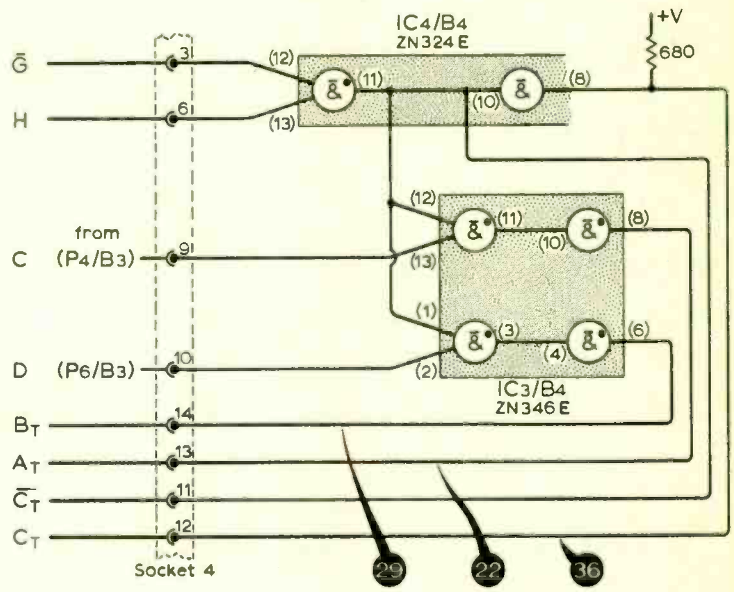


Fig. 64 The circuit necessary to form the Truth table variables

Personalities

Colin H. L. Goodman, M.A., B.Sc., F.Inst.P., has been appointed visiting professor in physics at Chelsea College of Science and Technology, University of London. Mr. Goodman, who is 42, has been with Standard Telecommunications Laboratories, Harlow, Essex, since 1960 and is head of the Materials

C. H. L. Goodman

Synthesis Department. He also acts as a general consultant to the laboratories on problems connected with electronic materials. The aim of the appointment, the first of its kind from S.T.L., is to bring industrial experience to university affairs in general. As well as lecturing in his specialist subject—the preparation and physical properties of materials used in electronics—Professor Goodman will also supervise some of the post-graduate work and act in an industrial advisory capacity.

Eric Willis-Jones, B.Sc. (Eng.), M.I.E.E., chairman of Thorn Automation Ltd, has been elected chairman of the B.E.A.M.A. Industrial Control and Electronics Board. Mr. Willis-Jones received his initial training with the Metropolitan-Vickers Electrical Company and, after various appointments with A.E.I., became managing director of G.E.C.-A.E.I. Control and Rectifiers. He joined the Thorn Group in August last year and is also deputy chairman and managing director of Avo Ltd., and Taylor Electrical Instruments Ltd., both of which are in the Thorn Group.

Robin Davies, M.A., of the B.B.C. Research Department, inventor of the field-store television standards converter, has been nominated to receive the S. G. Brown award and medal for 1969. The award is given annually by the Royal Society (jointly with the Institutions of Civil, Electrical and Mechanical Engineers). Mr. Davies, who is 34 and a graduate of Merton College, Oxford, has been with the B.B.C. since 1958 having previously spent two years with Decca Radar. He recently received the Pye travelling scholarship, worth 1000 guineas, plus a trophy "for the most significant technical contribution during the year to the development of colour television". He described the standards converter in our January 1969 issue.

R. A. Smith, C.B.E., F.R.S., principal and vice-chancellor of Heriot-Watt University, Edinburgh, has accepted an invitation to join the board of Hewlett-Packard Ltd as a part-time director. Dr. Smith graduated at Edinburgh University in 1930 with the degree of M.A. in mathematics and natural philosophy and obtained a B.A. degree at Cambridge University in 1932. Following three years research at the Cavendish Laboratory, Cambridge, he was awarded the degree of Ph.D. in 1936. Dr. Smith was Carnegie Research Fellow at St. Andrews University for two years. Then, after a short period as lecturer at Reading University, he joined, in August

Dr. R. A. Smith

1939, the Telecommunications Research Establishment (later the Royal Radar Establishment) for work on the development of radar, becoming head of the Physics Department there in 1945. He was appointed to the chair of physics at the University of Sheffield in 1961 and the following year was appointed to the chair of physics at the Massachusetts Institute of Technology and director of the Center for Materials and Science and Engineering at the Institute. He has been principal and vice-chancellor at Heriot-Watt University for the past year.

R. M. Glaister, B.Sc., Ph.D., A.Inst.P., recently joined ERG-A.C.I. Ltd., as general manager of their Maryport, Cumberland, electronic components manufacturing plant. The company, a manufacturing division within ERG Industrial

Dr. R. M. Glaister

Corporation and jointly owned with American Components Inc., is engaged primarily in the manufacture of precision metal film resistors. Dr. Glaister, lately chief engineer of the S.T.C. Microwave Transmission Group, graduated at Bristol University where he also carried out research on barrier layer dielectric capacitors to obtain his doctorate. Before joining S.T.C. he was in charge of electronic materials developed at G. V. Planer Ltd.

F. C. Thompson, Ph.D., B.Sc., F.I.E.E., assistant general manager of English Electric Valve Co. since 1962 has been appointed to the board. After graduating from Liverpool University, Dr. Thompson served with A.A. Command before becoming a senior scientific officer at the Telecommunications Research Establishment, Malvern, in 1942. He joined E.E.V. in 1945 as engineer in charge of microwave tube production, and was manager of the Radar Tube Division from 1956 to 1962. E.E.V. also announces the appointment of **R. H. Deighton** as a director and commercial manager. Mr. Deighton joined the Marconi Company in 1930, becoming chief of sales of the Aeronautical Division in 1945. He moved to the Central Division in 1951, becoming manager in 1954. Two years later he became commercial manager of E.E.V. and was appointed to the board of E.E.V. (Canada) in 1962 of which he has been president for the past year.

Dennis Ward recently resigned his post as manager of E.M.I. Sound Products and has joined the board of B & W Electronics, of Worthing. Mr. Ward has for the past 15 years been almost exclusively concerned with the design and production of high-quality loudspeaker units at the E.M.I. Cae Mawr Factory, Treorchy.

BIRTHDAY HONOURS

Among those honoured by H.M. The Queen in her Birthday Honours list are:

Knight Bachelor

Raymond F. Brown, O.B.E., Comp.I.E.R.E., joint founder of Racal Ltd of which he was chairman until his appointment by the Government in 1966 as Head of Defence Sales.

C.B.

Professor J. H. H. Merriman, O.B.E., M.Sc., F.I.E.E., senior director of development at the Post Office, and recently appointed visiting professor in the Department of Electronic Science and Telecommunication at the University of Strathclyde, Glasgow.

C.B.E.

Brigadier J. L. Dobie, B.Sc., M.I.E.E., late Corps of R.E.M.E.

A. H. Reeves, senior principal research engineer, Standard Telecommunication Laboratories, who invented pulse code modulation.

O.B.E.

Lieut.Col. F. D. Williams, B.Sc.(Eng.), M.I.E.E., Royal Corps of Signals.

H. Surtees, M.Sc., managing director, Elliott-Automation Space and Advanced Military Systems Ltd.

Miss Rosina Winslade, an assistant secretary to the Council of Engineering Institutions, who receives the award for "services to the Women's Engineering Society" of which she was president from 1965–7.

M.B.E.

J. C. Gallagher, head of relays and links, Transmitter Planning and Installation Dept., B.B.C.

E. C. A. Haviland, chief development engineer, Marconi Instruments Ltd.

O. B. Kellett, F.I.E.R.E., regional wireless engineer, Home Office.

C. J. Macpherson, B.E.M., assistant executive engineer, G.P.O.

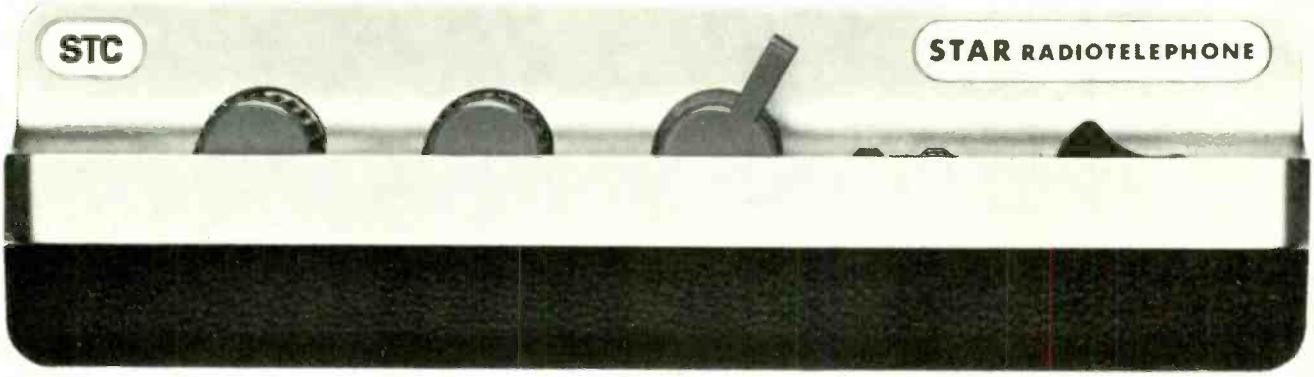
F. A. Messenger, radio officer, Eastern Region, British Railways Board.

I.S.O.

P. A. Hibberd, principal scientific officer, Royal Radar Establishment, Malvern.

B.E.M.

G. E. A. G. Barrett, senior scientific assistant, Radio and Space Research Station, Slough.



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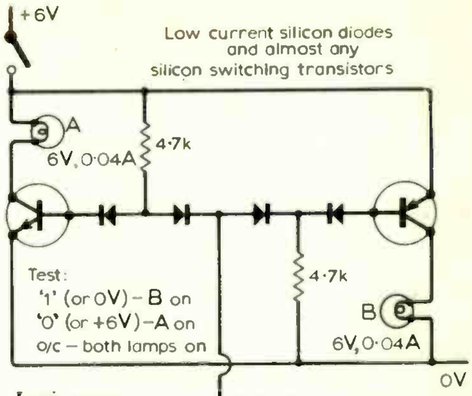


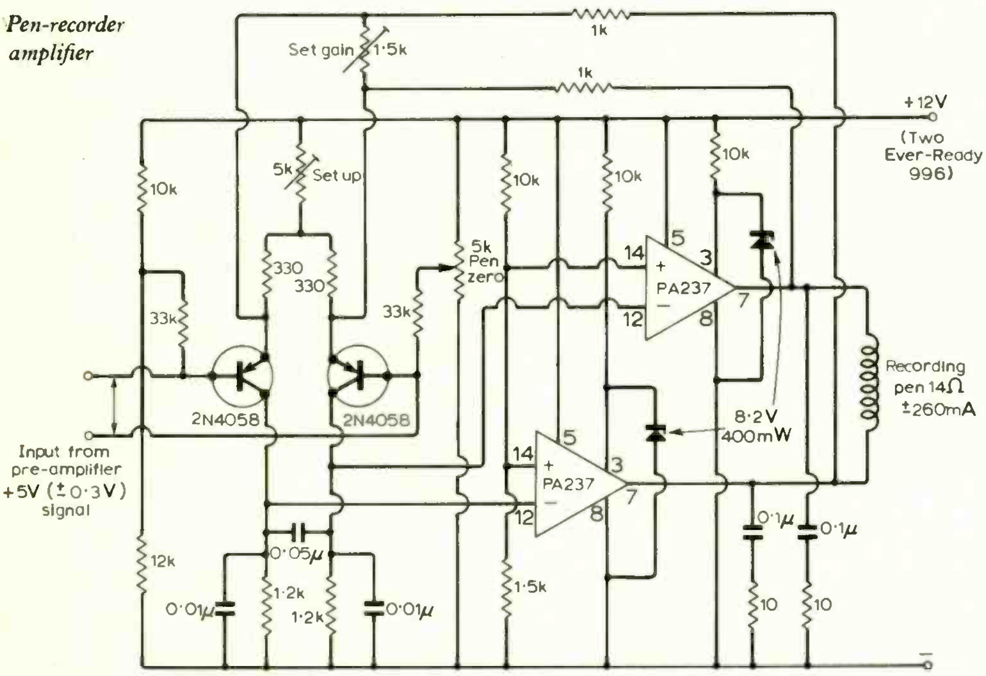
Logic tester

Simple logic tester

This logic-level tester indicates the presence of 1 or 0 in any logic system. It will also indicate the absence of either, i.e. an open circuit. Although primarily intended for static state testing it will indicate pulse waveforms of reasonable duration, say, 100ms or more—and, of course, repetitive waveforms such as the output of multivibrators. The circuit was developed for a +6V system using negative logic but can be adapted for any other system.

R. WILLIAMSON,
Norwich.

Pen-recorder amplifier



Driver amplifier for pen recorder

The construction of a direct-writing electrocardiograph called for a battery-powered amplifier to drive a moving-coil centre-zero pen recorder with a full-scale deflection of ±260mA from d.c. to 100Hz. The General Electric PA237, with a peak current output of over 500mA (2 W into 15 Ω), made design easy.

The balanced input from a d.c.-coupled pre-amplifier drives the long-tailed input pair, matched for h_{FE} at 1.2mA collector current, to provide a balanced drive to the inverting inputs of the pair of PA237s. The non-inverting inputs are set at 1.55 volts by a potential divider. The pen recorder is bridge-connected across the two i.c. outputs, the *RC* bypass on each being prescribed by the manufacturers to prevent oscillation. Further capacitors are required across the collector loads of the input pair for the same reason, and also to provide high-frequency roll-off. Balanced negative feedback to the emitters of the input transistors ensures linearity and sets gain.

Pin 3 on each i.c. is provided so that the external load resistor of the amplifying stage can be boot-strapped to the output for maximum positive voltage swing when used as an audio amplifier, and this is not feasible in d.c. applications. However, a pair of zener diodes of suitable voltage rating here, limit the positive output voltage swing in each i.c.

The preset long-tailed pair emitter resistor sets the output voltage to a mean of 4.5V, allowing a positive swing to 6.5V, and a negative fall to 2.5V.

G. B. C. HARROP,
Leeds 16.

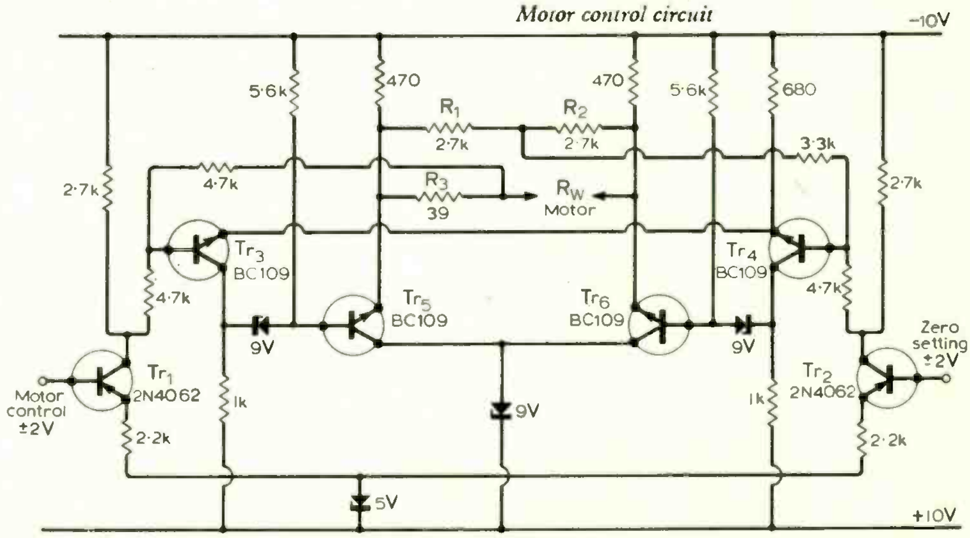
Motor control circuit with 200:1 speed range

In this circuit the motor driving voltage is made proportional to the difference between the control signal and the back e.m.f. of the motor. The latter are kept nearly equal and the small difference is amplified to drive the motor. The motor winding, of resistance R_W, is connected in one of the arms of a bridge (R_1, R_2, R_3, R_W). If $R_3 = R_W$ and $R_1 = R_2$ a voltage proportional to the back e.m.f. appears across the bridge[1]. A speed range of at least 200:1 has been obtained using an Ether type 950A motor with an armature resistance of 40 Ω and rated at 2.5V.

V. B. GERARD,
Dept. of Geodesy and Geophysics,
University of Cambridge.

1. Butterworth, H. M., "Speed control of d.c. model motors", *Wireless World*, Sept. 1967.

Motor control circuit



Letters to the Editor

The Editor does not necessarily endorse opinions expressed by his correspondents

Long-distance TV reception

On 30th May, I witnessed a phenomenon which I thought to be impossible. Reception of BBC-1, Channel 3, was badly distorted by foreign interference. By 19.20 G.M.T. the sound was swamped by a French station and the picture began to fade at intervals into a faint suggestion of another picture.

I tuned into other channels to check interference. On Channel 5, reception of French sound was perfect. On Channel 2, the impossible happened. A perfect picture was obtained of Tele Soir, the only abnormality being a double picture, side by side. The contrast at the peaks was better than normal BBC-1. We watched the French News for ten minutes (General de Gaulle's holiday being prominent) and then watched election speeches intermittently until 20.00. The sound was heard either by retuning Ch.2, or changing to Ch.5.

At 20.00 hrs, I went to fetch tools to realign Ch.2 to receive both vision and sound together. When I returned, the picture had disappeared because of swamping by Spanish sound!

First, we are 500 miles from the nearest point of France, and over 800 miles from Spain. Secondly, I understood that French TV uses negative modulation, but the technical editor of this journal informs me that the signal probably originated from one of several 20-kW "1st Programme" transmitters in the north of France. These transmit with positive modulation on 819 lines which is near enough double our 405 lines to lock the line timebase on a British receiver. This type of freak picture reception from France has been reported on several occasions in the past, but I have not heard of such great distances as were involved in this case.

For interest, the set is HMV 2614, and the aerial a Bands 1 + 3 modified Yagi aligned 228° true. I should be pleased to hear the comments of other readers, and their experiences of freak reception.

J. E. SCOTT,
Lochgilphead,
Argyll.

Who's to blame?

Mr. W. R. Seymour in his letter (July issue, p. 335) makes a valuable point by highlighting the paradox of the inexpensive bookshelf speaker calling for a costly amplifier to drive it satisfactorily.

The impedance/frequency curve of the speaker in question is by no means atypical as may be confirmed from any textbook on loudspeakers. Nevertheless, such speakers can be satisfactory in use since the increases in impedance are allied to increases in efficiency resulting in a smooth frequency response under constant voltage drive conditions.

At first glance it appears that a simple 10-W amplifier should suffice, the drop in delivered power at the frequencies in question being compensated by a corresponding increase in speaker efficiency. Unfortunately, many amplifiers rely on large quantities of feedback, both negative and positive (through the bootstrap circuit) to achieve low distortion, and such feedback is derived from a common point with the speaker. A rise in speaker impedance results in an abnormal amount of signal being injected into the feedback lines. This, together possibly with fluctuations caused in the h.t. rail, results in serious degradation of the sound.

The customary commercial answer is to drive bookshelf and other low-sensitivity speakers from amplifiers having considerably more power than the 10-W specified, since speaker load vagaries have little influence on an amplifier running at a fraction of its nominal rated power.

In the light of the above considerations we must apportion blame to any loudspeaker manufacturers who fail to make clear the loading imposed by their speakers and to amplifier manufacturers who fail to make clear the limits of acceptable load.

I. G. ABELSON,
Southgate,
London, N.14.

Classification by ability

Mr. Ibbotson's article "Are We Wasting Brain-power?" in the July issue was interesting and his suggested remedies to the existing system (or lack of system) would go a long way to clean up our "present system of labelling".

It is desirable that a system is not organized that favours students taking their degree on a full-time basis at a certain period of their lives, i.e. before entering employment. It is also important that the student has some control upon his rate of progress which ideally will be self-governed by his innate ability. Both these criteria can be achieved by setting up a system which is a natural extension of the G.C.E. Courses could be put on by polytechnics, colleges of technology, etc., in specialized subjects at various levels and the student awarded a pass certificate in that subject at the end of the year if he has satisfied the examiners practically, orally and by examination. The work that has been carried out by the student and the examination would be assessed by a central body whose function is to maintain, as far as possible, the same level at the various colleges.

In order to obtain a degree in a certain field the student would be required to obtain a series of certificates, the subjects and levels of which would have been previously decided upon for the particular degree.

This system would have the advantage that pressures would, to a certain extent, be removed from the students at examinations since a fail in one subject would no longer mean the possibility of wasting several years' work. I cannot see any virtue in making it essential that the student reaches the final level in all subjects simultaneously. Full-time courses could be pursued as usual with all the well-known advantages offered by them. Organized evening courses for the more mature student, however, would not be difficult to arrange. The student would have control over the rate at which he amasses the necessary certificates depending upon his capabilities and time available.

It is surprising that such a system has not been developed through the C.N.A.A. as it would give equal opportunities to study for a degree, the main criterion being enthusiasm and drive.

In a technologically advanced country that depends so much upon its industry for survival it is essential that a degree-awarding system is set up that will make development of the existing brain-power attractive, enjoyable and available to all.

J. R. HIPWELL,
Chelmsford,
Essex.

Surely we all know that if observed over a large population, "intelligence" has a continuous "normal" distribution (Mr. Ibbotson's article, July p.302). But a university class is a smallish sample taken from the upper end of this distribution; and therefore although we *may* find any value of ability drawn from the continuous distribution we shall probably find gaps in any particular class. Nonetheless the division between "honours" and "pass" is a difficult one and for this reason is often left until *too late* in the course. So am I among those who are excessively eager to classify students? No, not to classify for its own sake, but I am anxious to recognize as soon as possible how to give each student the most appropriate education which is available. I maintain that a "pass" degree which really means "failed honours" does not indicate that the graduate has received a useful education: instead of struggling with mathematical and abstract concepts which in the end he failed to master, that student should have been following a more limited and practically biased curriculum which he could have mastered and so obtained an honest "ordinary" (i.e. not honours) degree. Should such a curriculum be provided in universities? I think it should because the alternatives are unacceptable in the present climate of opinion: either one excludes from the universities all who might possibly fail to achieve honours (and so excludes many who would in fact succeed), or one throws out of the university all who fall below honours standard. Unless prepared to go to one of these extremes, one must have a "pass" course in the university as a safety net.

If the marks of two candidates differed by only 1%, one would be reluctant to give one of them a Class II(i) and the other a II(ii); but as long as classes are not so large as to make the distribution of marks statistically smooth, one stands a good chance of having gaps at about the right place to form boundaries of the different honours classes. But in spite of all that is said about lack of objectivity, one can in practice recognize outstanding ability and the corollary is that one should give no firsts if the candidates at the top of the lists are not good enough, just as it is generally accepted that prizes for literary or architectural competitions should be withheld if no entry of sufficient merit is submitted. Such judgments on a supposedly absolute scale are often distrusted; but university science degree classifications are based on the combination of quite a number of carefully monitored assessments of examination papers, course work, practical work, etc., and are by no means as subjective as is often suggested.

Finally there is the question of the attitude of the Engineering Institutions to the H.N.C. I used to be very sympathetic to the H.N.C. man (or woman, if there be such) but I am not so sure now. In addition to the old London External B.Sc. we now have the C.N.A.A. B.Sc. and are promised that there will be degrees from the Open University. With so much provision will there be any reason for the man or woman who has sufficient ability to gain a degree to go without one?

D. A. BELL,
Department of Electronic Engineering,
The University,
Hull.

Amplifier efficiency

Mr. Abelson's amplifier ("Letters", June p. 274) is essentially an active device in series with a 15 Ω resistor R, and a capacitively coupled load R_L. The circuit essentials are shown in Fig. 1.

The active device has two limiting conditions (a) it can bottom (full on in Abelson's circuit) (b) it can cut off. If the bias point is V_{DC}, then the bias current is $I_{DC}=\frac{V_S-V_{DC}}{R}$.

Thus if the transistor switches off, the capacitor (charged to V_{DC}) will oppose the supply voltage and the instantaneous output voltage will be $(V_S-V_{DC})\frac{R_L}{R+R_L}$. This

Fig. 1 (below)

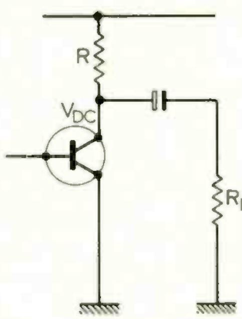
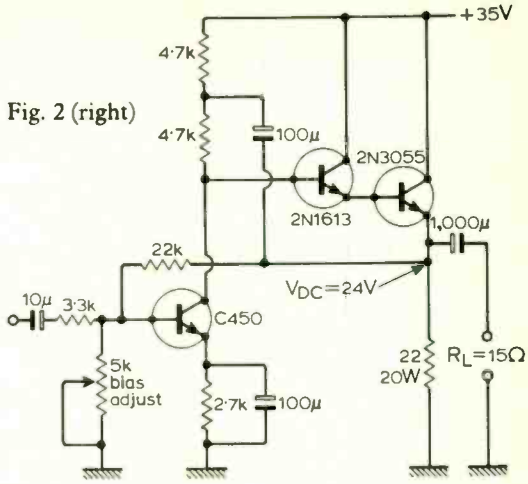


Fig. 2 (right)



represents the maximum positive output signal if the charge on the capacitor stays nearly fixed (as it is meant to). The maximum negative output voltage is $-V_{DC}$ if the transistor bottoms cleanly. One can see that the maximum voltage swing (and hence power output) is obtained when the two limits are of the same magnitude, or else clipping of the signal will occur prematurely.

Thus we have $V_{DC}=(V_S-V_{DC})\dfrac{R_L}{R+R_L}$ $=V_S\dfrac{R_L}{R+2R_L}$. If the load has an arbitrary phase angle (such as a loudspeaker) the analysis can be suitably generalized to give $V_{DC}=V_S\dfrac{/Z/}{R+2/Z/}$ where /Z/ represents the magnitude of load impedance. The minimum load impedance of a speaker is usually close to its d.c. resistance and this value gives the most useful criterion for V_{DC}.

For maximum efficiency, we must calculate power developed to quiescent power dissipated. The dissipated power is $I_{DC}V_S=\dfrac{(V_S-V_{DC})\,V_S}{R}$.

The power developed is $\dfrac{V_{out}^2}{2R_L}=\dfrac{V_{DC}^2}{2R_L}$. Letting $R=r R_L$ we can show, using the earlier formula for the optimum bias point, that the efficiency is given by $\eta=\dfrac{r}{2(r+2)(r+1)}$ and a little bit of calculus shows that $r=\sqrt{2}$ gives a maximum efficiency. For Mr. Abelson's conditions the average power output is $\dfrac{\left[(16)\dfrac{15}{15+15}\right]^2}{(2)\,(15)}=\dfrac{64}{30}$ watts ($\sim$2 watts) but my design gives about 3 watts with just slightly less total dissipation and considerably less heat sink need be used. The bias points to the driver may need alteration and a simple bootstrap to the bias chain would be required for the higher swing.

Several other features of Mr. Abelson's amplifier can be improved. The first stage has a large relative current variation and a small (47 Ω) emitter resistor, which causes considerable distortion (see *W.W.* July 1968 p. 228). This distortion will of course disappear rapidly at lower levels, so that on programme very little distortion is heard. Secondly, the BC119 may have some h_{FE} variation with current, which will lead to a rectification shift in the bias point at large signal level, because the bias resistors are high for the chosen bias current. Why not d.c. couple the driver to the output? A schematic of a circuit that I have built and tested is given in Fig. 2. The measured output voltage just before symmetrical clipping is 6.65 volts r.m.s. into a 15 Ω resistive load (2.95 watts). The bias point for highest undistorted output power is 24 volts across the 22 Ω resistor, in excellent agreement with the theory.

JOHN VANDERKOOY,
University of Cambridge

Amplifier input sensitivity

I have just realized what is an idiotic error in my article in the June "Amplifier Supplement", and one so elementary that readers may feel justified in questioning my sobriety at the time of writing it. I can only offer a feeble excuse, that of a rapidly approaching deadline, the imminence of which was no one's fault but my own.

The second paragraph under the heading "Input Sensitivity" was hastily conceived and is inaccurate. My arithmetic, for example, is quite wrong and any student will know that to attenuate the output of a power amplifier rated at 20 watts, down to 10 watts, the input signal voltage will be reduced by a factor of 0.7 not by half as implied. The remainder is thus reduced to muddled nonsense and I can only hope that readers with charity will overlook this aberration; I, in turn, have been duly rapped over the knuckles by my peers, and will remain in a corner until the next issue, clad in sackcloth and with burnt ashes of the June supplement upon my head.

REG. WILLIAMSON,
Norwich,
Norfolk.

Cross-over distortion

I was very interested to read R. Williamson's survey in the June 1969 issue and can only agree with his comments on cross-over distortions at low output levels in quasi-complementary class B output stages. However, I was surprised to find from the "Audio Amplifier Data" which followed his article that some manufacturers quote very low distortion figures at the 10mW output level apparently using the normal class B quasi-complementary output stage without modification. I would suspect that some of these manufacturers have not actually measured the distortion at this level due to the difficulties involved in measuring a 0.1% harmonic content in 10mW, and that they assume it must be at least as low as the full power level distortion. Can these claims be substantiated?

D. R. RAY,
Rochdale,
Lancs.

Aerial erection

We were interested to read the letter from P. J. A. Innes on page 235 of your May issue. We do, of course, supply our v.h.f./f.m. aerials through our appointed distributors to the retail trade and there should be no difficulty for members of the public to obtain their requirements from any local dealer.

A dealer who does not stock these aerials can, as a matter of course, always obtain any particular model for his customer through his wholesaler, but from Mr. Innes' letter it appears in Essex, at any rate, dealers are not very co-operative in this respect.

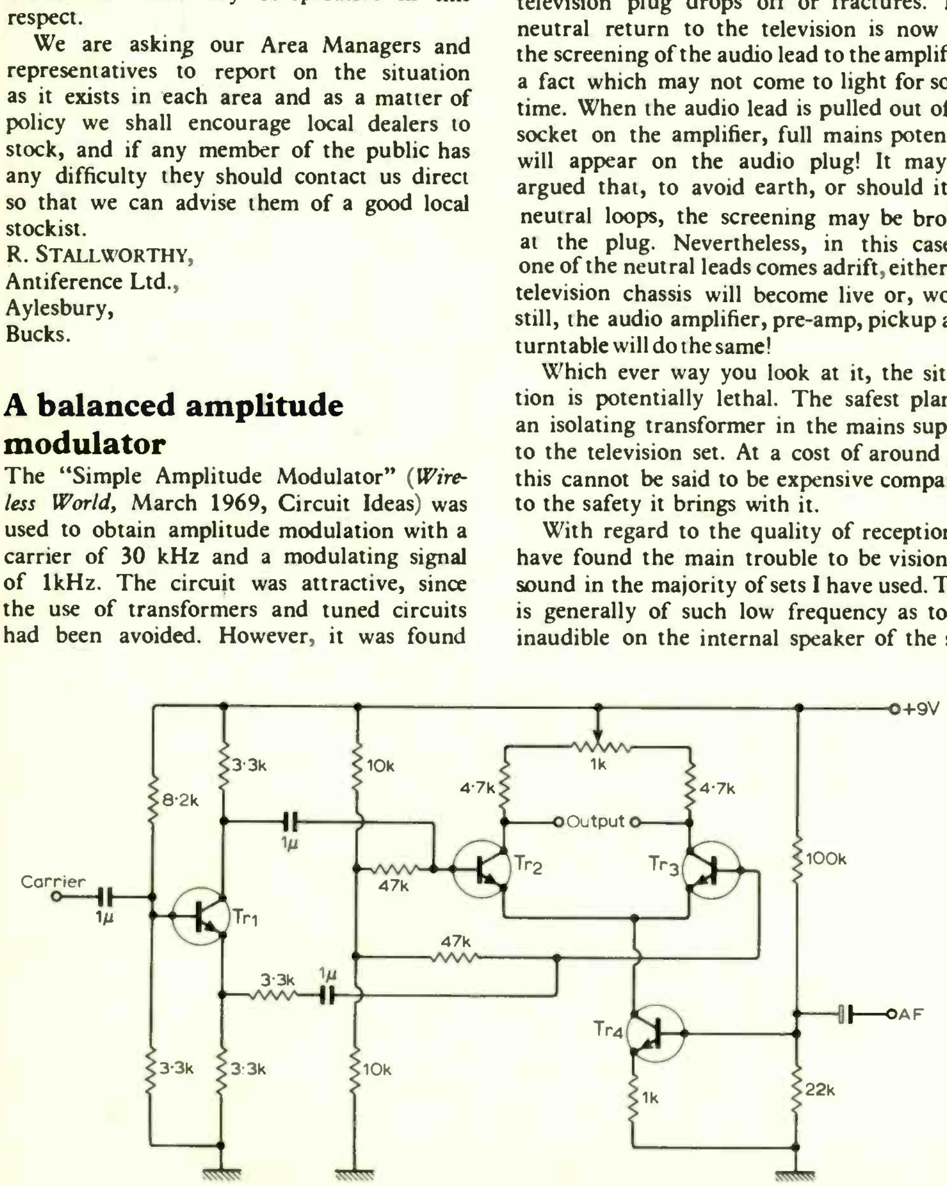
We are asking our Area Managers and representatives to report on the situation as it exists in each area and as a matter of policy we shall encourage local dealers to stock, and if any member of the public has any difficulty they should contact us direct so that we can advise them of a good local stockist.

R. STALLWORTHY,
Antiference Ltd.,
Aylesbury,
Bucks.

A balanced amplitude modulator

The "Simple Amplitude Modulator" (*Wireless World*, March 1969, Circuit Ideas) was used to obtain amplitude modulation with a carrier of 30 kHz and a modulating signal of 1kHz. The circuit was attractive, since the use of transformers and tuned circuits had been avoided. However, it was found that, at the collector of Tr_1 in the said reference, the output was a combination of the modulating signal and the amplitude modulated carrier. Since for the required purpose the presence of the modulating signal was undesirable, the following modification of the circuit has been tried and found useful. The circuit shown below has the additional advantage that by avoiding the use of the bypass capacitor C (of the circuit given in the reference) it presents no restriction regarding the relative choice of the modulating and carrier frequencies. It is however imperative that the difference (carrier) signal between the collectors be used to avoid the presence of the modulating signal.

P. E. SANKARANARAYANAN
and V. S. V. MANI,
Bangalore,
India



High-quality TV sound

Having read the letter from Mr. B. Pollard in the June issue, I am appalled at his suggestion of connecting the chassis of his television set and his hi-fi equipment to the neutral of the mains supply.

Consider what happens under fault conditions. Suppose the neutral wire in the television plug drops off or fractures. The neutral return to the television is now via the screening of the audio lead to the amplifier, a fact which may not come to light for some time. When the audio lead is pulled out of its socket on the amplifier, full mains potential will appear on the audio plug! It may be argued that, to avoid earth, or should it be neutral loops, the screening may be broken at the plug. Nevertheless, in this case if one of the neutral leads comes adrift, either the television chassis will become live or, worse still, the audio amplifier, pre-amp, pickup and turntable will do the same!

Which ever way you look at it, the situation is potentially lethal. The safest plan is an isolating transformer in the mains supply to the television set. At a cost of around £5, this cannot be said to be expensive compared to the safety it brings with it.

With regard to the quality of reception, I have found the main trouble to be vision on sound in the majority of sets I have used. This is generally of such low frequency as to be inaudible on the internal speaker of the set, but somewhat disconcerting on the hi-fi system.

Nevertheless, I must agree with your previous correspondents that the improvement in quality is really worth the small amount of effort and expenditure needed.

The most interesting effect I have noticed is that the background music to documentaries, plays etc., which seems to bring forth the wrath of so many people, falls into its proper perspective when heard through good equipment, whereas it appears very strident and annoying on the built-in speaker. Perhaps some of your readers have noticed this effect as well?

J. WEBSTER,
Critchley Bros. Ltd.,
Stroud,
Glos.

Sampling adaptor

I was very interested in the letter from Mr. Bennée in the May *Wireless World* commenting on the need for a sampling adaptor for use with a 10 MHz oscilloscope.

Your readers may be interested to know that AIM Electronics are the first British company to design and manufacture a sampling adaptor for use with any low-frequency readout device, including oscilloscopes with direct coupled X-inputs (a.c. coupling causes some trace distortion). The instrument can be used to look at signals up to 1GHz.

M. J. HOLLAND,
AIM Electronics,
Cambridge.

Parameters and people

As one very much on the electronic fringe—less than a tyro in hi-fi but concerned with the provision of sound reinforcement without benefit of Union card; and after reading through hundreds of copies of *W.W.* over the years with diminishing comprehension—I was delighted to be able to read and understand "Vector" on organization in the May issue. He has however pointed in the wrong direction.

I have followed, mostly at a distance and sorrowfully, the fortunes of many of the "professional" or "quasi-professional" groups and have seen them one after another eventually reach similar conclusions to his on the desirability of organization—but of the wrong kind.

I have seen professional bodies sworn to eschew trade union organization by their constitutions, form parallel organizations with trade union constitutions and registered as such with virtually the same membership. And others clinging to their vocational respectability until pressures from below force them into action. The Nurses?

I am with Vector up to and (dare I say) including his statement that ". . . we were stupid".

Why does he boggle at *trade* union?

Some do because of the cloth cap connotation—snobbishness in fact!

Some think, like Vector it seems, that trade unions are synonymous with demarcation disputes; strikes; sending to Coventry; affiliation to the Labour Party and the like. The Union I serve (and have served for over 20 years in both honorary and paid capacities) has suffered none of these and there are many the same. Yet have not *highly respectable* "trade unions" like the B.M.A. (Professor Bell and Vector's choice?) threatened to boycott the Health Service; bank employees and their managers taken militant action; and did not (a good comparison?) electrical engineers come close to abandoning their posts some years ago?

Vector dwells on the "latent power of the electronics engineer" the application of which would bring "complete chaos"; then shies away at the prospect, however remote, of a soldering dispute. He can't have it both ways nor need he. The main everyday "power" of the trade union ("Association" is still more acceptable to many) lies in *organization* and all that follows *not* in redblooded militancy. Unfortunately the Press (particularly the "lay" section) blows up out of all proportion the "silly" disputes—these are, it seems, news and, regretfully, many of their readers *want* evidence that the trade unions are wicked and at the bottom of all our ills. Vector with me, recognizes there are other villains. Meantime the enormous amount of joint discussion and activity in industrial and human relations which keep the wheels turning (perhaps to an even greater effect than electronics) go virtually unreported and certainly unsung.

If Vector is right about the redundancy, bewilderment, humiliation and sense of grievance in the profession then there can be no doubt that organization is urgently needed. I have no doubt that for legal, technical and particularly practical reasons trade union organization is the only answer. The problems are not susceptible to the ministrations of learned societies. Professional standards; learned papers; libraries; research and all that these societies undertake so well do not fit them for the hurly-burly involved in, for example, negotiations or in bringing Parliamentary pressures to bear —militant or otherwise. Indeed their vocational pre-occupations may well, as hitherto, militate against the approach necessary to protect their members' bread-and-butter interests. There is a world of difference between dealing with parameters and dealing with people.

Of course the learned societies (at least the sensible ones) are not receptive nor would they be. They are not equipped to deal with the financial jugglers. They are more insular (or snobbish in the nicest sense) than individuals. If they did "bite" they would have to form separate sections to deal with the problems. Any new section would certainly represent "organization" (which I would strongly urge the enlightened to become) but it would be inhibited and could do but half a job.

I have found some antipathies between the "professionals" and the "technical" self-styled elite on the one hand and the "sales" and "admin" types on the other in some organizations and a learned society would probably have similar built-in shortcomings.

Politics have not, I think, been raised but all three political parties are on record as recommending membership of trade unions.

If therefore your professional and technical readers want to have *some* say in their futures, bread-and-butter wise, I urge them to "get organized" and, in the absence of anything better, in a trade union.

My guess is that the up-the-ladder brigade; the shortsightedly ruthless (as is the financial juggler); the politically right; and the don't knows provide sufficient inertia to stop any movement before it starts. If so then, like Vector, may they have the grace in due course to admit it—"we were stupid".

ENIBAS.

Full cycle thyristor firing

In the review of the Physics Exhibition (May issue), we were particularly interested to read about the work done by Derby & District College of Technology using binary logic systems for triac control.

Your readers may like to know that we demonstrated a control system of this type at the E.D.A. Exhibition in Brighton last year, and our demonstration also included automatic protection against failure of the triac irrespective of whether the failure occurred whilst in use or out of use.

Patent applications were filed some time ago on binary and other more complex systems, bearing in mind the possibility of association with computer operation.

G. R. SHEPHERD,
Diamond H Controls Ltd,
Norwich,
Norfolk.

Sterile symbology

I was interested in the letter with the above heading in your July issue (page 335), and whilst in general I find myself in agreement with Mr. Green, I cannot agree with his interpretation of symbol 22.6.8. Having been trained as a power engineer, this to me means a broken and defunct three-phase alternator!

Perhaps other engineers have other interpretations.

M. G. FOSTER,
Croydon,
Surrey.

Components, complaints and complacency

Please accept our congratulations on your June Editorial. We are in agreement with all you say, but would like to enlarge on several points from a retailer's angle.

We have for the last eighteen years endeavoured to supply the amateur constructor with his needs, finding out what new components are coming along and having them in stock. The path we tread is a difficult one and we have often cast envious eyes on wholesalers and manufacturers, who can make immediate increases in prices, while it takes us six months to pass it on to *our* customers.

The basic trouble today is high labour costs—the larger the firm the higher the overheads—and in turn the higher the value of the minimum order they will deal with. At least two large firms asked us if we would deal with all their orders under £5. This is no reflection on their efficiency.

We started off supplying only the general public, but inevitably we had to supply universities, schools, Government Departments and general industrial firms with their small orders. May we at this point mention your reader who was starting a small business and was asked for Trade and Banker's references for a catalogue? Our catalogue costs us £1 per copy and it is necessary that we get some of this amount back. We therefore charge everyone except schools and universities for our catalogue. Small firms are very bad risks, we have found to our cost. Many firms think that headed note paper entitles them to discount, however small their order—no doubt they learn in time that discount depends on quantity. Many large firms expect to run a credit account for an order of under 5s. One such firm, when we wrote and asked for cash, said it was impossible to obtain!!!

One of our almost insurmountable problems is making absolutely sure we have sufficient of any particular component for a design which you may bring out. Even if it were possible for you to tell us in advance what was required, it would not help because no one knows when a project is going to "catch on"—when it does, a situation arises where a component which sells at the rate of twelve in a year suddenly sells fifty in a week. The supplier as well as the retailer is sunk!

A. SPROXTON,
Home Radio (Components) Ltd.,
Mitcham,
Surrey.

Conferences and Exhibitions

Further details are obtainable from the addresses in parentheses

MANCHESTER

Aug. 25-29 — The University
Datafair
(Brit. Computer Soc., 23 Dorset Sq., London N.W.1)

OVERSEAS

Aug. 5-7 — Boulder
Automatic Control Conference
(I.E.E.E., 345 E.47th St., New York, N.Y.10017)

Aug. 19-22 — San Francisco
Western Electronic Show & Convention
(Wescon, 3600 Wilshire Blvd., Los Angeles, Calif.90005)

Aug. 22-31 — Copenhagen
Electronica—Electronics, Radio & TV Show
(Electronica, Grabrodretorv 16, 1154 Copenhagen K)

Aug. 26-28 — Ithaca, N.Y.
Computerized Electronics
(I.E.E.E., 345 E. 47th St., New York, N.Y. 10017)

Aug. 29-Sept. 7 — Stuttgart
German Radio & Television Show
(Stuttgarter Ausstellungs-GmbH, 7 Stuttgart 1, Postfach 990)

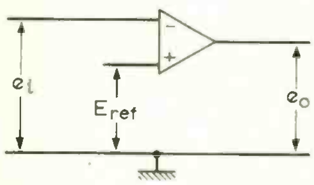
Operational Amplifiers

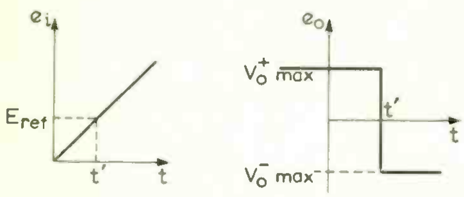
7. Voltage comparators and multivibrators

by G. B. Clayton,· B.Sc., A.Inst.P.*

A comparator is a device used to sense when a varying signal reaches some threshold value. Some operational amplifiers may be used open-loop to provide excellent comparator characteristics. Their very high open-loop gain means that only a very small differential input signal is needed to cause the amplifier output to make a transition between saturated states.

Comparator Using Differential Input.



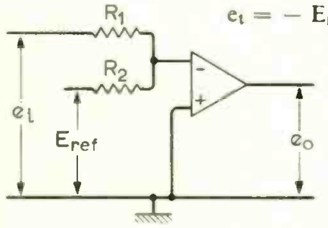


In this circuit the input threshold voltage is equal to E_{ref}. This E_{ref} must not exceed the maximum common-mode voltage (E_{cm}) for the particular amplifier in use. If required e_i and E_{ref} may be interchanged, so changing the polarity of the output transition.

Comparator Using Single Input.

Input threshold voltage

$$e_i = -E_{ref}\frac{R_1}{R_2}$$



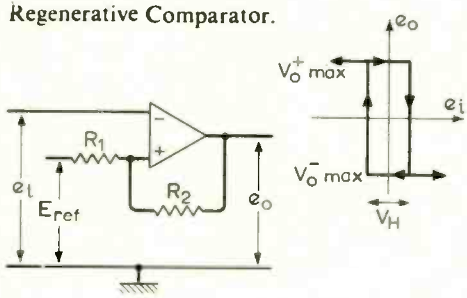
In this arrangement the reference and input voltages are applied to the same input terminal of the op. amp. through appropriate resistors. The other input terminal of the amplifier is earthed and consequently no common-mode limitations exist. E_{ref} may be any convenient voltage opposite in polarity to the signal voltage. The threshold voltage is set by a choice of input resistors.

In both of these comparators the input voltage must swing past the threshold voltage by an amount

$$\frac{V_{o\max}^{+} - V_{o\max}^{-}}{A_{VOL}}$$

for the full output transition to take place. In the case of rapidly changing input signals the output transition time is dependent on amplifier characteristics, but when the input voltage varies comparatively slowly this time is dependent on the rate of change of input voltage. In the latter case it is often advantageous to speed up the output transition time by using some form of regenerative comparator.

Regenerative Comparator.



In this arrangement positive feedback is applied between output and input via resistors R_2 and R_1 and when e_i reaches the threshold voltage the amplifier switches regeneratively between saturated states, the output transition time being made virtually independent of the rate of change of input voltage. The circuit exhibits hysteresis, i.e. the transition takes place for different values of e_i dependent on whether e_i is increasing or decreasing to E_{ref}. The transfer curve for the comparator is illustrated for a value of E_{ref} equal to zero. The input threshold voltage at which the transition takes place has a value

$$\simeq V_{o\max}\frac{R_1}{R_1 + R_2}$$

and with $V_{o\max}$ having its positive and negative saturation values the amount of hysteresis is thus

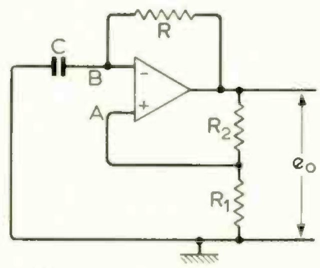
$$V_H \simeq (V_{o\max}^{+} - V_{o\max}^{-})\frac{R_1}{R_1 + R_2}$$

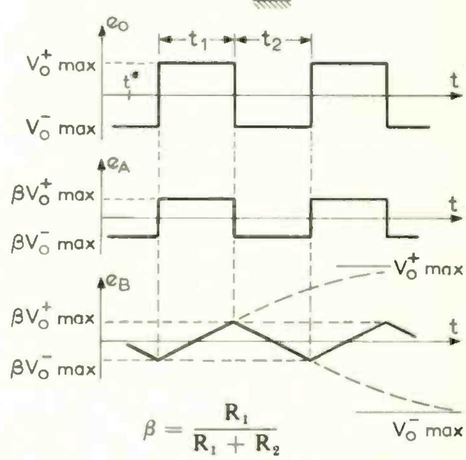
In all comparators outputs may be clamped to desired values rather than using saturation limiting, and it is emphasised again that care must be taken to ensure that reference and input voltages do not exceed allowable limits for common-mode and differential input signals.

Multivibrators

Multivibrators are circuits which provide two possible states. There are three types: astable multivibrators (free running), monostable multivibrators (one shot) and bistable multivibrators (flip-flop). In an astable multivibrator the two states of the circuit are momentarily stable and the circuit switches repetitively between these two states. The monostable multivibrator has only one stable state; it can be made to change to its other state by a suitable trigger, but it then returns to its stable state after a time interval determined by circuit values. The bistable multivibrator has two stable states in one of which it will remain indefinitely until appropriately triggered, when it will switch to the other state. Op. amps arranged with appropriate positive feedback can be made to operate well as multivibrators of all three types.

Astable Multivibrator.





$$\beta = \frac{R_1}{R_1 + R_2}$$

The two states of this circuit between which it switches are those in which the amplifier output is at positive and negative saturation. The output voltage is thus a square wave, its period is determined by the time constant CR and the feedback ratio established by the potential divider R_1, R_2.

Starting at time t^* (above) when the amplifier is in negative saturation and the voltage at terminal A is $\beta\, V_{o\max}^{-}$

$$\left(\beta = \frac{R_1}{R_1 + R_2}\right),$$

* Liverpool College of Technology.

terminal B is positive with respect to terminal A and its potential is decreasing as C charges down through R. When the potential difference between the two input terminals approaches zero the amplifier comes out of saturation and the positive feedback from the output to terminal A causes a regenerative switching, which drives the ampliffer to positive saturation. The voltage across a capacitor in series with a resistor cannot change instantaneously and the potential of the terminal B therefore remains substantially constant during this rapid transition. C now charges up through R, the potential of the input terminal B rises exponentially and the amplifier makes the transition to negative saturation again when B reaches $\beta V_{o_{max}}^{+}$.

A capacitor C with an initial voltage V_i charged through a resistor R by a voltage V_f reaches a voltage V_b in a time

$$t = CR \log_e \frac{V_f - V_i}{V_f - V_b}.$$

Then:

$$t_1 = CR \log_e \frac{V_{o_{max}}^{+} - \beta V_{o_{max}}^{-}}{V_{o_{max}}^{+} - \beta V_{o_{max}}^{+}}$$

$$= CR \log_e \frac{V_{o_{max}}^{+} - \beta V_{o_{max}}^{-}}{V_{o_{max}}^{+}(1-\beta)}$$

$$t_2 = CR \log_e \frac{V_{o_{max}}^{-} - \beta V_{o_{max}}^{+}}{V_{o_{max}}^{-} - \beta V_{o_{max}}^{+}}$$

$$= CR \log_e \frac{V_{o_{max}}^{-} - \beta V_{o_{max}}^{+}}{V_{o_{max}}^{-}(1-\beta)}$$

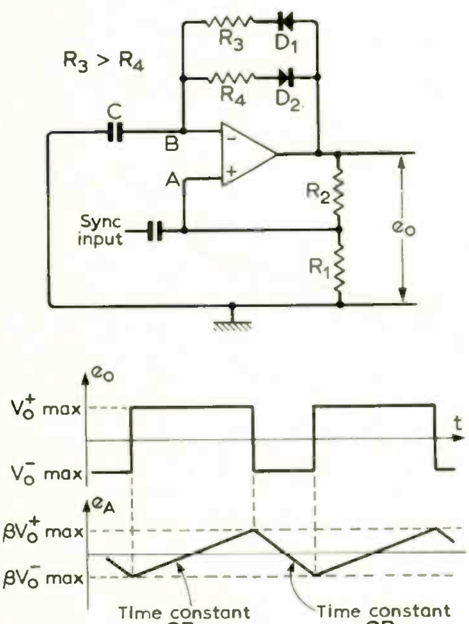
If the positive and negative values of the amplifier saturation voltage have the same magnitude, i.e. if $V_{o_{max}}^{+} = -V_{o_{max}}^{-}$, $t_1 = t_2$ and the expression for the period of oscillation becomes

$$t = t_1 + t_2 = 2\,CR \log_e \frac{1+\beta}{1-\beta}$$

or

$$t = 2\,CR \log_e \left(1 + 2\frac{R_1}{R_2}\right)$$

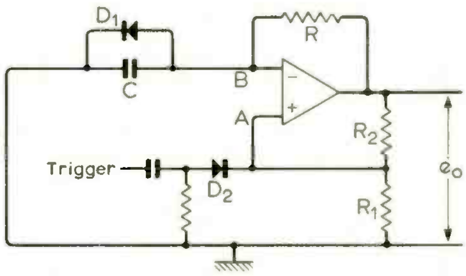
Non Symmetrical Multivibrator.

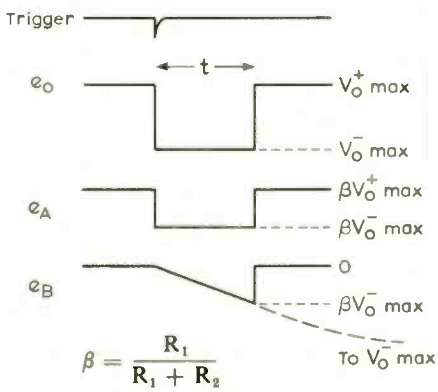


Non-symmetrical operation is obtained by the use of two separate timing resistors R_3 and R_4 as shown. In this circuit the appropriate timing resistor for each timing period is selected by the action of the two diodes D_1 and D_2.

Astable multivibrators may be arranged so that the period is an exact multiple of the period of a synchronizing signal which may be injected into the circuit at the positive input terminal of the amplifier as indicated.

Monostable Multivibrator (1).





$$\beta = \frac{R_1}{R_1 + R_2}$$

$$t = CR \log_e \left(1 + \frac{R_1}{R_2}\right)$$

The connection of a diode D_1 in parallel with the timing capacitor in an astable circuit prevents the phase inverting input terminal (B) from going positive and results in a monostable circuit. In the permanently stable state of this circuit the amplifier output is at positive saturation, terminal B is clamped to earth by diode D and terminal A is positive with respect to earth by an amount $\beta\ V_{o_{max}}^{+}$. If the potential of A is brought down to earth by the application of a sufficiently large negative pulse the circuit switches regeneratively to its temporarily stable state in which the amplifier output is at negative saturation. Terminal A is then negative with respect to earth by an amount $\beta\ V_{o_{max}}^{-}$ and the potential of B falls exponentially as C charges down through R; diode D_1 is reverse biased. The circuit switches back to its permanently stable state when the potential of B reaches the value $\beta\ V_{o_{max}}^{-}$.

The expression for the timing period may be written by making use of the general expression for an exponential charging period, thus

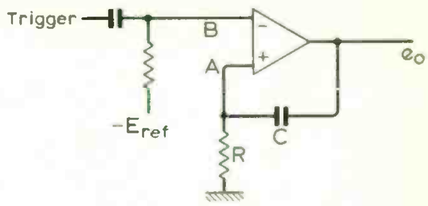
$$t = CR \log_e \frac{V_{o_{max}}^{-} - 0}{V_{o_{max}}^{-} - \beta V_{o_{max}}^{-}}$$

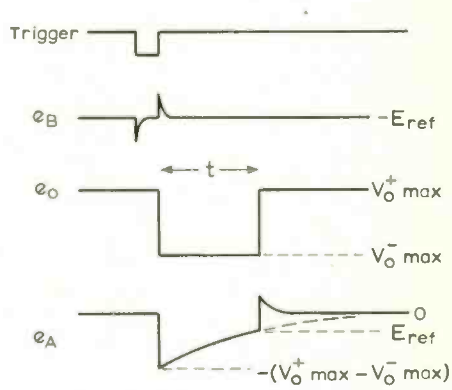
$$= CR \log_e \frac{1}{1-\beta}$$

Substitution for β gives

$$t = CR \log_e \left(1 + \frac{R_1}{R_2}\right)$$

Monostable Multivibrator (2).

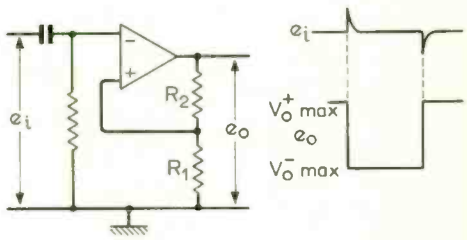




$$t = RC \log_e \frac{V_{o\,max}^{+} - V_{o\,max}^{-}}{E_{ref}}$$

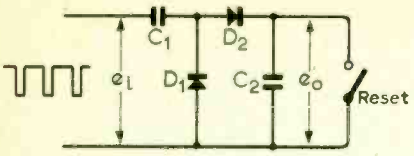
The circuit shows an alternative arrangement whereby the monostable timing period is controlled by the value of a negative reference voltage that is applied to the phase inverting input terminal (B) of the amplifier. The timing capacitor connected between amplifier output and the non-phase-inverting input terminal (A) provides the necessary positive feedback path. In the permanently stable state of the circuit the amplifier output is at positive saturation, the input terminal A is at earth potential and input terminal B is at the reference potential. A positive trigger of magnitude greater than E_{ref} applied to the terminal B brings the amplifier out of saturation and the circuit switches regeneratively to its temporarily stable state in which the amplifier output is at negative saturation. The negative voltage step at the output is communicated to A by the capacitor C, the potential of A then rises exponentially as C charges up through R. The circuit switches back to its permanently stable state when the potential at A reaches E_{ref}. In the expressions above for multivibrator timing periods the effects of amplifier offsets have been neglected.

Bistable Multivibrator.

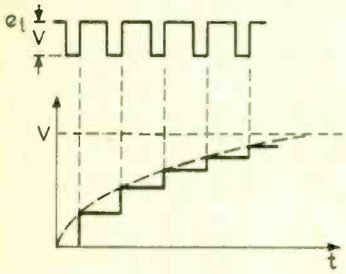


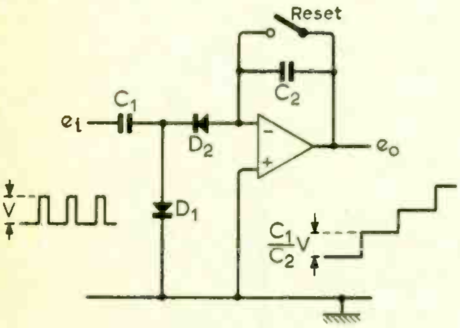
The two stable conditions for this circuit are with the amplifier output at positive or negative saturation. It is held in one or other of these states by the positive feedback applied via resistors R_1 and R_2. A triggering pulse of suitable polarity applied to the phase-inverting input terminal causes the circuit to switch states regeneratively.

Staircase Generator.



Simple diode pump (a)





Linear staircase generator (b)

The output from a simple diode pump staircase generator (circuit (a)) is non-linear. If a sequence of input pulses of constant amplitude is applied the output steps become progressively smaller as the total output voltage approaches the magnitude of the input pulse amplitude. The action of the simple circuit is as follows: The capacitors are assumed to be initially uncharged; the first pulse charges C_1 through D_1 to a voltage equal to the pulse amplitude (V). The time-constant associated with C_1 and the source resistance must be shorter than the duration of the pulse. At the termination of the input pulse D_1 is reverse-biased and the charge on C_1 is transferred through D_2 to capacitor C_2. If C_2 is much larger than C_1 practically all the charge on C_1 is transferred to C_2. The process is repeated at each subsequent input pulse, but as the total voltage on C_2 increases the charge transferred through D_2 at the termination of each input pulse becomes less and less.

In circuit (b) the capacitor C_2 is connected between the output and the phase inverting input terminal of an op. amp. The feedback holds the phase inverting terminal at earth potential; equal increments of charge are "pumped" into C_2 at the termination oi each input pulse and the steps at the amplifier output are thus of equal magnitude.

Both circuits must be provided with some means of resetting the voltage across C_2 to zero after some predetermined number of steps. In (b) amplifier bias current will cause output drift and a practical circuit would require some form of offset balancing (see section on integrator drift.)

Books Received

Semiconductors for Engineers, by P. F. Dunster, is a guide to the semiconductor devices used in modern electronics. It is intended to assist the understanding of the ideas behind the working of these devices, particular emphasis being placed on their function as circuit elements. The approach is mainly qualitative. All the ideas are developed from first principles, making it possible for an engineer with little or no academic background in semiconductor theory to understand the advanced concepts which are explained. Whenever possible, complications beyond the theme under discussion are ignored, and simplifying assumptions are made in order to develop a line of argument more clearly. At the same time, no simplification is taken beyond its usefulness, and at least the nature of the further problems involved is drawn to the reader's attention. (The author is principal lecturer in the Electrical Engineering Department of West Ham College of Technology, London.) Pp.278. Price £6. London Business Books Ltd., Mercury House, Waterloo Road, London S.E.1.

VHF-UHF Manual, by G. R. Jessop. The purpose of this specialized manual is to give a wide range of material for each of the amateur bands, so that the constructor has a selection of designs from which to choose and to suit his own individual need, together with some basic information on general matters. The first four short chapters discuss modulation, propagation, tuned circuits, and filters. Two long chapters cover a wide range of receiver and transmitter designs using both valves and transistors. The final chapters are on mobile systems, single-sideband transmission, aerials, and aerial test gear and accessories. There is a good index. Pp. 244. Price 21s. Radio Society of Great Britain, 35 Doughty Street, London W.C.1.

Designing with Linear Integrated Circuits, edited by Jerry Eimbinder. This book is a collection of 18 contributions by 21 applications engineers drawn from a variety of American i.c. manufacturers. Detailed applications are suggested for the variety of i.cs now available. Applications discussed include a.m. and a.m./f.m. receivers, d/a and a/d converters, logarithmic amplification, active filters, audio amplification, and voltage regulation. Pp.301. A good index is included. Price 105s. John Wiley & Sons Ltd., Baffins Lane, Chichester, Sussex.

Micropower Circuits, by James D. Meindl, is an introduction to the design of semiconductor circuits with quiescent power drain less than one milliwatt. Although written for practising engineers, the subject of each chapter is developed from a fundamental viewpoint. The treatment presumes that the reader is familiar with the basic principles of semiconductor devices and circuits, which include the more prominent features of integrated circuits. It is emphasized that the minimum-power design criterion tends to produce a special-purpose rather than a general-purpose circuit. A wide range of amplifiers, oscillators and digital circuits using bipolar transistor and f.e.ts is discussed There is a concise index and an extensive list of symbols. Pp.257. Price 105s. John Wiley & Son Ltd., Baffins Lane, Chichester, Sussex.

Electrical & Electronic Trader Year Book 1969: Radio, Television and Electrical Appliances. 40th Edition. All sections in this new edition have been revised and brought up to date with details of new wage rates for service technicians, recent legislation, an enlarged service depots section, etc. The continuing aim of this reference book to the radio, television and domestic electrical industries is to assist traders to keep abreast of changes in the industries. Pp.500. Price 35s net (postage 2s 6d). I.P.C. Electrical-Electronic Press Ltd., Dorset House, Stamford Street, London S.E.1.

Announcements

A vacation school on **engineering aspects of microelectronics** will be held at the University of Essex, Colchester, from 15th to 19th September. Details are available from the Secretary, I.E.E., Savoy Place, London W.C.2.

Wolverhampton College of Technology has arranged a course of eight lectures on **high fidelity sound reproduction** to be held on Wednesday evenings from 15th October to 10th December. Fee £2.

A post-graduate evening course of fifteen lectures on **integrated circuit application theory** will be held at West Ham College of Technology, Romford Road, Stratford, London E.15, on Thursdays commencing 16th October. Fee £4.

Donald Blakey Ltd, Montauban Chambers, 339 Clifton Drive South, St. Annes-on-Sea, Lancs, have produced a **film on television servicing** and installation which will become available later this year for rental or purchase.

The Plessey Company Ltd and Illinois Tool Works Inc. of Chicago have formed a joint company in Britain for the manufacture and sale of **miniature electro-mechanical switches.** The new company, Licon Electronics Ltd, will for the present be located at the Plessey factory at Litchfield, Hants.

Celdis Ltd, of 43-45 Milford Road, Reading, Berks, are to act as distributors for **Transistor A.G.'s** range of thyristors, triacs, planar p-n-p transistors and rectifiers.

P.F. & A. R. Helme, Butcher Pasture, Summerbridge, Harrogate, Yorks, have been appointed sole U.K. distributors for **Peerless Fabrikkerne A/S,** of Copenhagen, Denmark, manufacturers of loudspeakers.

Americon Corporation, suppliers of **miniature coaxial connectors,** have appointed Microwave & Electronic Systems Ltd, of Newbridge, Midlothian, as their exclusive stockists and representatives in the U.K. and Eire.

Racal-BCC Ltd have received an order worth £250,000 from the Malaysian Ministry of Defence for 'Syncal' and 'Squadcal' **military manpack radio-telephones.** 'Syncal' is the new synthesized h.f. military radio manpack with 6,000 channels.

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Test Your Knowledge

*Series devised by L. Ibbotson,** B.Sc., A.Inst.P., M.I.E.E., M.I.E.R.E.

15. Semiconductor diodes

1. Silicon junction diodes are being used increasingly for power rectification. The maximum power which can be handled by a single silicon diode (available at the present time) is of the order of:
   (a) tens of watts
   (b) hundreds of watts
   (c) thousands of watts
   (d) millions of watts.

2. Four normal p-n junction diodes of similar construction are made from the materials listed below. The diodes are connected in series across a direct voltage source so that all are forward biased. The diode across which the smallest voltage drop will occur will be that made of:
   (a) germanium
   (b) silicon
   (c) gallium arsenide
   (d) gallium phosphide.

3. Germanium point-contact diodes are used extensively in detection and demodulation circuits for radio and TV. Their advantage in this application, when compared to p-n junction diodes is:
   (a) low capacitance when reverse biased
   (b) low leakage current when reverse biased
   (c) high reverse-bias breakdown voltage
   (d) low forward-bias resistance.

4. A germanium photodiode has a load resistor connected across its terminals. When light of a frequency above the threshold value for electron-hole pair generation falls on the junction:
   (a) no current will flow in the load
   (b) current will flow in the load with a conventional direction out of the p side of the diode
   (c) current will flow in the load with a conventional direction out of the n side of the diode
   (d) the direction of current flow will depend on the value of load resistance.

5. A photodiode is required to feed an amplifier which has a high input impedance. In order that the input signal to the amplifier shall be proportional to the intensity of illumination the photodiode must:
   (a) be unbiased
   (b) have a reverse-bias voltage applied
   (c) have a forward-bias voltage applied of a value less than the diffusion-potential of the junction
   (d) have a forward-bias voltage applied of a value greater than the diffusion-potential of the junction.

*West Ham College of Technology, London, E.15

6. The essential feature of the construction of a tunnel diode is that it must:
   (a) be made of germanium
   (b) have a narrow junction region with very heavily doped material on each side
   (c) have a wide graded junction
   (d) have a wide layer of intrinsic semiconductor between the p and the n doped parts.

7. A germanium tunnel diode is to be used as a v.h.f. oscillator. For this purpose it requires:
   (a) zero bias
   (b) a reverse bias of about 0.2 volts
   (c) a forward bias of about 0.1 volts
   (d) a forward bias of about 0.3 volts.

8. In a backward diode the mechanism of current flow across the junction depletion layer in the low resistance direction is:
   (a) diffusion
   (b) drift
   (c) tunnelling
   (d) avalanching (impact ionization).

9. Voltage stabilizing and reference diodes all are used at a part of their characteristic where the current increases very rapidly with applied voltage. Of the mechanisms of current increase listed below one is not made use of for this purpose. It is:
   (a) thermal generation of carriers in the depletion layer
   (b) carrier tunnelling through the depletion layer
   (c) impact ionization in the depletion layer
   (d) a combination of Zener and avalanche breakdown.

10. The varactor diode, in addition to its use in parametric amplifiers, is used at microwave frequencies for all but one of the following applications. It is *not* normally used as:
   (a) a detector
   (b) a harmonic generator
   (c) a switch
   (d) a limiter

11. The most common use of a p-i-n diode is as a microwave
   (a) oscillator
   (b) switch
   (c) amplifier
   (d) detector

12. The important property of the Schottky-barrier (metal-semiconductor) diode is that:
   (a) it has a very low forward resistance
   (b) it has a very high reverse resistance
   (c) it has a very low diffusion capacitance
   (d) it has a very high depletion-layer capacitance.

13. A p-n junction diode, biased to a reverse voltage at which a significant amount of avalanching occurs in the depletion layer, can be used as a microwave
   (a) oscillator
   (b) switch
   (c) limiter
   (d) detector.

14. The essential feature of the construction of a Gunn diode is that:
   (a) it has two p-n junctions
   (b) it is made from a direct-energy-gap semiconductor
   (c) it has a graded junction
   (d) it has a wide layer of intrinsic semiconductor between the p and n doped parts.

15. The basic difference between a normal Gunn diode and a l.s.a. diode is that:
   (a) the l.s.a. diode has one extra p-n junction
   (b) the l.s.a. diode is used at much lower frequencies than the Gunn diode
   (c) in the l.s.a. diode dipole domains are not allowed to form
   (d) the l.s.a. diode must be made of an indirect-energy-gap semiconductor.

16. Step-recovery diodes find substantial use as harmonic generators to multiply up oscillations produced at v.h.f. into the microwave region. The property which makes the step-recovery diode suitable for this application is that it exhibits:
   (a) a sudden drop of current a short time after the applied voltage changes from forward to reverse
   (b) a negative-resistance region in its forward-bias characteristic
   (c) very low voltage Zener breakdown for both directions of applied voltage
   (d) a discontinuous increase in forward current at a particular applied voltage.

Answers and comments, page 397

Thyristor-stabilized Power Supplies

Essential considerations in the development of d.c. power supplies using thyristor control

*by Arthur R. Bailey**

The conventional method of stabilizing power supplies is to use linear devices as shunt or series regulators with an already smoothed d.c. power supply. For low powers shunt regulation with a zener diode is very common. For high powers a series transistor is normally used as the d.c. power loss is least with this circuit. It is also possible to control the output voltage of a d.c. supply by varying the angle of conduction of the main rectifier diodes.

The main advantage of using thyristors to stabilize d.c. supplies is that the power dissipated in the thyristor is far less than in a series transistor because the thyristor is either 'off' or hard 'on'.

The simplest regulation circuits are those where two of the diodes in a conventional full-wave rectifier circuit are replaced by thyristors (Figs. 1 and 2).

In Fig. 1 it will be seen that the two diodes in a conventional circuit have been replaced by two thyristors, the gates of these thyristors being returned to a fixed positive reference supply which can be obtained from a zener diode. The thyristors will conduct until their gate-cathode potential falls to below about 0.5V when they will cease to 'fire' with forward-applied anode voltage. The output voltage is therefore theoretically held to within a fraction of a volt of the value fed to the gate supply. Unfortunately the circuit does not operate correctly when used in this form, the defect being particularly noticeable at low values of load current. The cause of the trouble is that conduction does not cease when the output voltage is correct, but only when the current falls to zero. At low load values, this has the effect of giving a large step in output voltage when one thyristor fires for its full period. As the load is low the output voltage may exceed the set value for many cycles, and the thyristors therefore conduct in single pulses separated by many cycles. This gives rise to large sub-mains-frequency ripples on the supply line.

To prevent this effect, which is shown in Fig. 3, it is necessary that the thyristors are given a superimposed quadrature alternating voltage on their gate circuits. This has the effect of starting conduction at the end of the possible 'on' period when the supply voltage is nearly correct and opening up the conduction angle as the output voltage falls. Unfortunately this reduces the regulation of the system to some degree, but for stability it is a price that has to be paid. Nevertheless, it is possible to obtain a stability of better than 2% in a 60V supply.

The quadrature stabilizing voltage is readily obtained from the a.c. supply, either by cross-coupled capacitors with the centre-tapped transformer or with an integrating network for both systems. The connections necessary are shown in Figs. 4 and 5.

Either of the two systems mentioned is capable of driving into inductive or capacitive loads such as occur with choke input or capacitor input filters. Tests however indicate that with choke-input filters there is little problem of sub-harmonic generation as compared with capacitor input filters. Unfortunately capacitor input filters are the most common, and even with quadrature voltage fed to the thyristor gates, there is a serious possibility of uneven firing of the thyristors. As mentioned before, this occurs at low values of load currents, so the effect would be serious with a class B power amplifier supply but of no concern with the constant load of a class A amplifier.

The problem arises due to the low output impedance of normal power supply trans-

*University of Bradford.

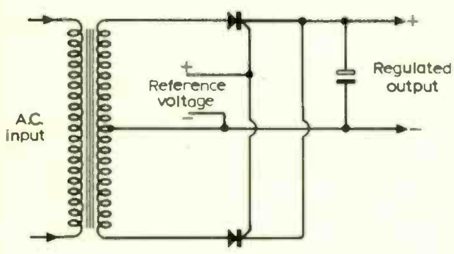


Fig. 1. Basic d.c. stabilizer using full-wave rectifying thyristors.

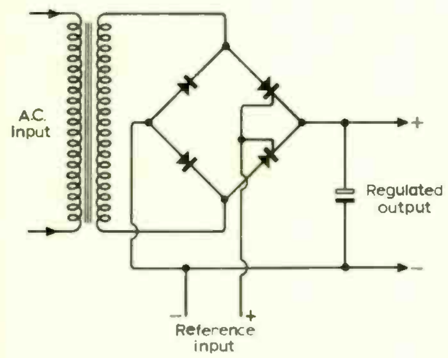


Fig. 2. D.c. stabilizer using thyristors as part of a conventional bridge rectifier.

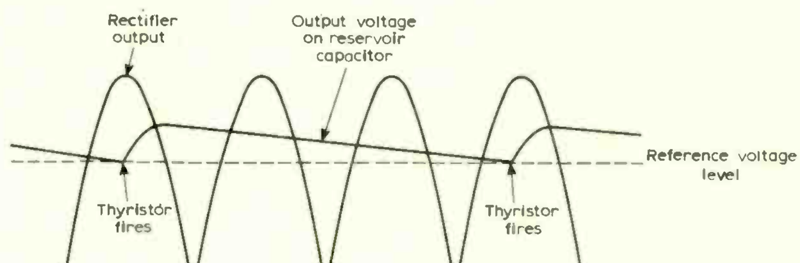


Fig. 3. Sub-harmonic generation caused by a thyristor.

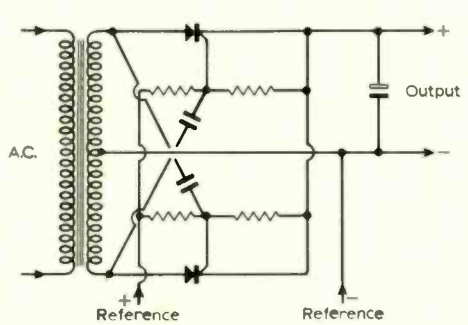


Fig. 4. Quadrature voltage supply obtained by differentiation.

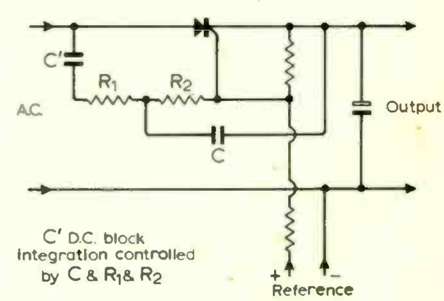


Fig. 5. Quadrature supply obtained by integration.

ormers. If the rate of rise of output voltage on the output smoothing capacitor can be held ufficiently low the trouble does not occur. t is therefore obvious that what is required s a transformer with a fairly large leakage eactance. As this reactance reduces the full-oad output voltage of the transformer, this unfortunately necessitates a greater open-circuit voltage for adequate full-load stabiliza-ion. As large leakage reactances tend to ause bad stray hum fields from transformers t is preferable to use a separate choke for this purpose. This is not readily obtained using the entre-tapped transformer without involving d.c. in the windings, but it is readily applied n the bridge rectifier circuit. The full circuit hen appears as shown in Fig. 11 discussed ater.

Overload protection

For many purposes it is advisable that a power supply be protected against short-circuits. This is particularly important with thyristors, as they do not have good long-period overload characteristics. Provided that the overload can be restricted to say 20% greater than full load current then there is ittle likelihood of serious damage and the supply could be designed to cope with this current on a continuous basis if required. Using a very simple circuit it is possible to give overcurrent protection to the supply with little degradation in regulation. With a little more complexity the regulation need not be affected, and this circuit is shown in Fig. 6.

The basis of operation is that of shorting out the reference voltage supply by a transistor that is turned on when the designed load current is exceeded. The current-measuring resistor R is included in the supply side of the return current path so that its voltage drop does not affect the regulation of the output. As the current in this return lead has a large a.c. component it is necessary to smooth this out before feeding it to the base of the overload sensing transistor Tr_1. When the voltage across this series resistor exceeds about 0.6V, the silicon transistor starts conducting and drops the reference voltage across the zener diode. If the overload is sufficiently severe the output voltage will fall to nearly zero.

For many purposes this overload performance will be quite adequate, but for some applications a more rapid onset of current limitation will be required. For these applications the circuit can be modified as shown in Fig. 7. Here a second transistor is used to amplify the output of the first one with consequent improvement in performance. If necessary, current lock-out can then be applied so that the circuit will trip out until the mains is switched off and then reapplied. This is done by the use of the two resistors shown dotted in Fig. 7. The presence of these resistors gives positive feedback around the two transistors which, if sufficient, will cause the circuit to act in a bistable manner.

An additional refinement that is frequently advisable in power supplies—particularly in audio-frequency amplifiers—is that the output voltage rises smoothly at switch-on. If the time-constant of the output-voltage rise is about a second or so, then unwanted surges in the amplifier can be greatly reduced. This is readily obtained in the circuit by splitting the feed resistor to the zener diode and using a large value decoupling capacitor at the junction of the two resistors. This modification is seen in the 60 volt stabilized supply circuit of Fig. 11.

So far two thyristors have been assumed to be necessary. If a full-wave conventional system is used with a reservoir capacitor, then it is possible to use only one thyristor with a consequent saving in cost. The essential factor is that the reservoir capacitor must be sufficiently large to stop the main rectifiers conducting over part of each cycle. If this condition is fulfilled, then a thyristor can be used in series with a conventional transformer-rectifier configuration before the reservoir capacitor. This is shown in Fig. 8. Here it is seen that the quadrature voltage is obtained by integration of the anode voltage as before. In fact the anode voltage is non-sinusoidal and at double the mains frequency, but the action of integration improves the waveshape and gives perfectly adequate results. The doubled frequency also allows smaller smoothing capacitors to be used.

Practical circuits

Two examples of the application of these types of stabilizer now follow. The first is a case where a sub-harmonic generation is no particular disadvantage and is a controller for model railways. In fact the circuit is useful for low-impedance control of any d.c. motor, but has refinements that can be of particular value to model railways.

In large d.c. motors it is necessary to keep the supply as pure as possible or commutation can be seriously affected. In small motors without interpoles (such as typical 'universal' motors) this restriction does not apply. In the circuit shown in Fig. 9 the size of the smoothing capacitor is deliberately kept small so that the motor runs on only slightly smoothed rectified a.c. During the rectifier 'off' state, the resonant circuit formed by the motor inductance and resistance, and the small reservoir capacitor, resonates and destroys the stored energy. For small motors of low efficiency the circuit is heavily damped and the current falls to zero value before the next rectifier 'on' period. This means that the zener diode reference that determines the gating of the thyristor is therefore measuring the actual back e.m.f. of the machine. The circuit therefore is relatively insensitive to motor-

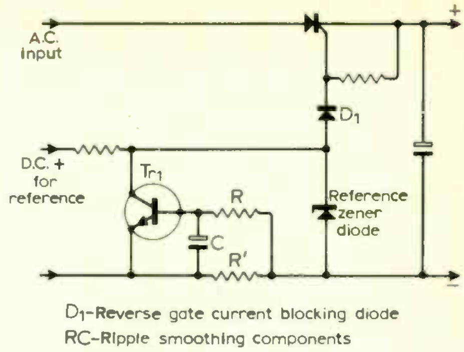


Fig. 6. *Overload protection circuit.*

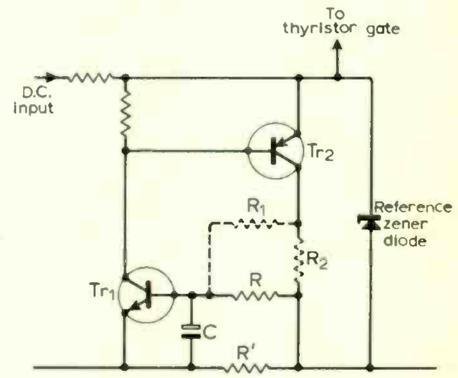


Fig. 7. Overload protection circuit giving more abrupt control than Fig. 6.

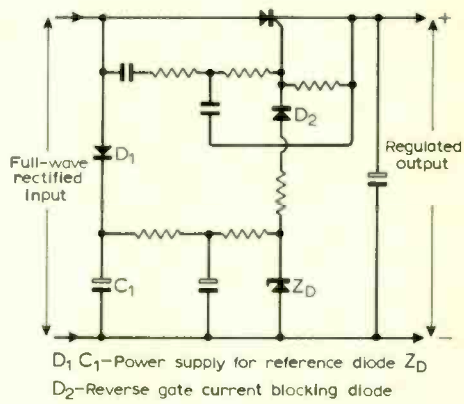


Fig. 8. Basic stabilizer circuit diagram for a single rectified input.

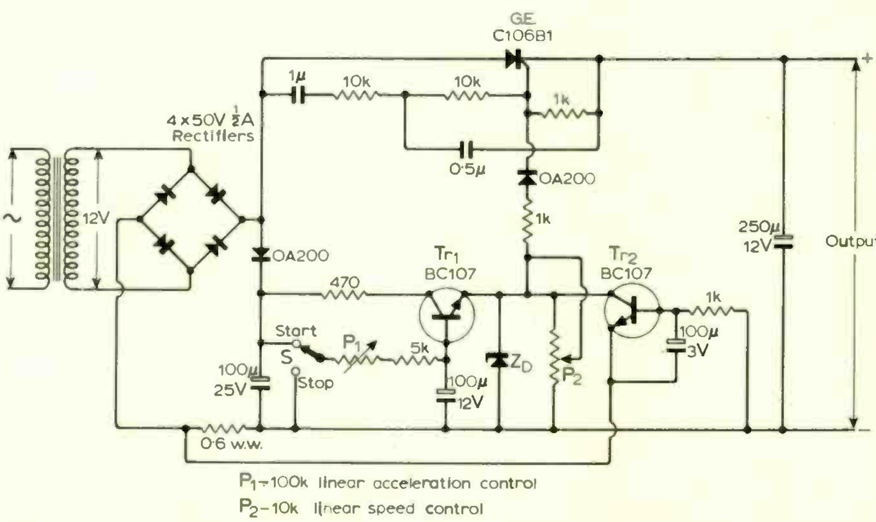


Fig. 9. Speed control system for small permanent-magnet or separately excited d.c. motor.

resistance drop and tends to run at constant speed irrespective of load. In practice the applied mean d.c. voltage to the motor rises as mechanical load is applied, the motor speed remaining approximately constant. When stalled nearly the full supply voltage appears across the motor. This performance is far better than that of a stabilized d.c. supply such as is obtained from a conventional smoothed regulator.

It is suspected that many of the thyristor electric drill controllers utilize this effect, relying on the residual magnetism in the field for the back e.m.f. generation.

As the thyristor is a rectifier in its own right, it is unnecessary to use a bridge rectifier if a transformer of twice the voltage is used for the supply. In this case the thyristor is gated at half the previous frequency and the amended values and parts of the circuit are shown in Fig. 10.

The overall performance of the circuit is extremely good and allows better 'constant-speed' characteristics to be obtained from small motors.

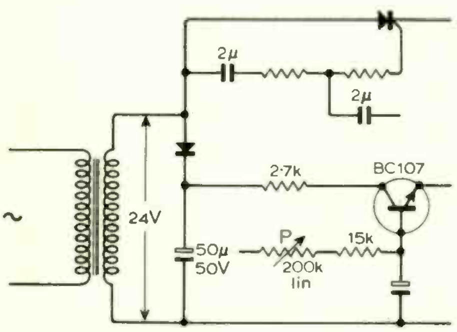


Fig. 10. A.c. drive modifications for Fig. 9.

In the circuits, the thyristor type given is specified on account of its high gate sensitivity. For the more common low sensitivity types where the gate current exceeds 1 mA (and may rise as high as 25 mA) a transistor is required to amplify the gate drive signal, the modifications being shown in Fig. 12.

The motor speed can be increased smoothly from zero to the set level by the 'start' switch *S, Fig. 9*. Equally, if this is switched off the speed will fall to zero gradually. The rate of acceleration and deceleration under these conditions is set by the potentiometer P_1. Overload protection is provided by the transistor Tr_2 which prevents damage to the thyristor. Practical tests on the completed circuit show that the wheel loading of a typical gauge 00 locomotive can be increased from zero to the value where the motor is 'full-on' with very little speed change. This performance is obtained even with the motor running at very low speed. The performance is certainly far better than that of conventional variable resistance controllers.

The second circuit, previously referred to, is shown in Fig. 11, and is of a 60V 1.6A stabilized supply suitable for a.f. amplifier applications. In fact the author developed this for the amplifier previously described in *Wireless World*[1] when used with the single h.t. rail modification.[2]

A choke is used in series with the transformer secondary to prevent uneven firing of the thyristor. This is not so much of a disadvantage as might be expected, as the longer thyristor condition angles resulting give rise to better transformer utilization and consequently a smaller mains transformer. In addition the ripple on the h.t. line is reduced by a factor of some 2.5 times by this increased period of conduction. Overload protection apart from fusing has not been applied as the system was designed for one application. If overload protection is required, and also a variable output voltage, then the modified circuit shown in Fig. 13 can be utilized.

The performance is quite adequate, regulation being about one volt change from no load to full load. Where sustained output is required from class B amplifiers such stability is necessary to prevent loss of power.

Where wide-range high-power stabilized supplies are required the thyristor regulated system has many advantages. For example a 60V, 5A fully variable supply would dissipate over 150 watts at half output voltage and full current, if a normal series transistor was used. In a thyristor supply the dissipation would only be some 6 to 8W. Nevertheless the low ripple and very good regulation of normal series regulators are often very attractive. In this case it is frequently the best solution to use a thyristor supply to stabilize some 5V above the wanted value and drop the remaining 5V in a conventional series regulator. Depending on the transistor type only two volts or so may be necessary with consequent power dissipation saving.

In conclusion, the author feels that there is a definite place for the thyristor regulated supply in applications where very low ripple voltages are not required. In high-power stabilized supplies the thyristor is advantageous as a pre-stabilizer to minimize the size and power dissipation of the series regulating transistors that are required.

REFERENCES

1. Bailey, A.R. 30-watt High-fidelity Amplifier, *Wireless World*, May 1968.
2. Bailey, A.R. 30-watt Amplifier Modification, *Wireless World*, November 1968.

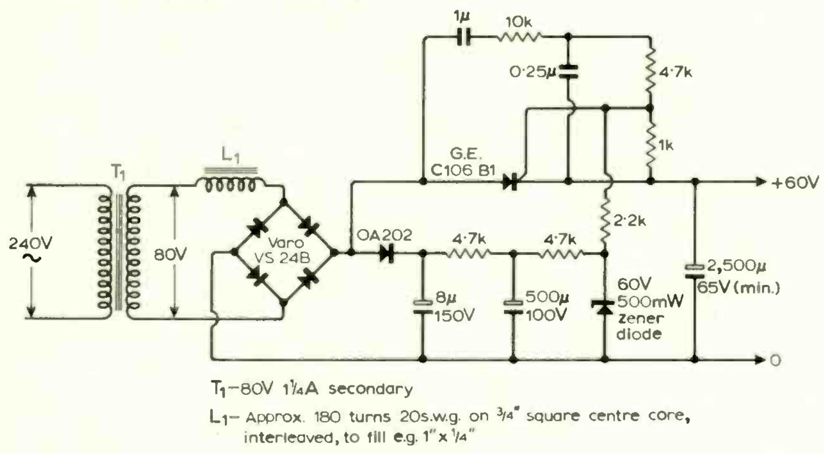


Fig. 11. Circuit for 60 volt 1.6 ampere stabilized d.c. supply.

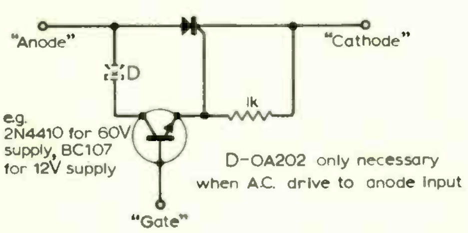


Fig. 12. Gate amplifying circuit for use when low sensitivity thyristors are used.

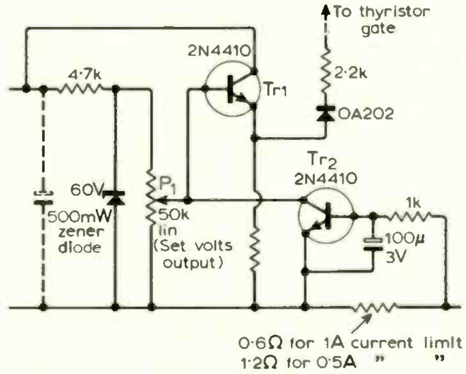


Fig. 13. Required modifications to Fig. 11 for variable output and current limiting.

THE SEPTEMBER ISSUE

A correspondent in this month's "Letters" mentions freak long-distance reception of television transmissions—a French station being received in Scotland. To facilitate the identification of Continental stations we plan to include in our next issue reproductions of a selection of test and identification cards used by some of the broadcasting services.

The issue will also include the second in the series of articles on active filters and, in addition to the continuation of the two constructional articles, contributions dealing with better stereophonic reproduction and acoustical holography.

ɴew Products

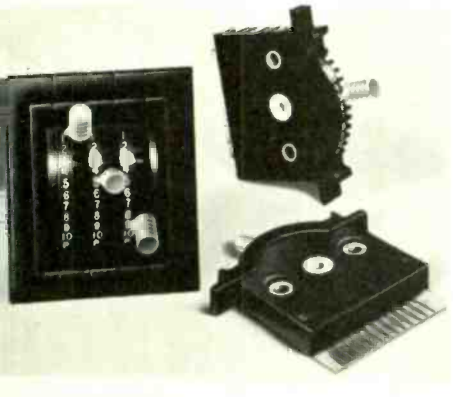
ariable Waveform ɪenerator

–Iodel A100 variable phase waveform :nerator from Prosser Scientific Instru- ents, is a source of precisely shaped ɔltage waveforms. Both the frequency ıd the phase between outputs can be ıried linearly over a large range. The nplitude of the waveshapes can be pre- sely selected and can be off-set and ipped. Simultaneously available are sine, –juare, triangle and ramp output wave- rms in the frequency range 0·001Hz to ɔokHz. The variable phase facility extends

ıe usefulness of the instrument into studies phase and frequency modulation, and :rvo and circuit testing. The remote ɔntrol of frequency and phase is intended ɪr use on semi-automatic and automatic :st gear. Voltage-to-phase conversion and ɔltage-to-frequency conversion relation- ıips are linear. The output level is up to : 10V. Prosser Scientific Instruments td, 1 Northampton Street, Cambridge.
/W312 for further details

:ircuit Selector with P.C. 'erminations

ealectro's slide switch programming circuit :lector is designed with printed-circuit utput terminations which mate with andard edgemount p.c. card connectors. : is engineered for a minimum of 250,000 -perations as a random-access unit which 'ill switch from one given position to any



of eleven others without making contact with intermediate switch points. It has a modular, expandable construction which allows any practical number of units to be stacked side-by-side. Internal p.c. board construction permits special electrical cod- ings to be supplied at minimum cost. Contacts will carry 3A d.c. and have a resistance of only 75 milliohms maximum. Sealectro Ltd, Walton Road, Farlington, Portsmouth, Hants. PO6 1TB.
WW317 for further details

Low-Cost Decade Capacitor

Hewlett-Packard's model 4440B decade capacitor provides capacitances from 40pF to 1·2μF, accurate to within ±0·25% (+3pF). It has four easy-to-read in-line decade ranges for selecting capacitances in steps of 100pF. It also has an air capacitor vernier which allows continuous adjustment between the 100pF steps of the smallest decade. Resolution of the vernier is 1pF. Silvered-mica capacitors are used in all decade steps, in order to obtain high accuracy, low dissipation, and good stability with temperature. The capacitors in the HP 4440B are housed in a double shield and

can be operated in either a two-terminal or three-terminal connection. The accuracy specification of ±0·25% (+3pF) applies to the three-terminal connection. However, the increase in capacitance for the two-terminal connection is less than 1pF. Typical values for the resonant frequency of the HP 4440B are 450 kHz at 1μF, 4MHz at 0·01μF, and 40MHz at 100pF. The maximum voltage is 500V peak, and insulation resistance is greater than 5GΩ after 5 minutes at 500V d.c. The cost is £111. Hewlett Packard Ltd, 224 Bath Road, Slough, Bucks.
WW313 for further details

Electronic Multimeter

The Comark portable electronic multimeter type 1231 is an accurate, high sensitivity instrument with high input impedance and wide bandwidth. It has more than 70 different measurement ranges, and readings are clearly indicated on a robust 130mm

meter. Overall accuracy of the 1231 is ±2% of full scale for d.c. measurements and ±3% of full scale for a.c. measurements over a bandwidth from 10Hz to 100kHz (3Hz to 250kHz for −3dB). Voltage sensitivity is from 1mV full scale to 300V in 12 ranges, with an input resistance of 1MΩ/V at d.c. The maximum current sensitivity is 1μA full scale with a meter volt drop of less than 12mV. Resistance is measured to an accuracy of ±5% of reading from 1Ω to 100MΩ and greater accuracy (±2%) may be achieved using the linear ohms ranges. Centre-zero operation may be selected on all d.c. ranges, for use as a galvanometer or differential voltmeter. Battery powered, the multimeter is protected on all ranges against overload greatly in excess of full scale of the selected range. The portable model is supplemented by alternative models suitable for laboratory and rack mounting; a leather carrying case is available for the portable version. U.K. list price £50. Comark Electronics Ltd, Brookside Avenue, Rustington, Sussex.
WW318 for further details

Wide-range A.F. Power Meter

Accurate measurement of power and voltage is possible with the a.f. power meter TF2500 announced by Marconi Instruments. The instrument is accurate to ±2·5% full scale and measures power up to 20kHz from 100μW full scale to 25W full scale in seven ranges. Frequency response is 0·5dB over the a.f. range. Load impedance is 2·5Ω to 20kΩ in forty steps. A centre-tap terminal on the input transformer extends still further the impedance range. An outstanding feature of TF 2500 is that it also measures voltage up to 1MHz in nine ranges from 15mV to 150V full scale. Input impedance on the voltmeter is

1MΩ and the voltmeter may be used as an a.c./d.c. converter. The TF2500 is suitable for use with audio amplifiers, receivers and a wide variety of transmission systems including f.d.m. base-band networks. Its high sensitivity permits direct measurement of very low power levels, down to less than 10μV, so that it may be used for signal-to-noise ratio and noise factor measurements on low-noise equipment. This sensitivity is achieved by the use of an active measuring system based on what is essentially an amplifier-detector type voltmeter calibrated in terms of power, dBm, and voltage. Power measurement can be made with unbalanced, balanced or fully floating load. TF2500 has 50W overload capability on power and the meter is fully protected through the amplifier on all impedances. The instrument is battery operated and fully self-contained, with a built-in battery check facility. The price is £285. Marconi Instruments Ltd, St. Albans, Herts.
WW325 for further details

TO3 Ceramic Heat-transfer Washers

The A26-2004 aluminium oxide ceramic washer from Jermyn exhibits very low thermal impedance and a breakdown voltage of 1,000 volts minimum. The low thermal resistance (0·15°C per watt) allows the full power capability of the semiconductor to be utilized with complete electrical insulation.

The thermal performance is approximately five times better than mica and is comparable with an equivalent hard anodized aluminium washer. It should be noted that aluminium oxide is non toxic. Samples are available upon request from Jermyn together with full information. Jermyn Industries, Vestry Estate, Sevenoaks, Kent.
WW301 for further details

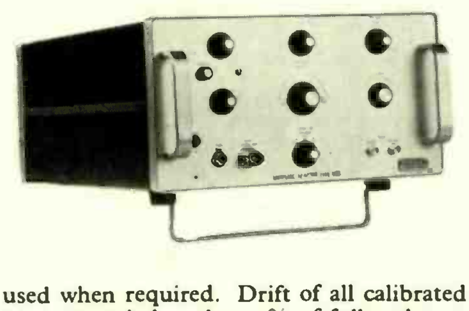
Single-Reed Encoders and Decoders

Resonant reed encoders and decoders, types J-610A and J-510A, from Kynmore, cover the frequency range 67 to 1600Hz. They are designed for use where one or several frequencies need to be detected or generated in a single carrier system. Using these devices, it is possible to obtain as many as 100 frequencies in a single octave, with excellent separation. Typical applications include generating and sensing audio frequencies in telemetry, telecommunications,

signalling equipment, transponders, and controls. Claimed to be vibration-proof, they are well suited to railway signalling, alerting systems and telemetry systems operating in difficult environments. One of the reasons for their development was the need for a simple unit for use in squelch circuits in mobile communications equipment. Both encoder and decoder provide a tuning tolerance of ±0·3% or ±1Hz, whichever is less, for frequencies below 1kHz, and ±0·1% for frequencies above 1kHz. They will not generate external fields, and they are not influenced by such fields. They operate equally well in any position, irrespective of any mass to which they may be mounted. They are designed to operate over a temperature range from −40° to +85°C. They are enclosed in a nickel-plated drawn-copper can with a seven-pin hermetic seal header. The decoder has a sensitivity of 1·0V r.m.s. ±0·5V r.m.s., and a bandwidth of 5Hz ±3Hz at the 3·0V r.m.s. operating point. Kynmore Engineering Company Ltd, 19 Buckingham Street, London, W.C.2.
WW319 for further details

Oscilloscope Sampling Adaptor

A single-channel oscilloscope sampling adaptor from G. & E. Bradley allows waveforms at frequencies up to 1000MHz to be examined on any general purpose oscilloscope. It is capable of displaying signals with a rise time of 0.5ns. Sample density is continuously variable from 100 to 1,000 samples per sweep, and density is independent of sweep expansion, which is switchable from ×2 to ×100. Maximum sampling speed on a 100mm oscilloscope tube provides a display at just above flicker rate, simplifying waveform analysis. For permanent records, the instrument can be coupled directly to a chart recorder. The sampling technique used depends on the generation of a very fast pulse coincident with the incoming signal, which switches a sampling gate. Time separation is determined by comparing the pulse against a staircase generator. Automatic c.r.t. blanking is provided and manual sweep can be



used when required. Drift of all calibrated parameters is less than 1% of full scale per 10°C change in ambient temperature, and noise is reduced to less than 2mV by a smoothing control. G. & E. Bradley Ltd, Electral House, Neasden Lane, London N.W.10.
WW323 for further details

Universal Meter

Model TVM 1070 transistor universal meter from British Physical Laboratories replaces model TVM1063 and provides a total of 43 different a.c. and d.c. ranges. Particular attention has been paid to styling and presentation to provide ease of opera-

tion: all ranges are selected by a singl control clearly marked with a colour-code scale. All ranges—both a.c. and d.c.—hav linear scales, including a new 0/100mV a. range. The internal batteries, which can b changed with the minimum of inconvenience, can always be checked by selecting th 'battery check' position. The instrument i available at an ex-works price of £7 British Physical Laboratories, Radlet Herts.
WW302 for further details

Coaxial Stripline Couplers

A comprehensive range of stripline coaxi directional couplers is announced by Radial Within the frequency band 150MHz t 8000MHz they are offering 35 devices in families, each covering one frequenc octave. 'N' and 'RIM' coaxial connector outlets are incorporated and couplings c 3, 6, 10, 20 and 30dB can be specified. Th 8000MHz 3dB type has overall dimension of less than 39 × 25 × 8mm. They ar designed for use under very severe environmental conditions which includes a temperature range from −55°C to +100°C. 3dl quadrature hybrids may be used as balance mixers, duplexers, power dividers, phas shifters and for other applications requirin equal division of power between two transmission lines. Radiall Microwave Com ponents Ltd, Station Approach, Grov Park Road, Chiswick, London W.4.
WW305 for further details

Marine Radio Equipment from Redifon

A range of v.h.f. radiotelephones for fishin vessels and small merchant ships, and radio selector unit which affords speedie and more efficient operation of ship station are announced by the Marine Division o Redifon. Three new all-transistor radiotelephones, types GR471, GR472 an GR473, are designed to comply wit G.P.O. specifications TSC 53d, 55a, an 57a. Similar in size and appearance th three versions provide 12, 18 and 24 channe operation respectively, with a transmitte output power of 14 watts from the GR471 and 20 watts from the GR472 and GR473. Intended for bulkhead mounting, each se is constructed on a single hinged chassi which swings open to left or right to ensure full access, and is fitted into a waterproo diecast case. All three sets operate from a nominal 24 volt d.c. supply but will tolerate supply variations over the range 19 volts to 32 volts.

The RS11 radio selector unit is a compact control unit into which are concentrated facilities for switching the muting and signalling circuits for all m.f., i.f. and h.f. equipment in a ship's radio station. It serves as an aerial exchange for up to four receivers, and also provides a single termination panel for the supply and interconnection cables of the

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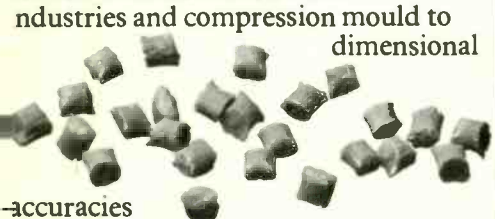

-accuracies ɔf .001 in., with contact spacings as :lose as .050 in. And our research and development boys are constantly working to push these specifications to even finer limits.

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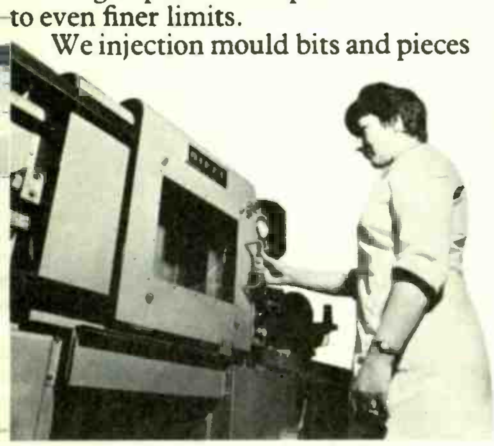
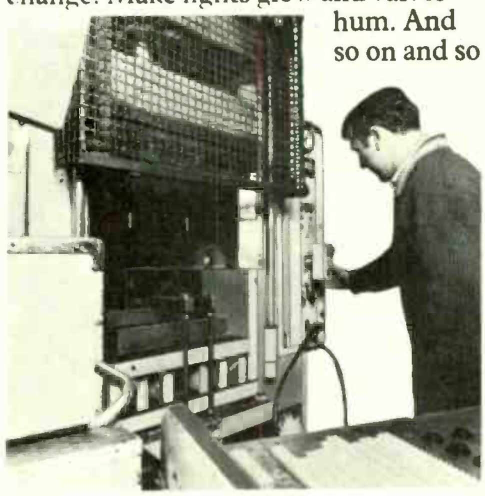


for practically every other industry you care to mention. And make the dies and moulds for these parts in our own toolroom. And if the raw material doesn't happen to come in the colours we require - and they often don't - we dye the mouldings in our own dye house.

From which you'll gather that we have *all* the facilities to shape and colour the thousands of very different mouldings that go into our vast product range, as well as the capacity to produce them in millions!

We don't leave off there either! By themselves plastic mouldings can only perform a certain number of functions. But marry them to metal and you can really start doing things. Make currents flow, or change. Make lights glow and valves hum. And so on and so



forth. Adding the metal bits can be difficult if you don't have the know-how. But we have it. Lots of it. And we'll even make the metal parts for you as well, if you like! In any metal, with any refinements such as plating, tempering, soldering, riveting etc, etc thrown in.

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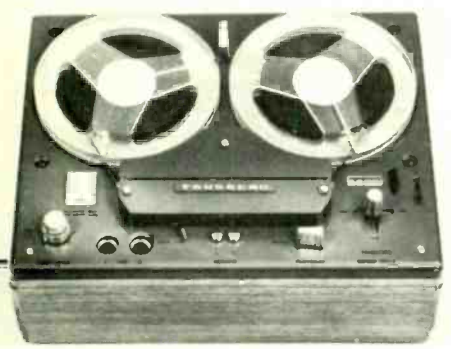
ntire installation. It can be fitted into most any existing radio installation and is eadily adaptable to individual systems for essels where special facilities are to be rovided. Redifon Ltd, Broomhill Rd., Vandsworth, S.W.18.
VW327 for further details

Stereo Tape Deck

'he Tandberg 1600X has been designed to ive mono or stereo recording and playback acilities of very high quality, but with simlicity of operation. It will be available in track, teak cabinet versions only. It is uitable for vertical or horizontal mountng, and employs the cross-field technique vith combined heads, as used in the Series 200X. At the speeds 7½, 3¾, and 1⅞ i.p.s. requency response is 40-18,000, 40-14,000, 0-8,000 Hz ±2dB; wow and flutter less han 0·1, 0·15, and 0·35; and signal to oise ratio better than −55dB, −53dB



nd −52dB. Cross talk is better than −60dB. The output is 0·9V each channel. There are two microphone inputs—impedance 200Ω. The price is £89 10s 0d, which s a list price of £71 15s 6d, plus £17 14s 6d purchase tax. Elstone Electronics Ltd, Hereford House, Off Vicar Lane, Leeds Yorks, LS2 7NS.
VW306 for further details

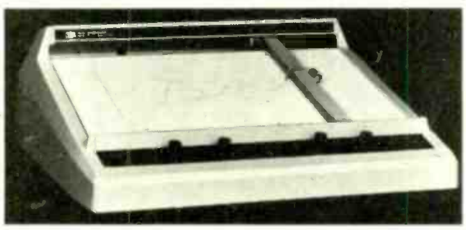
Electronic Thermometer

The Wayne Kerr electronic thermometer MB300 is available with a choice of 20 different sensors for a wide range of applications. Direct readings from −50°C to +150°C are obtained from solids, liquids or gases with the thermistor probe located at any distance up to 100 feet from the self-

contained instrument. With a response time between 1 and 7 seconds, the thermometer is suited to many industrial, medical, and biological requirements. The thermometer with its probes is supplied in a leather carrying case with a shoulder strap. Accuracy is to within 1°C from 0° to 100°C, reducing to only 1·5°C from −50° to 0°C and from 100° to 150°C. Price in the U.K. is £70 including one probe, with alternative probes ranging in price from £7 to £54. Wayne Kerr Co. Ltd, New Malden, Surrey.
WW326 for further details

X-Y Recorder Plots Graphical Solutions

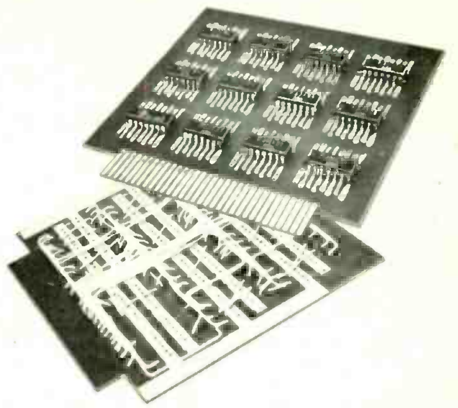
An X-Y recorder, designed by Hewlett-Packard for use with their Model 9100A computing calculator, makes permanent graphs of functions solved by the calculator and does so with greater precision and speed than hand plotting, and at a cost lower than that required to add a plotter to a digital computer. The calculator-recorder combination can be used to evaluate solutions for a wide variety of problems including statistical distribution analysis and curve fitting to data points, analysis of solutions of differential equations in fluid dynamics, heat transfer, mechanical resonance, and electrical network response, determinations of aerial patterns, orbital trajectories, and of shear force, bending moment and deflection in structures. Functions plotted by the calculator-recorder usually are iterative problems, in which the independent variable is incremented in small steps. The calculator computes the value of the dependent variable for each value of the independent variable, places the two values (appropri-



ately scaled) in its X and Y display registers, commands the recorder to move to the new coordinate point thus indicated, and plot it. It then increments the independent variable and computes the next point while the recorder is plotting the last. The calculator-recorder system takes only 0·9 second to plot each point. The recorder can plot the solution as a series of points, or it can draw line segments between adjacent points, tracing straight lines between points at any angle so that curves are smooth and do not have the "scalloping" that is characteristic of some incremental recorder plots. The plotting programme can be arranged so that the recorder draws dashed lines or dot-dash lines. Hewlett-Packard, 224 Bath Road, Slough, Bucks.
WW308 for further details

Printed Circuit Boards

CP series printed circuit boards from Circuit Integration are designed for the assembly of permanent of semi-permanent breadboards, or for small scale production of i.c. equipment. The standard range of 5 CP boards cater for 6, 12, 25, 30 and 42-14 or 16 pin circuits, respectively. The design of the CP series boards is such that a wide variety of actual board sizes may be achieved



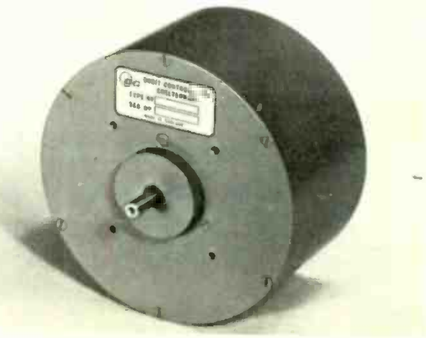
economically. Circuit Integration are prepared to carry out the manufacture of boards to customers' requirements: minimum order quantity 10 boards. Edge connectors may be gold plated or roller tinned coated. Circuit Integration Ltd, 99 Bancroft, Hitchin, Herts.
WW310 for further details

Metal Film Resistors

The Rn5 is an addition to the resistor range available from G. A. Stanley Palmer. It is a low-value metal film resistor available between 0·1 and 68 ohms with a working voltage of 750V d.c. and a 1·5 watt rating at 70°C. It will operate over the temperature range −55°C to +170°C and has a temperature coefficient between +3,000 and +5,000 p.p.m. Dimensions are 23·0mm long by 6·5mm diameter. Resistors with tolerances of ±10% and ±20% are available, and prices range from 63s 6d to 207s per 100, depending upon quantity. G. A. Stanley Palmer Ltd, Island Farm Avenue, West Molesey Trading Estate, Surrey.
WW320 for further details

Rotary Transducers

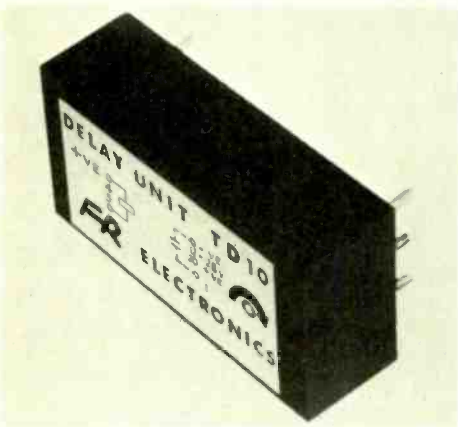
Control and instrumentation engineers frequently need to convert rotary or angular movement into a train of electrical impulses. The electrical signal thus produced can be processed by appropriate electronic control or measuring equipment. Such devices, normally termed incremental shaft encoders, comprise an input shaft carrying a multi-aperture disc which modulates an optical light path, producing one impulse per aperture. Orbit Controls have introduced a new series of rotary transducers into their Orbit 70 series which is designed specifically for industrial applications. The transducers employ a solid state photo-optic system which eliminates the conventional lamp source, and uses, instead, infra-red light radiators in conjunction with silicone light sensors.



Each unit houses its own pre-amplifier system, and is thus able to transmit a high-level signal along its associated connecting cables. Standard single-line output transducers are available, giving either 60 or 100 impulses per revolution, thus providing a simple conversion to r.p.m. or to decimal measurement. Other disc configurations are available to cover a wide variety of application. A further refinement is provided in two quadrature-output versions, each containing two internal photo-optic systems so disposed that their outputs are phase displaced by 90°. Examination of the phase relationship of one output to the other enables the direction of rotation to be determined, thus making these transducers suitable for machine tool control. The transducers are housed in rugged aluminium cases and are fitted with robust low-torque bearings. Connections are brought to a terminal block at the rear of the unit. The transducers are capable of operating at speeds up to 4,000 r.p.m. Orbit Controls Ltd, P.O. Box 16, The Runnings, Cheltenham, Glos. GL51 9PL.
WW311 for further details

Miniature Time-Delay Unit

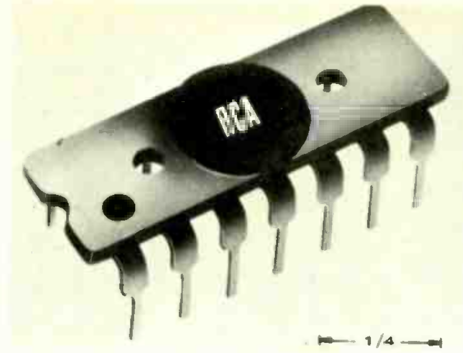
A miniature time-delay unit designated T.D.10 provides a time delay adjustable up to 10 seconds. Operating voltages in the range 12 to 60V d.c. can be used. Its small size and printed circuit mounting make it a suitable component for operation with reed relays, solid state control schemes and



electro-mechanical devices. It is designed to operate over a wide temperature range, and is totally encapsulated. FR Electronics (a division of Flight Refuelling Ltd.), Wimborne, Dorset.
WW309 for further details

General Purpose Linear I.Cs

Two new general-purpose linear integrated circuits operating from d.c. to 120MHz are now being offered by RCA. The CA3045 and CA3046 'building blocks' each contain five general purpose n–p–n transistors on a common monolithic substrate, two of the transistors being internally arranged to form a differentially-connected pair. The CA3045 is contained in a 14-lead dual in-line ceramic package (photo) and is rated for operation over the temperature range −55°C to +125°C. The CA3046 is electrically identical to the CA3045, but is contained in a dual in-line plastic package for applications requiring a limited temperature range, between 0°C and +85°C. Other features include a wide operating current range and a low noise figure,



3·2dB being typical at 1kHz. The CA3046 is available at 13s 9d each for quantities of 100 and over from RCA's three distributors: Semicomps Northern Ltd, Robert Electronics Ltd, and Electronic Component Supplies (Slough) Ltd. RCA Ltd, Sunbury-on-Thames, Middlesex.
WW314 for further details

High-power Moulded Capsule Thyristors

Westinghouse are now marketing nine moulded-capsule type converter-grade high power thyristors for single- or double-side cooling. Being generally symmetrical in shape, the capsule may be mounted either anode face or cathode face to heat sink. They are available either as devices or complete stacks. Current ratings are 75A to 370A single-side cooled and 110A to 550A double-side cooled. Semiconductor Division, Westinghouse Brake and Signal Co. Ltd, 82 York Way, Kings Cross, London N.1.
WW303 for further details

Slide-rule Component Bridge

An unusual feature of Wayne Kerr's Logarithmic LCR Bridge B500 is a slide-rule scale for balancing and reading. The bridge is balanced by sliding a cursor along a logarithmic scale to give a null indication on a meter. The final setting gives the *L*, *C* or *R* value, and a scale on the cursor itself indicates tolerance limits from −15% to +15% at all settings. The main scale of the slide-rule has a span of 1 to 16, which gives a good overlap from range to range (the ranges being selected by a rotary switch).

Overall coverage is: 10 nanohenrys to 16 kilohenrys; 10 femtofarads to 16 millifarads; and 100 micro-ohms to 160 megohms. Accuracy is claimed to be 1% on all ten ranges. There is also a calibrated control, operated when balancing, for measuring phase angle—range 0 to 45 degrees. The bridge is energized from 1kHz or 100 (or 120) Hz internal sources, selected by a switch. Detector sensitivity automatically rises as the balance point is

approached, but there is also a control fc varying the sensitivity.

Four terminals are provided, caterin for normal 2-wire components, in situ an screened components, and precise measure ments of very low impedances. A "subtrac 1" button extends the effective range of th logarithmic scale from 1 to 0. Price is £12: The Wayne Kerr Company Ltd, Ne Malden, Surrey.
WW304 for further details

Picosecond Pulse Diode

Microwave Associates have developed picosecond pulse switching diode, the firs of a new series of charge control devices The MA4-B200 diodes perform over wide temperature range and have a mini mum breakdown voltage of 70 volts, and capacitance range of 3-5pF. Typical turn o and turn off times are 500ps and 75p respectively. Typical circuit application are in pulse conversion circuits, variabl pulse delays, impulse generation, an extremely wide band pulse counting dis crimination. Microwave Associates Ltc Cradock Road, Luton, Beds.
WW307 for further details

Core-Driver Transistors

Motorola announces six multiple core driver transistors that are compatible wit i.cs in size and construction, and comple ment i.cs by performing a task that presen i.cs cannot handle well. Their compac construction saves space and permits shor leads, which are vital for fast high-curren core driving. They can also be used as r.f drivers at frequencies up to 200MHz. Th new devices are multiple versions of th 2N3762 and 2N3467 fast, high-curren p–n–p switches. Like the single transistors the new devices have high current handlin ability, low saturation voltage, low capacit ance (11pF, C_{eb}) and extremely fast switch ing time (22ns typical turn-on time, 46n turn-off time, at rated current). Th V_{ceo} is 40V. The MD3467 dual transista in a TO5 type case, the MD3467F dual in a small 6-pin ceramic flat pack, and th MQ3467 quad in a standard 14-pin ceramic flat pack, are 0·5A transistors. The TO5 cases can dissipate a total of 600mW (500mW maximum per transistor) at 25°C ambient temperature. The small flat-pack duals are rated at 350mW total 250mW per transistor, and the 14-pin flat packs containing four transistors 500mW total, 400mW per transistor. For popular complementary circuitry, the MD3725, MD3725F and MQ3725 dual and quad transistors are n–p–n complements in similar packages. Motorola Semiconductors Ltd, York House, Wembley, Middlesex.
WW321 for further details

Collapsible Cabinets

A new range of instrument cabinets that will shortly be available will be delivered "packed flat". The component parts quickly slot together to produce the required cabinet. The main objects of this design are to ensure fast delivery by reducing handling problems and to reduce the storage space that needs to be set aside by users of the range. Bedco Ltd, Datum Division, Colne Way, Watford, WD2 4NE.
WW502 for further details.

)igital Picoammeter

—here are two versions of this Keithley instru- ent, the model 445, which has fully auto- ıatic range changing, and the 440, which has manual range-change switch. The 445 has full scale range from 10^{-9} to 10^{-2}A with)$^{-12}$A resolution. The 440 is one range more :nsitive having a 10^{-13} resolution. Apart om these differences the two models are ısically similar. On the most sensitive range :curacy is ±0.5% ± 1 digit and on the ghest range ±0.2% ± 1 digit. Stability with mperature is better than 0.05% per °C and, —t constant temperature, drift will not exceed ne digit per day. A front-panel control is rovided to compensate for any small drift.

'he m.o.s.f.e.t. input stage is provided with verload protection that even a 1kV trans- :nt will not damage the instrument. To revent inaccurate measurements being btained the display is blanked during periods —f overload. In no circumstances must the ıput current be allowed to exceed 125mA. :ommon mode rejection is such that 100V .c. or 200V peak-to-peak at mains frequency ʌill not affect the reading. When properly eroed the input voltage drop is less than mV for f.s.d. The display rate is adjustable rom 20 readings per second to 1 reading very two seconds. Sockets on the rear of the ıstruments allow connection to a printer nd external control circuits. Keithley nstruments, Reading.

WW501 for further details

Aerial Rotator

. Beam Engineering Ltd, are British agents —or Stolle automatic aerial rotators. Each otator system is made up of a transistor ontrol unit and an aerial drive unit. The :ontrol unit has a single selector knob set in dial marked with compass points. When the .erial is still the whole system is switched off. Resetting the selector causes the aerial to otate until it 'reaches' the dial position. The lrive unit has a carrying capacity of 25kg and :onsumes approximately 65 watts (at 20V) during operation. Speed of rotation is one revolution in 50 seconds. A magnetic disc orake and self-restraining worm gear drive ıold the aerial in its chosen position. Two nodels are available with different positioning accuracy. J. Beam Engineering Ltd, Rothers- .horpe Crescent, Northampton.

WW508 for further details

Cathode-ray Tubes

An inexpensive 3-inch flying-spot scanner tube (Brimar Q8-100AA) giving good resolu- tion and a high light output has been introduced by Thorn Radio Valves & Tubes. The deflection angle of 58° coupled with a carefully engineered gun construction, ensures that uniform focus of the 0.08mm spot can be maintained over the whole useful screen area of 53 × 38mm. The overall length of the tube is 245mm. Typical operating voltages are: final anode 20kV, first anode 1kV, and grid-to-cathode voltage for cut-off is −20 to −50V. Heater voltage is 6.3V at 0.3A. Thorn Radio Valves & Tubes Ltd, 7 Soho Square, London, W.1.

WW503 for further details

Transistor Coolers

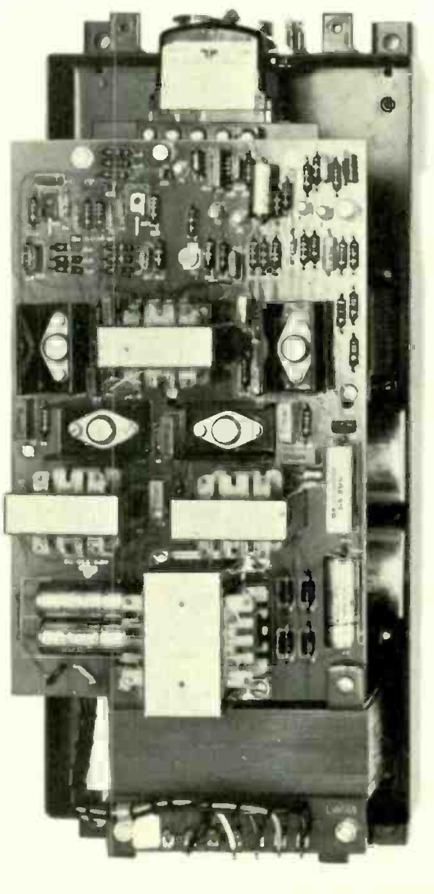
Rastra Electronics Ltd, offers new types of Bentron-coolers for TO5 and TO18 transistor cans in five different colours (blue, black, yellow, red and green). The coolers come in two pieces which are clamped to the transistor can very easily with a single spring. The different colours are useful for marking various stages in a circuit. Order numbers are BC 105A, BC 118A (normal 5.5mm) and BC 105B, BC 118B (high 10mm). Rastra Electronics Ltd, 275 King St., Hammersmith, London, W.6.

WW316 for further details

Sine-wave Inverters

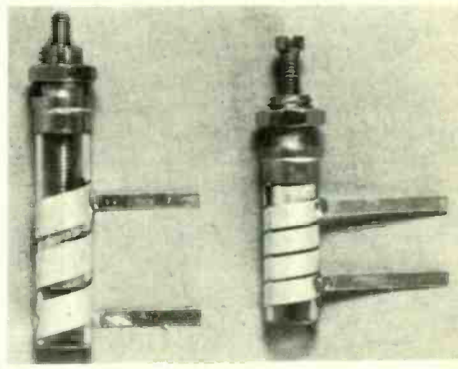
Avel Products Ltd, introduce the Knud Lindberg range of sine-wave static inverters to the U.K. Available in three types for 24V, 110V or 220V d.c. input, these units provide a stabilized output at 220V, 50Hz, with a low-distortion sinusoidal waveform. The inverters use thyristors as the switching elements providing wide margins of safety under all conditions of input voltage and current. Output voltage stabilization is achieved by the use of constant voltage transformers giving overall efficiency of 70% and output frequency is maintained at 50Hz ± 1%. Effective protection is provided against overload and also against over-voltage on the input to the inverter. Reliable operation is guaranteed under any load condition up to the maximum of 200VA. Priced between £75 and £80, these inverters are available from Avel Products Ltd, South Ockendon, Essex.

WW315 for further details



Adjustable High-Stability Inductors

High-stability inductors designed to provide smooth adjustment of inductance within very close limits have been released by Oxley Developments. A silver conductor coil is fixed at high temperature on to a low-expansion

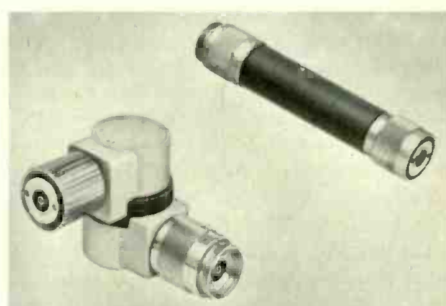


glass tube to give high mechanical adhesion, and inductance is adjustable ±10% from nominal value by movement of a piston within the tube. Inductance values are from 0.03μH to 0.15μH and a typical Q for 0.04μH at 180MHz is 150. Oxley Developments Co. Ltd, Priory Park, Ulverston, North Lancs.

WW330 for further details

Flexible Coaxial Fittings

Coaxial fittings which allow movement in three dimensions in hook-ups using rigid co-axial lines are released by Hewlett-Packard. The electrical stability of rigid lines is maintained. Insertion loss is less than 0.5dB over



the frequency range d.c. to 12.4GHz and the effect of rotation during reflection measurements is more than 52dB below a full reflection. The coaxial rotary joint (model 11588A) costs £82 and the coaxial rotary air line (model 11606A) costs £53. Hewlett-Packard Ltd., 224 Bath Road, Slough, Bucks.

WW324 for further details

World of Amateur Radio

V.H.F. news

An Icelandic amateur, Finar Palsson, TF3EA, has successfully received 70-MHz signals from the GB3GM beacon station at Thurso in the north of Scotland, and has also heard the Irish station, EI4RF. These are believed to be the first British Isles stations on 70 MHz to be logged in Iceland. The times of reception (about 23.55 to 00.55 G.M.T.) suggest that this may be due to an auroral E pattern opening. A few days later, on the morning of June 27th, the Icelandic amateur succeeded in making the first amateur two-way v.h.f. contacts from Iceland when he was in communication with Mike Walters, G3JVL, of Hayling Island, and Miss Constance Hall, G8LY, of Lee-on-Solent, on 70.25 MHz, probably the result of sporadic E. It is hoped that a 70-MHz beacon station (TF2VHF) will be established in Iceland. The Gibraltar beacon station (ZB2VHF) is now operating on 50.09, 70.31 and 145.13 MHz. During widespread sporadic E openings in June, the effects of which extended as high in frequency as the 144-MHz band, P. W. Haylett, G3IPV, of Norfolk, was in contact on two metres with HG5AIR near Budapest.

Amateurs' role in Arctic Trek

The recent successful completion of the 464-day, 3500-mile transarctic expedition led by Wally Herbert has underlined the valuable communications assistance provided by two British amateurs—Dennis Collins, G2FLB (Mintech) and Rowley Shears, G8KW (KW Electronics). These two amateurs, with occasional help from others, have taken over each weekend (for over 16 months) from Cove Radio (MPO) of the Royal Aircraft Establishment the task of maintaining radio contact with the expedition's base station (MPE) operated by S/Ldr Freddie Church. This base station, after some months at Point Barrow, Alaska, moved to the floating ice station T3 (85° N, 125° W). MPE was thus always within the Polar Cap absorption zone recognized as presenting many problems for h.f. point-to-point operation. This is believed to be first time that a British radio link to this zone has been maintained over such a long period, and has provided R.A.E. with valuable radio propagation information.

The two amateurs, using the callsign G7AE on 13999 kHz, passed over 160 official messages for the expedition as well as handling many technical enquiries. They achieved a success rate approaching 95 per cent compared with the 96.2 per cent of Cove Radio with its large, sloping vee aerials and 3-kW linear amplifier. Almost all contacts were made on manual Morse, and both the amateurs and R.A.E. attribute the remarkable success of this difficult h.f. radio link to the use of this mode.

In the Arctic, S/Ldr Church used simple aerials and amateur-type equipment (Collins KWM2A transceiver, backed up with Plessey PR155 receiver) and kept in telephony contact with the sledge party who carried Redifon 15-watt s.s.b. GR345 packsets. Both Rowley Shears and Dennis Collins used amateur equipment from the standard range of KW Electronics. By using a four-element Yagi, 60-ft high, the G7AE signals were often reported as exceptionally strong in the Arctic—the high-gain aerial gave an effective radiated power approaching 7.5 kW.

Contrary to expectations, the link was maintained throughout the period using the single twenty-metre channel. The results have shown clearly, that for weak but readable Morse signals, the path stays open far longer than might seem likely from the official propagation predictions.

New secretary for I.A.R.U. Region I

To fill the vacancy resulting from the death of John Clarricoats, G6CL, the British amateur Roy F. Stevens, G2BVN, has been elected secretary of the Region I (Europe and Africa) Division of the International Amateur Radio Union. Roy ("Steve") Stevens was the 1966 president of the R.S.G.B. and has been closely associated with national and international amateur radio activities for many years. He is an amateur enthusiast whose profession—surveyor for a major insurance group—has no connection with radio or electronics, although in 1939 as a young member of the old Civilian Wireless Reserve, he was one of the group of "Early Birds" rushed to France on the outbreak of war for wireless duties.

Long-delay echoes

Amateur assistance in the investigation of the 40-year-old mystery of long-delay h.f. echoes (of the order of 8 seconds delay or even more)—often called "cosmic echoes" —is being sought by a team at the Radioscience Laboratory of Stanford University, California. These strange echoes first attracted attention in the late 1920s (Stormer a Van der Pol) and were followed up wi experimental work in the early 1930s whi appeared to verify that such echoes ca occur on h.f. signals, if only rarely. Howeve a year-long investigation at Cavendish Labo atory, Cambridge, just after World War failed to find positive proof of any echoe Little work has been done in this field f some time, despite occasional reports amateurs hearing their own closing remar (quite strongly and with relatively litt distortion) when switching over to receptio Now the American team, which believes th new work in plasma physics could accou for the existence of long-delay echoes, a appealing for exact details of any furth amateur experience of this phenomenon.

Some August events

R.S.G.B. v.h.f. contests: 144 MHz s.s. August 4th; 432 MHz open contest Augu 10th; 70 MHz c.w. August 16th–17 (23.00 to 07.00 G.M.T.).

Mobile rallies include the R.S.G.B. nati nal mobile rally at Woburn Abbey c August 10th; Derby and District (Rykniel School, Bedford Street) on August 17 (details Tom Darn, Sandham Lodge, Sandham Lane, Ripley DE5 3HE); Augu 24th Torbay and Swindon; August 31 Hartlebury Castle, near Kidderminster ar Kimberley Barracks, Preston.

Contest results

The main, high-power section of the 32n BERU Contest, held in March, was won b A. R. W. Cake 9H1BL, of Malta with a scor of 6336 points from a record 819 contac with Commonwealth stations. Over 10 stations submitted entries and some 120 stations are believe to have participate Leading British entrant was D. L. Courtie Dutton, G3FPQ, with 6142 points from 34 contacts—he used a home-made receive 100-watt transmitter and two-element qua aerials on 14 MHz and above. During th 1969 R.S.G.B. low-power 3.5-MHz contes the winner, R. A. Wybrow (G3JVJ), mac 50 contacts using 0.45-watt input. On entrant J. J. R. McDonnell (G3DOP), mac almost 30 contacts using an all-f.e. transmitter with three small signal 2N381 devices and an input power of 176 milliwatt

In Brief: A special-event amateur statior using the call GB3SMG will be operatin during the International Stoke Mandevill Games for the Paralysed (July 27th to August 2nd) . . . the International Amateu Radio Club is holding a convention ir Geneva from September 12th–14th (detail I.A.R.C., P.O. Box 6, 1211 Geneva 20, Swit zerland) . . . Lerwick Radio Club plan to rur a special exhibition station during August to mark the 500th anniversary of the pledgin of the Shetland Islands by the King o Denmark to the Scottish Crown. . . . The prefix C3A has been allotted for amateu operation in Andorra . . . Ray Folgate G3KDY, is using the call ZD9BE fron Tristan da Cunha where he is now Master o Posts and Telegraphs. . . . It is hoped that the frequencies 3500–3510 and 3790–3800 kH may be reserved for inter-continenta amateur working.

PAT HAWKER, G3VA

Answers to "Test Your Knowledge"—15

Questions on page 387

1. *(d)*

2. *(a)* The "threshold" voltage for a diode is dependent on the energy gap of the material. Of the materials listed germanium has the smallest energy gap and thus the lowest threshold voltage.

3. *(a)* With respect to the other three factors p-n junction diodes are generally better than point-contact diodes. Point-contact diodes also have the advantage of cheapness.

4. *(b)* The light energy acts as a source of e.m.f. In the absence of light there is a balance in the diode between minority carriers from each side "drifting" through the depletion layer, and majority carriers from each side diffusing in the opposite direction. The optically-generated minority carriers increase the drift current, whereas the generated majority carriers have negligible effect. Thus a reverse current flows through the diode.

5. *(b)* If load-lines for a high resistance are drawn on a set of photodiode characteristics it will be seen that an output voltage proportional to light intensity requires the diode to be reverse-biased.

6. *(b)* The materials on each side of the junction must be degenerate, i.e. the Fermi level must lie in the conduction band on the n side and in the valence band on the p side. In addition, to allow the tunnelling to occur, the depletion layer must not be much wider than 100 Å.

7. *(c)* The diode must be biased to the point on its characteristic where it has the largest value of negative a.c. resistance. For germanium this is about 0.1 V forward bias.

8. *(c)* A backward diode is similar in construction to a tunnel diode; there is, however, little tunnelling for forward voltage, only for reverse voltages.

9. *(a)*

10. *(a)*

11. *(b)*

12. *(c)* For forward applied voltage the electrons enter the metal at a high energy. They rapidly come into thermodynamic equilibrium with the lattice, however, and are thus not able to return across the Schottky barrier when the applied voltage is reversed.

13. *(a)* A pulse of current generated by avalanching in the depletion layer takes a finite time to drift through the bulk material. An alternating voltage is induced which is in antiphase with the alternating component of the current so that the device acts as a negative resistance. Special structures, such as the IMPATT diode, are made for this purpose, but in principle any p-n junction diode can be used.

14. *(b)* The mechanisms of Gunn diode oscillations depend on properties of the structure of the conduction band which are only possessed by direct-energy-gap semiconductors (p-n junctions play no part).

15. *(c)* A diode operating in the Limited Spacecharge Accumulation mode is so arranged that for part of each r.f. cycle the voltage drops below the critical value so that any dipole domains which have started to form will disperse.

16. *(a)* The step-recovery diode has a doping profile which causes the current due to stored carriers to end abruptly a short time after the applied potential is changed from forward to reverse. In consequence when an alternating potential is applied the output is rich in harmonics.

Literature Received

CATALOGUES

The range of **semiconductors** manufactured by Newmarket Transistors Ltd (St. Andrews Rd., Cambridge CB4 1DP) is described in five broadsheets. **(1)** germanium devices, **(2)** silicon devices, **(3)** packaged circuits, **(4)** film attachment devices and **(5)** hybrid microcircuits. (1)—**WW 401,** (2)—**WW 402,** (3)—**WW 403,** (4)—**WW 404** and (5)—**WW 405** for further details.

Pergamon Press (Headington Hill Hall, Oxford OX3 0BW) have produced two catalogues which list the range of **technical** books they publish. **(1)** mathematics and **(2)** engineering science and technology. (1)—**WW 406** and (2)—**WW 407** for further details.

A six-page **f.e.t. selector guide** and cross reference chart (SG-15) is obtainable from Motorola (York House, Empire Way, Wembley, Middlesex). Equivalents lists are included. **WW 408** for further details.

Semiconductors, including e.c.l., and m.o.s. devices, from the Siemens range are described in a short-form catalogue available from Cole Electronics (Components Division, Lansdowne Rd., Croydon CR9 2HB). **WW 409** for further details.

Amendment No. 11 for the Hivac Ltd. (Stonefield Way, South Ruislip, Middlesex) **loose leaf catalogue** is available. **WW 411** for further details.

Additions to the catalogue of Erie Electronic Ltd. (South Denes, Great Yarmouth, Norfolk) are also available. **WW 412** for further details.

Brimar Industrial **Cathode Ray Tubes** catalogue 1969-70 lists more than 160 types (Thorn Radio Valves and Tubes Ltd., 7, Soho Square, London W.1). **WW 413** for further details.

APPLICATION NOTES

The Application of Linear Microcircuits (Vol. 1, 144 pages, price 30s.; Vol. 2, 36 pages, price 12s 6d) is the title of two soft cover books that are mines of information. Vol. 1 deals with the applications of the μA/ -702A, -709, -710, and -711 while Vol. 2 covers types L/ -103, -123, -127, -141, -/T2. The booklets may be obtained from SGS (United Kingdom) Ltd, Planar House, Walton Street, Aylesbury, Bucks.

(1) A.C. Voltage Regulators using Thyristors (AN-3886) and **(2) U.H.F. Power Generation using r.f. Power Transistors** (AN-3755) are two new titles from R.C.A. Electronic Components, Harrison, New Jersey. (1)—**WW 414,** (2)—**WW 436** for further details.

The Dual Photocell is the title of a booklet which shows how analogue multipliers and low-noise choppers can be built with this component. Hewlett Packard, 224, Bath Rd., Slough, Bucks. **WW 415** for further details.

Power Module Users Handbook published by Advanced Industrial Electronics (Raynham Rd., Bishop's Stortford, Herts.) contains data, advice and circuits showing how the Advance range of modular power supplies can be used to best advantage. **WW 416** for further details.

The Advanced Products Department of the Corning Glass Company have produced a number of application notes concerned with **glass delay-lines** which are available from Electrosil Ltd., Pallion, Sunderland, Co. Durham. They are **(1)** Parallel operation of digital glass memories, **(2)** Glass memories bibliography, **(3)** Time multiplex operation of digital glass memories, **(4)** Sharpening TV pictures with glass memories, **(5)** Glass memories in low-cost computer driven displays, and **(6)** Digital memory modules in high-speed buffers. (1)—**WW 417,** (2)—**WW 418,** (3)—**WW 419,** (4)—**WW 420,** (5)—**WW 421** and (6)—**WW 422** for further details.

PRODUCT LITERATURE

Magnetic proximity switch, type MPS 16 is described in a leaflet from Herbert-BSA Electrics Ltd, Shaftmoor Lane, Birmingham 28. **WW 423** for further details.

Paper-tape reader series 119 manufactured by Oohr-tronics of Americ is described in literature available from Data Recognition Ltd., 7 Loveroc Rd., Battle Farm Estate, Reading, Berks. **WW 424** for further details.

Aluminium electrolytic capacitors, turret terminal style, are describe in an engineering bulletin 3430 from Sprague Electric Company, Nort Adams, Mass., U.S.A. **WW 432** for further details.

GENERAL INFORMATION

Adhesives Directory 1969 contains much valuable information such a manufacturers' addresses, trade names, glossary of terms and a "who' who". It is available from A. S. O'Connor & Co. Ltd., 30 Paradise Rd. Richmond, Surrey. Price 20s.

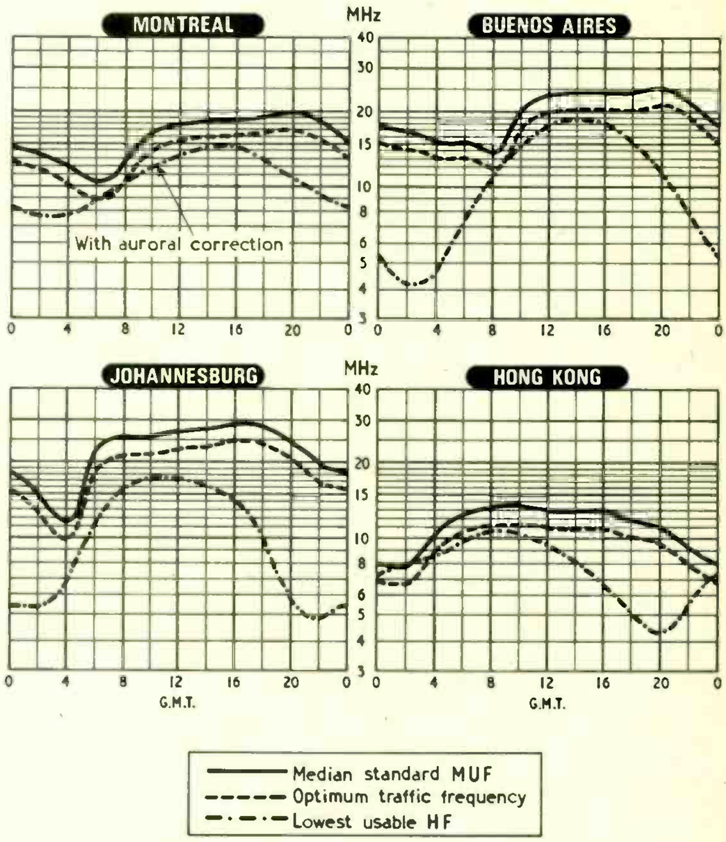
I.E.A. Purchasing Directory 1969, fifth edition, is prepared by th publishers of *Control & Instrumentation* and *Electronic Engineering*. It cover the instruments, electronics and automation industry and contains a compre hensive buyers' guide, manufacturers' addresses and lists many trade names. I can be obtained from Morgan-Grampian (publishers) Ltd, Summit House Globe Way, West Wickham, Kent. Price 100s.

Two new supplements (Nos. 2 and 3) have been produced by Motorola for th **Semiconductor Data Book.** Motorola Ltd, Empire House, York Way, Wem bley, Middlesex. **WW 434** for further details.

The 1969-70 **prospectus** of full- and part-time courses is now available from Northern Polytechnic, Holloway, London N.7.

Government Surplus Wireless Handbook gives circuits and descriptions o a wide range of equipment on the surplus market. Giltext Ltd, 23, Stansfiel Chambers, St. Georges St., Leeds 1. Price 45s.

H.F. Predictions—August

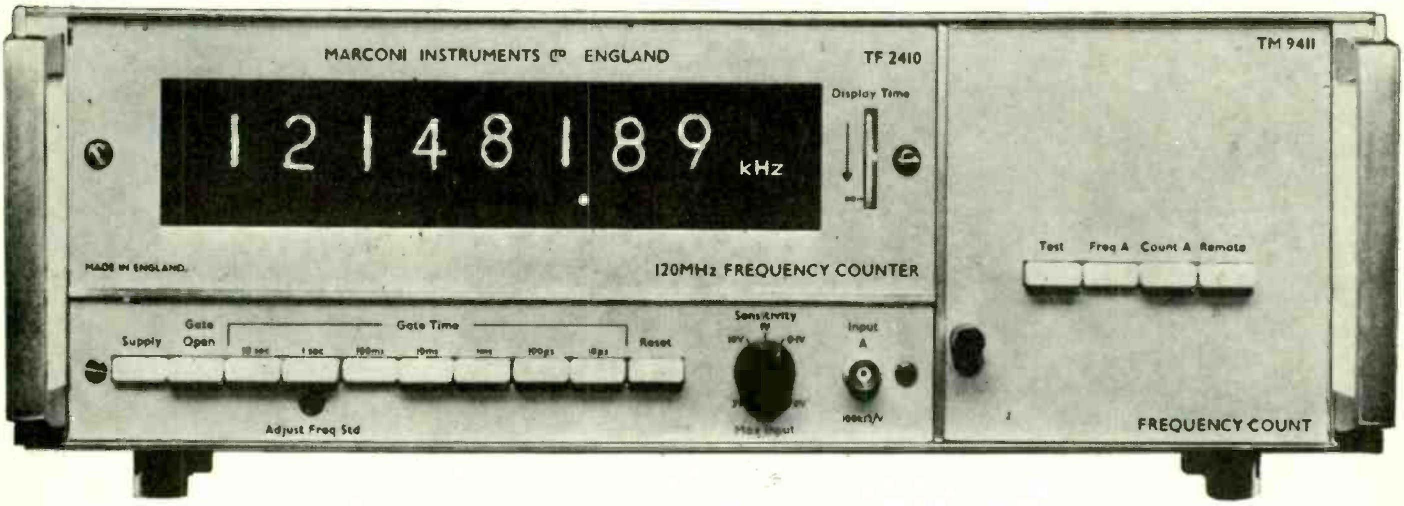


The upsurge of solar activity in March has been maintained to date. Current activity is on a par with that of twelve months ago, which was considered a maximum in the sunspot cycle.

Though not unexpected, such trends are masked in the predictions which are based on smoothed values of recent observed activity as well as comparison with corresponding periods of previous cycles. Seasonal trend, coupled with continued high solar activity, would produce median MUFs up to 10% higher than shown.

Frequency usage for the month will be the same as last year with magnetically disturbed days totalling about seven, but an increase in the number of fade-outs is expected; about six in the northern hemisphere.

Direct frequency counting to 120MHz...3·3GHz with plug-in units...and 90-second warm-up



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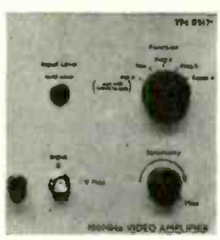
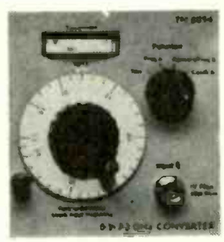


TM 8517 extends sensitivity to 1 mV r.m.s.

TM 8334 extends frequency to 600 MHz.



TM 8094 extends frequency to 3.3 GHz.

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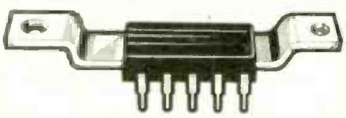

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SPECIFICATION (ratings at 25°C): Output power typically 3W from 250mV input. Frequency response 20Hz to 80KHz+3dB. Max operating voltage 21V. Min operating load 7.5 ohms. Pre-amp. input imp. 2M/Ohms. Pre-amp. D.C. input current 50nA.

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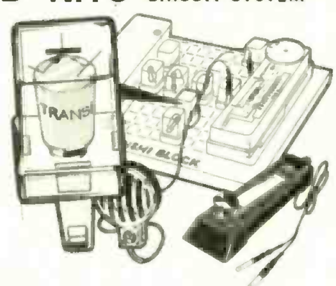

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DENSHI BOARD KIT SR-2A *as SR-1A plus:* 2SB transistor for AF; 2 resistors; 1 capacitor; crystal microphone; test probes; electrode; additional connecting pieces; 9V battery. **This kit permits the building of 30 circuits.**

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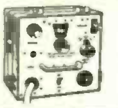

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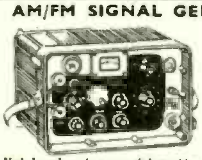

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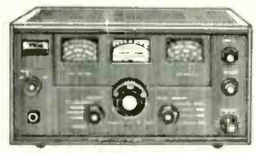

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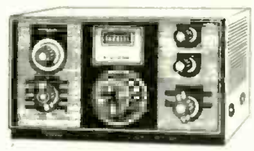

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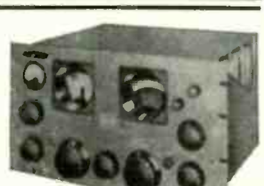

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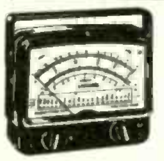

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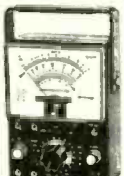


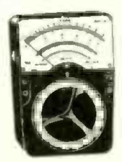
MODEL AS-100D. 100KΩ/Volt. 5in., mirror scale. Built-in meter protection 0/3/12/60/120/300/600/1,200 v. D.C. 0/6/30/120/300/600 v. A.C. 0/10µA/6/60/300MA/12 Amp. 0/2K/200K/2M/200MΩ. —20 to +17dB. **£12/10/-.** P. & P. 3/6.

PROFESSIONAL 20,000 O.P.V. LAB TYPE MULTITESTER. Automatic overload protection, mirror scale. Ranges 1/10/50/250/500/1,000 v. D.C. and A.C. 0-500µA, 10mA, 250mA, Current: 0/20K, 200K, 2megohm, Decibels:—20 to + 22db. **£5/19/6.** P. & P. 2/6.

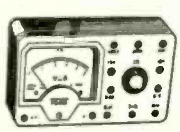
MODEL TE-70. 30,000 O.P.V. 0/3/15/60/300/600/1,200 v. D.C. 0/6/30/120/600/1,200 v. A.C. 0/30µA/3/30/300mA. 0/16K/160K/1.6M/16 MegΩ. **£5/10/-.** P. & P. 3/-.

MODEL TE-90 50,000 O.P.V. Mirror scale overload protection. 0/3/12/60/300/600/1,200 v. D.C. 0/6/30/120/300/1,200 v. D.C. .03/6/60/600 MA. D.C. 16K/160K/1.6/16 MEG Ω. —20 — + 63db. **£7/10/0.** P. & P. 3/-.

MODEL TE-12. 20,000 O.P.V. 0/0.6/6/30/120/600/1,200/3,000/6,000 v. D.C. 0/6/30/120/600/1,200 v. A.C. 0/60µA/6/60/600 mA. 0/6K/600K/6Meg./60 Meg.Ω. 50 PF. .2 MFD **£5/19/6.** P. & P. 3/6.

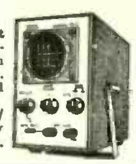


MODEL TE-80. 20,000 O.P.V. 0/10/50/100/500/1,000 v. A.C. 0/5/25/50/250/500/1,000 v. D.C. 0-50µA. 5/50/500mA. 0/6K/60K/600K/6 meg. **£4/17/6.** P. & P. 3/-.



MODEL PT-34. 1,000 O.P.V. 0/10/50/250/500/1,000V. a.c. and d.c. 0/1/100/500 mA. d.c. 0/100 K Ω **39/6.** P. & P. 1/6.

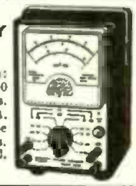
TO-2 PORTABLE OSCILLOSCOPE



A general purpose low cost economy oscilloscope for everyday use. Y amp. Bandwidth 2 CPS—1 MHZ. Input imp. 2 meg Ω. 25 PF. Illuminated scale. 2" tube. 115 x 180 x 230 mm. Weight 8lbs. 220/240v. A.C. Supplied brand new with handbook. **£22/10/-.** Carr. 10/-.

FIELD TELEPHONES TYPE L. Generator ringing, metal cases. Operate on 2 1.5 v. batteries (not supplied.) Excellent condition. **£4.10.0** per pair. Carr. 10/-.

T.E.40 HIGH SENSITIVITY A.C. VOLTMETER



10 meg. input 10 ranges: .01/.03/.1/.3/1/3/10/30/100/300 v. R.M.S. 4 cps.-1.2 Mc/s. Decibels —40 to +50 dB. Supplied brand new complete with leads and instructions. Operation 230 v. A.C. **£17/10/-.** Carr. 5/-.

AUTO TRANSFORMERS

0/115/230v. Step up or step down. Fully shrouded.
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500 W. **£3/10/0.** P. & P. 6/6
1,000 W. **£5/10/0.** P. & P. 7/6
1,500 W. **£6/10/0.** P. & P. 8/6
7,500 W. **£15/10/0.** P. & P. 20/-.

TE22 SINE SQUARE WAVE AUDIO GENERATORS

Sine: 20 cps to 200 kc/s. on 4 bands. Square 20 cps to 30 kc/s. Output impedance 5,000 ohms. 200/250 v. A.C. operation. Supplied brand new and guaranteed with instruction manual and leads. **£16.10.0.** Carr. 7/6.

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Reuter ¼-track. As fitted to Collaro Mk. IV and Studio Decks. High imp. record playback, low imp. erase. Lower track only. Brand new **19/6** pair.
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Erase. Low imp. **20/-**
Marriott ½ track heads:
Record/Playback, high imp. **65/-**
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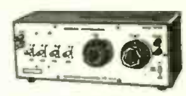
High quality instrument with 28 ranges. D.C. volts 1.5-1,500 v. A.C. volts 1.5-1,500 v. Resistance up to 1,000 megohms. 220/240v. A.C. operation. Complete with probe and instructions **£17/10/0.** P. & P. 6/-. Additional Probes available; R.F. 35/- H.V. 42/6.

TE111 DECADE RESISTANCE ATTENUATOR



Variable range 0-111 db. Connections. Unbalanced T and Bridge T. Impedance 600 ohms. Range (0.1 db x 10) + (1 db x 10) + 10 + 20 + 30 + 40 db. Frequency: DC to 200 KHZ (—3db). Accuracy: 0.05 db. + indication db x 0.01. Maximum input less than 4 watts (50 volts). Built in 600 Ω load resistance with internal/external switch. Brand new **£27/10/-.** P. & P. 5/-.

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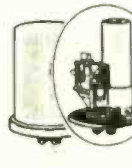
CAR LIGHT FLASHERS



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M1 2/10
M3 2/10
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OA211 13/6
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OAZ204 9/-
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OC23 5/-
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OC29 23/6
OC30 5/-
OC35 5/-
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OC38 11/6
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OC45 1/9
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OC78D 3/-
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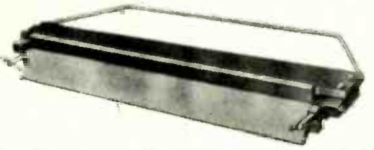

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1·25μF	16 volt	6μF	6 volt	30μF	6 volt		
2μF	3 volt	8μF	3 volt	30μF	10 volt		
2μF	350 volt	8μF	12 volt	50μF	6 volt	All at 1/- each.	
2·5μF	16 volt	8μF	50 volt	64μF	2·5 volt		
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3·2μF	64 volt	10μF	25 volt	100μF	9 volt	(our selection)	
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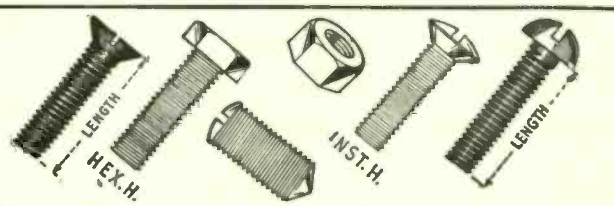

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1C ..	25-33-40-50....	6	£5 19 6	8/6
1D ..	25-33-40-50....	3	£3 12 6	7/6
2A ..	4-16-24-32	12	£6 10 0	7/6
2B ..	4-16-24-32	8	£4 17 6	7/6
2C ..	4-16-24-32	4	£3 5 0	6/–
2D ..	4-16-24-32	2	£2 2 6	5/–
3A*..	25-30-35	40	£14 17 6	15/–
3B*..	25-30-35	20	£9 7 6	9/6
3C ..	25-30-35	10	£6 10 0	7/6
3D ..	25-30-35	5	£3 15 0	6/6
3E ..	25-30-35	2	£2 15 0	6/6
4A*..	12-20-24	30	£11 15 0	10/–
4B ..	12-20-24	20	£7 10 0	8/6
4C ..	12-20-24	10	£4 15 0	7/6
4D ..	12-20-24	5	£3 5 0	6/6
5A ..	3-12-18	30	£8 15 0	7/6
5B ..	3-12-18	20	£6 10 0	7/6
5C ..	3-12-18	10	£3 17 6	6/6
5D ..	3-12-18	5	£2 12 6	6/6
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7A*..	6-12..........	50	£9 7 6	9/6
7B ..	6-12..........	20	£5 10 0	7/6
7C ..	6-12..........	10	£3 10 0	6/6
7D ..	6-12..........	5	£2 10 0	5/6
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7*	2250	30 lb	£16 10 0	12 6

*Completely enclosed in beautifully finished metal case fitted with two 2-pin American sockets, neon indicator, on/off switch, and carrying handle.

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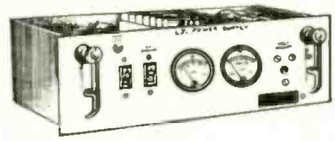

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6 figs inc. 1/10ths, 1/100ths 40v. A.C. but complete with transformer for 240v. A.C. operation. All in plastic case. Size 6¼ × 6¼ × 3in. Condition as new 45/-. P. & P. 5/-.

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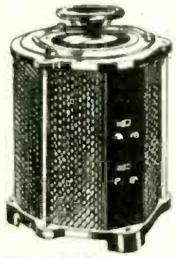

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0–260 v. at 5 amps.	£9 15 0
0–260 v. at 8 amps.	£14 10 0
0–260 v. at 10 amps. ...	£18 10 0
0–260 v. at 12 amps. ...	£21 0 0
0–260 v. at 15 amps. ...	£25 0 0
0–260 v. at 20 amps. ...	£37 0 0
0–260 v. at 37.5 amps. .	£72 0 0
0–260 v. at 50 amps. ...	£92 0 0

20 DIFFERENT TYPES AVAILABLE FOR IMMEDIATE DELIVERY.

Double Wound Variable Transformers

Fully isolated, low tension Secondary winding. Input 230 v. A.C. OUTPUT CONTINUOUSLY VARIABLE 0-36 v. A.C.

0-36 v. at 5 amp. £9.12.6— p. & p. 8/6

0-36 v. at 20 amp. £21.0.0— 15/- p. & c.

These fully shrouded. Transformers, designed to our specifications, are ideally suited for Educational, Industrial and Laboratory use.

SPEEDIVAC

HIGH VOLTAGE HIGH FREQUENCY GENERATOR

Input 100/110 volts or 200/250 volts AC/DC. Output 19KV variable. Ideal for testing insulation, vacuum, leakage path, gas discharge lamps, neon etc. A useful ozone and HF supply. Manufactured by Edwards High Vacuum Ltd. Brand new in maker's polished wooden carrying case Offered at fraction of maker's price. £10.0.0 plus 7/6d. p. & p.

5Amp. AC/DC VARIABLE VOLTAGE OUTPUT UNIT

Input 230 v. A.C. Output 0-260 v. A.C. Output 0-240 v. D.C. Fitted large scale ammeter and voltmeter. Neon indicator, fully fused. Strong attractive metal case 15in. × 8¾in. × 6in. Weight 24 lb. Infinitely variable, smooth stepless voltage variation over range. Similar in appearance to illustration below.

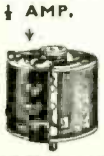
OPEN TYPES

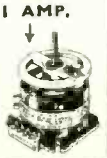
Designed for Panel Mounting. Input 230 v. A.C. 50/60 Output variable.
0-260 v.

¼ amp	£3 10 0
1 amp.	£5 10 0
2½ amp.	£6 12 6

P. & P. 7/6

¼ AMP. **1 AMP.**





PORTABLE

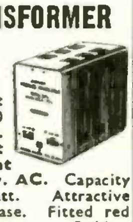
VARIABLE VOLTAGE TRANSFORMER

Input 230 v. A.C. Output variable 0-260 v. A.C. at 1.5 amp. Fitted in beautifully finished steel case. Complete with voltmeter, pilot lamp, fuse, switch, carrying handle. **£9/5/-.** P. & C. 10/-. Also 2.5 amp. as above. £11/7/6. P. & C. 10/-.

ADVANCE VOLSTAT

LT constant voltage Transformer. Input 205/250 volts. Output 6.3 volts. RMS Load 7-10 amps. £3. 6/6 p.p.

CONSTANT VOLTAGE TRANSFORMER



Input 185-250 v. A.C. Output constant at 230 v. AC. Capacity 250 watt. Attractive metal case. Fitted red signal lamp. Rubber feet. Weight 17lbs. Price **£11/10/-**, P. & P. 10/-.

LATEST TYPE SOLID STATE VARIABLE CONTROLLER

Ideal for lighting and heating circuits, compact panel mounting. Built in fuse protection. CONTINUOUSLY VARIABLE.
Input 230v AC output 25-230v AC
5 amp model **£8. 7. 6**
10 amp model **£13. 5. 0**

INSULATION TESTERS (NEW)

Test to I.E.E. Spec. Rugged metal construction, suitable for bench or field work, constant speed clutch. Size L. 8in., W. 4in., H. 6in. Weight 6lb. 500 volts, 500 megohms. Price £22 carriage paid. 1,000 volts, 1,000 megohms, £28 carriage paid.

36 volt 30 amp. A.C. or D.C. Variable L.T. Supply Unit

INPUT
220/240 v. A.C.
OUTPUT
CONTINUOUSLY VARIABLE 0-36 v.

Fully isolated. Fitted in robust metal case with Voltmeter, Ammeter, Panel Indicator and chrome handles. Input and Output fully fused. Ideally suited for Lab. or Industrial use. £55 plus 40/- p. & c.

SERVICE TRADING COMPANY →

R.S.C. SENSATIONAL HIGH FIDELITY STEREO PACKAGE OFFERS

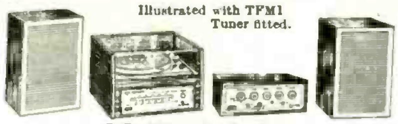
Matching as recommended for optimum performance. Compare prices with equipment and cabinets purchased individually.

30 Watt Output

★ Goldring Transcription Turntable on Plinth.
★ Shure or Goldring Magnetic Pick-up Cartridge.
★ Super 30 Amplifier in veneered housing.
★ Pair of Stanton Loudspeaker Units.

Special total price. Four fully wired units ready to "plug-in". Really superb performance. **86 Gns.** Send S.A.E. for leaflet. Carr. 25/-

Illustrated with TFM1 Tuner fitted.



30 Watt Output

★ Garrard SP25 Mk. II Turntable on Plinth.
★ Goldring CS90 Ceramic P.U. Cartridge.
★ Super 30 Amplifier in veneered housing.
★ Pair of Stanton Loudspeaker Units.

Special total price. Four fully wired units ready to "plug-in." **76 Gns.** Carr. 25/- **Extremely Attractive and Versatile Plinths** finished in Teak or Afrormosia veneer. Tinted Transparent Plastic "roll over" cover with satin chrome handle.

13 Watt Output

★ Garrard SP25 Mk. II 4-speed Player Unit, on plinth.
★ Goldring CS90 Ceramic P.U. Cartridge.
★ TA12 Amplifier in veneered housing.
★ Pair of Dorchester Loudspeaker Units.

Special total price. Transparent Plastic cover 3 gns extra. Or Dep. £10 and 9 monthly payments £5.11.0 **51 Gns.** (Total £59.19.0) Carr. 25/-

BLACKPOOL AGENT APPOINTED See addresses

AUDIOTRINE HIGH FIDELITY LOUDSPEAKERS

Heavy construction. Latest high efficiency ceramic magnets. Treated Cone surround giving low fundamental resonance. "D" indicates Tweeter Cone providing extended frequency range 40-15,000 c.p.s. Exceptional performance at low cost. Impedance 3 or 15 ohms.

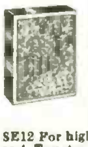
Prices include carriage. PLEASE STATE IMPEDANCE

HF 510L 5" 10W	57/9	HF 138 13" × 8"	10W	84/-
HF 801D 8" 8W	59/9	HF 120 12"	15W	79/9
HF 811D 8" 10W	£4/4	HF 120D 12"	15W	89/9
HF 102D 10" 10W	65/-	HF 126 12"	15W	£5/5/-
HF 100D 10" 15W	£5/15	HF 126D 12"	15W	£5/15/-

AUDIOTRINE HI-FI SPEAKER SYSTEMS

Consisting of matched 12in. 11,000 line 15 watt 15 ohm high quality speaker, cross-over unit and tweeter. Smooth response and extended frequency range ensure surprisingly realistic reproduction. **£5.15.0**
Or Senior 15 watt inc. HF 126 15,000 line Speaker £6/15. Carr. 6/6. Carr. 5/9

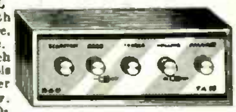
HI-FI 'SPEAKER ENCLOSURES



Teak or Afrormosia veneer finish. Modern design. Acoustically lined. Prices inc. carr.
JE8 Size 16 × 11 × 9in. Pressurised. Gives pleasing results with any 8in. Hi-Fi speaker. **£4.10**
SE8 For optimum performance with any 8in. Hi-Fi speaker. 22 × 15 × 9in. Ported **£5.10**
SE10 For outstanding results with 10in. Hi-Fi speaker. 24 × 15 × 10in. Ported **£5.15**
SE12 For high performance with 12in. Hi-Fi speaker and Tweeter. Size 25 × 16 × 10½in. Pressurised. **£6.15**

R·S·C· TA12 13 WATT STEREO AMPLIFIER

FULLY TRANSISTORISED, SOLID STATE CONSTRUCTION HIGH FIDELITY OUTPUT OF 6.5 WATTS PER CHANNEL



Designed for optimum performance with any crystal or ceramic Gram P.U. cartridge, Radio tuner, Tape recorder, 'Mike' etc. ★ 3 separate switched input sockets on each channel ★ Separate Bass and Treble controls ★ Slide Switch for mono use ★ Speaker Output 3-15 ohms ★ For 200-250 v. A.C. mains ★ Frequency Response 30-20,000 c.p.s. —2dB ★ Harmonic Distortion 0.3% at 1000 c.p.s. Hum and Noise —70dB ★ Sensitivities (1) 300 mV (2) 50 mV (3) 100 mV (4) 2 mV ★ Handsome brushed silver finish Facia and Knobs. Output rating I.H.F.M. Complete kit of parts with full wiring diagrams and instructions. 12½ GNS. Carr. 7/9. Factory built with 12 mth. gntee. 16 GNS. Or Dep. £5/2/6 and 9 mthly pymts. 31/6 (Total £19/6/0). Or in Teak or Afrormosia veneer housing 19½ GNS. or Dep. £5/10/6 and 9 mthly. pymts. 39/- (Total £23/1/6.)

HIGH FIDELITY LOUDSPEAKER UNITS

Cabinets of latest styling Satin Teak or Afrormosia veneer. Acoustically lined or filled with woollen damping material. Ported where appropriate. Credit terms available.

DORCHESTER Size 16 × 11 × 9in. Appr. Range 45-15,000 c.p.s. Rating 8-10 watts. Fitted High flux 13 × 8in. Dual cone speaker. Impedance 3 or 15 ohms. **£8.19.9** Carr. 7/6

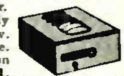
STANTON IIIS Size 18 × 11 × 10in. Rating 10 watts. Incorporating Fane 803b speaker with roll rubber cone surround and 15,000 line magnet. High flux tweeter. Handsome Scandinavian design cabinet. Range 30-20,000 c.p.s. Impedance 15Ω. Gives smooth realistic sound output. Inc. carr. **16Gns.**

GLOUCESTER Size 25 × 16 × 10in. 12in. High flux 12,000 line speaker. Cross-over unit and Tweeter. Rating 10 watts. Frequency range 40-20,000 c.p.s. Impedance 15 ohms. **12½ Gns.**

THE 'YORK' HIGH FIDELITY 3 'SPEAKER SYSTEM

• Moderate size approx. 25 × 14 × 10 in. • Range 30-20,000 c.p.s. Impedance 15 ohms. • Performance comparable with units costing considerably more. Complete kit. **20Gns.** Consists of (1) 12 in. 15 watt Bass unit with cast chassis, Roll rubber cone surround for ultra low resonance, and ceramic magnet. (2) 3-way quarter section series cross-over system. (3) 8 × 5in. high flux middle range speaker (4) High efficiency tweeter. (5) Measured weight of woollen acoustic damping material. (6) Teak veneered cabinet. (7) Circuit and full instructions. HEAR IT AT ANY BRANCH.

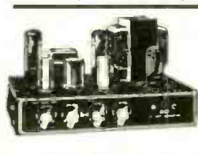
R.S.C. BATTERY/MAINS CONVERSION UNITS



Type BM1. An all-dry battery eliminator. Size 5½ × 4½ × 2in. approx. Completely replaces batteries supplying 1.5 v. and 90 v. where A.C. mains 200/250 v. 50 c/s. is available. Complete kit with diagram 49/11 or, Ready for use, 59/11.

SELENIUM RECTIFIERS
F.W. Bridged 6/12v. D.C. O/P input Max. 18v. A.C. 1a., 4/3. 1½a. 5/6; 2a., 6/11; 3a., 9/9; 4a., 12/9; 6a., 15/9.

R.S.C. A10 30 WATT ULTRA LINEAR HI-FI AMPLIFIER



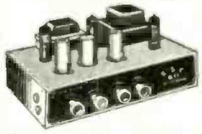
Highly sensitive. Push-Pull high output, with Pre-amp./Tone Control Stages. Performance figures: Hum level —70dB. Frequency response ±3dB 30-20,000c/s. Sectionally wound output transformer. All high grade components. Valves EF86, EF86, ECC83, 807, 807, GZ34. Separate Bass and Treble Controls. Sensitivity 36 millivolts. Suitable for High Impedance mic. or pick-ups. Designed for Clubs, Schools, Theatres, Dance Halls or Outdoor Functions, etc. For use with Electronic Organ, Guitar, String Bass, etc. Gram, Radio or Tape. Reserve L.T. and H.T. for Radio Tuner. Two inputs with associated volume controls so that two separate inputs such as Gram and "Mike" can be mixed. 200-250 v., 50 c/s. A.C. mains. For 3 and 15 ohm speakers. Complete Kit parts wiring diags., instructions. Twin-handled perforated cover 27/6. Or factory built with EL34 output valves and 12 months' guarantee for 17 gns. Tech. figs. apply to factory built units. Carr. 12/6 **14 Gns.**
TERMS: Deposit £6 and 9 monthly payments of 32/- (Total £20/8/0.) Send S.A.E. for leaflet.

INTEREST CHARGES REFUNDED On Credit Sales settled in 3 months.

R.S.C. TA6 6 Watt HIGH FIDELITY SOLID STATE AMPLIFIER

200-250v. A.C. mains operated Frequency Response 30-20,000 c.p.s. —2dB. Harmonic Distortion 0.3% at 1,000 c.p.s. Separate Bass and Treble 'lift' and 'cut' controls. 3 input sockets for Mike, Gram, Radio or Tape. Input selector switch. Output for 3-15 ohm speakers. Max. sensitivity 5mV. Output rating I.H.F.M. In fully enclosed enamelled case, 9¾ × 2¾ × 5½in. Attractive brushed silver finish facia plate 10½ × 3½in. and matching knobs. Complete kit of parts with full wiring diagrams and instructions. Carr. 7/6. Or factory built with 12 months' guarantee. £8.19.9. **£6.19.9**

R.S.C. A11 HIGH FIDELITY 12-14 WATT AMPLIFIER



Push-pull ultra linear output "built-in" tone control pre-amp. Two input sockets with associated controls allowing mixing of "mike" and gram, etc. etc. High sensitivity. 5 valves—ECC83 (2), EL84 (2), EZ81. High quality sectionally wound output transformer. IND. BASS AND TREBLE CONTROLS. Frequency response ±3dB 30-20,000 c/s. Hum level—60dB. SENSITIVITY 40 millivolts. For Crystal or Ceramic PUs. High Impedance "mikes". For Musical Instruments such as String Bass, Electronic Guitars, etc. Size approx. 12 × 9 × 7in. For AC mains 200-250v. 50 cps. Output for 3 and 15 ohm spkrs. SAE for leaflet. Complete kit. **9 Gns.** Full instructions and point-to-point wiring diagrams. Carr. 11/6 (or factory built 12 Gns.) Twin handled metal cover 27/6. Terms on assembled units. Deposit 97/6 and 9 monthly payments of 22/-. (Total £14/15/6). RSC A11T transistorised version of above complete kit 9 Gns. (Assembled 13 gns.)

R.S.C. COLUMN SPEAKERS

Covered in two-tone Rexine/Vynair. Ideal for vocalists and Public Address. 15 ohm matching. Type C57 15 watts inc. five 7 × 4in. spkrs. £7/19/11. Type C48S, 30 watts. Fitted four 8in. high flux 8 watt speakers. Overall size approx. 42 × 10 × 5in. 16 Gns. Or deposit 67/- and 9 mthly pmts. 34/9 (Total £18/19/9). Carr. 10/-.
Type C412s. 50 watts. Fitted four 12in. 11,000 lines 15 watt speakers. Overall size 56 × 14 × 9in. approx. 26 Gns. Or deposit £5/17/6 and 9 monthly payments Carr. 15/- of 54/6 (Total £30/7/-).

R.S.C. MAINS TRANSFORMERS

FULLY GUARANTEED. Interleaved and Impregnated. Primaries 200-250 v. 50 c/s. Screened

MIDGET CLAMPED TYPE 2½ × 2½ × 2½in.

250 v. 60 mA; 6.3 v. 2 a.	15/11
250-0-250v., 60mA, 6.3v. 2a.	16/11

FULLY SHROUDED UPRIGHT MOUNTING

250-0-250v. 60mA., 6.3v. 2a., 0-5-6.3v. 2a.	21/9
250-0-250v. 100mA. 6.3v. 4a., 0-5-6.3v. 3a.	37/9
300-0-300v. 100mA. 6.3v. 4a., 0-5-6.3v. 3a.	37/9
300-0-300v. 130mA. 6.3v. 4a., c.t., 6.3v. 1a. For Mullard 510 Amplifier	45/9
350-0-350v. 100mA., 6.3v. 4a., 0-5-6.3v. 3a.	37/9
350-0-350v. 150mA. 6.3v. 4a., 0-5-6.3v. 3a.	47/9
425-0-425v. 200mA. 6.3v. 4a. c.t., 5v. 3a.	69/9
425-0-425v. 200mA. 6.3v. 4a., 6.3v. 3a. 5v. 3a	75/-
450-0-450v. 250mA. 6.3v. 4a., ct., 5v. 3a.	87/9

TOP SHROUDED DROP-THROUGH TYPE

250-0-250v. 70mA. 6.3v. 2a., 0-5-6.3v. 2a.	21/9
250-0-250v. 100mA. 6.3v. 3.5a.	25/9
250-0-250v. 100mA. 6.3v. 2a., 6.3v. 1a.	26/9
350-0-350v. 80mA. 6.3v. 2a., 0-5-6.3v. 2a.	27/9
250-0-250v. 100mA. 6.3v. 4a., 0-5-6.3v. 3a.	37/9
300-0-300v. 100mA. 6.3v. 4a., 0-5-6.3v. 3a.	37/9
300-0-300v. 130mA. 6.3v. 4a., 0-5-6.3v. 1a. Suitable for Mullard 510 Amplifier	44/9
350-0-350v. 100mA., 6.3v. 4a., 0-5-6.3v. 3a.	37/9
350-0-350v. 150mA. 6.3v. 4a., 0-5-6.3v. 3a.	45/11

FILAMENT or TRANSISTOR POWER PACK Types 6.3 v.1.5a. 7/9; 6.3v. 2a. 8/9; 6.3v. 3a. 10/9; 6.3v. 6a. 21/9; 12v. 1a. 8/9; 12v. 3a. or 24v. 1.5a. 21/9; 0-9-18v. 1½a. 17/9; 0-12-25-42v. 2a. 29/9.
CHARGER TRANSFORMERS 0-9-15v. 1½a. 14/11; 2½a. 17/9; 3a. 19/11; 5a. 23/9; 6a. 27/9; 8a. 33/9. 10a. 55/11.
AUTO (Step UP/Step DOWN) TRANSFORMERS 0-110/120v.-200-230-250v. 50-80 watts 15/9; 150 watts. 29/11; 250 watts 49/9; 500 watts 99/9

OUTPUT TRANSFORMERS

Standard Pentode 5,000Ω or 7,000Ω to 3Ω	8/9
Push-Pull 8 watts EL84 to 3Ω or 15Ω	12/9
Push-Pull 10 watts 6V6 ECL86 to 3, 5, 8 or 15Ω	22/9
Push-Pull EL84 to 3 or 15Ω 10-12 watts	21/9
Push-Pull Ultra Linear for Mullard 510, etc.	30/9
Push-Pull 15-18 watts, sectionally wound 6L6 KT66, etc., for 3 or 15Ω	35/9
Push-Pull 20 watt high quality sectionally wound EL34, 6L6, KT66, etc. to 3 or 15Ω	59/9

SMOOTHING CHOKES 150mA. 7-10H. 250Ω 12/9; 100mA. 10H. 200Ω 10/9; 80mA. 10H. 350Ω. 8/9; 60mA. 10H. 400Ω 4/11.

R.S.C. TFM1 SOLID STATE VHF/FM RADIO TUNER

Total cost of parts with detailed wiring diagrams & instructions. Inc. Carr. **14 Gns.** Or factory built 16½ gns. Or in Teak finished cabinet as illustrated 19½ gns. Terms: Deposit £5 and 9 monthly payments £2. Total £23.

★ High-sensitivity ★ 200-250v. A.C. Mains operation. ★ Sharp A.M. Rejection. ★ Drift-free reception. ★ Output ample for any amplifier (approx. 500 m.v.). ★ Simple alignment instructions. ★ Output available for feeding tuning meter. ★ Output for feeding Stereo Multiplexer. ★ Tuner head using silicon Planar Transistors. ★ Designed for standard 80 ohm co-axial input. Visually matching our Super 15 and 30 amplifiers and of the same high standard of performance and reliability. The pre-wired tuning head facilitates speed and simplicity of construction. Printed circuitry. Only high grade transistors and components used. A quality product at considerably less than the cost of comparable units. Stereo version. All parts 20 gns. Inc. Carr. Assembled 22½ gns. Inc. Carr.

High Quality LOUDSPEAKERS

In teak or afrormosia veneered cabinets. L13 13" × 8" 10 Watt Model. Gauss 10,000 lines. 3 or 15 ohms. **£4/19/9** Carr. 7/6
L12 12" 20 Watt Model. 15 ohm. Size 18 × 18 × 10in. Gauss 10,000 lines. Rexine. covered 10/- extra. Carr. 8/9 **£8/19/9**

TWO-WAY 'PHONE AMPLIFIER

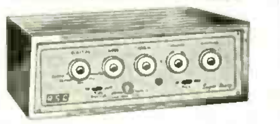
Listen and speak with both hands free. Handsome black case. Battery operated. **59/9**

R.S.C. SUPER 15 HI-FI AMPLIFIER

SOLID STATE

FULLY TRANSISTORISED 200/250v. A.C. Mains.
OUTPUT 10 WATTS R.M.S. continuous into 15 ohms.
15 WATTS R.M.S. continuous into 3-4 ohms.
TRANSISTORS. 9 current types of high quality by leading manufacturers.
5 POSITION INPUT SELECTOR SWITCH EQUALISATION to Standard R.I.A.A. and C.C.I.R. Characteristics for Gram and Tape Heads.
FULL TAPE MONITORING FACILITIES
SENSITIVITIES: Magnetic P.U. 4 mV. Crystal or Ceramic P.U. 400 mV. Microphone 4.5 mV. Tape Head 2.5 mV. Radio/Aux. or Ceramic P.U. 110 mV.
FREQUENCY RESPONSE: ±2 dB 20-20,000 c.p.s.
TREBLE CONTROL: +15dB to —14dB at 10 Kc/s. NEG. FEEDBACK: 52dB.
BASS CONTROL: +17dB to —15dB at 50 c/s. HUM LEVEL: —75dB.
HARMONIC DISTORTION at 10 watts 1,000 c.p.s. 0.2%
Complete Kit of parts with full constructional details and point to point wiring diagrams. Carr. 12/6. **12½ Gns.**
Supplied factory built. 15½ Gns. Carr. 12/6. Terms: Deposit 4 Gns. and 9 monthly payments 31/1 (Total £18/3/9). Or in Teak or Afrormosia veneer housing as ill. 19 Gns.
COMPONENTS ETC. ARE OF A HIGH STANDARD AND SUPPLIED BY LEADING MANUFACTURERS.

SPECIFICATIONS COMPARABLE WITH UNITS COSTING CONSIDERABLY MORE



R.S.C. SUPER 30 STEREO AMPLIFIER

A DUAL CHANNEL VERSION OF THE SUPER 15. Employing Twin Printed Circuits. High quality Ganged Pots. Matched Components. CROSS TALK:—52dB at 1,000 c.p.s.
CONTROL: 5 position Input Selector. Bass Control. Treble Control. Volume Control. Balance Control. Stereo/Mono Switch. Tape Monitor Switch. Mains Switch. INPUT SOCKETS (Matched Pairs). (1) Magnetic P.U. (2) Ceramic or Crystal P.U. (3) Radio/Aux. (4) Tape Head/Microphone. Operation of the Input Selector Switch assures appropriate equalisation. Rigid 18 s.w.g. Chassis. Size approx. 12in. wide, 3in. high and 8in. deep. Neon Panel indicator. Attractive Facia Plate and Spun Silver Matching Knobs. Above facilities, etc., except for Ganging and Balance control, apply also to Super 15.

THESE UNITS ARE EMINENTLY SUITABLE FOR USE WITH ANY MAKE OF PICK-UP OR MICROPHONE (Crystal, Ceramic, Magnetic, Moving Coil, Ribbon) CURRENTLY AVAILABLE. SUPERB SOUND OUTPUT QUALITY CAN BE OBTAINED BY USING WITH FIRST RATE ANCILLARY EQUIPMENT. All required parts, point to point wiring diagrams and detailed instructions. Carr. 15/- **21 Gns.**
Unit factory built 28 Gns. or deposit £7/5/- and 9 monthly payments 56/3. (Total £32/13/3). Or in Teak or Afrormosia Veneered housing. 31 Gns. Carr. 15/- or Deposit £7/3/6 and 9 monthly pymts. 64/- (Total £35/19/6). *Send S.A.E. for leaflet*

Record Playing Units

MONEY SAVING UNITS Ready to plug into Amplifier
RP2 Consisting of Garrard SP25 Mk. II (with heavy turntable) fitted Goldring CS90 high compliance ceramic Stereo/Mono cartridge with diamond stylus. Mounted on plinth. Transparent plastic. Cover included. Inc. carr. **22Gns.**
RP3 As above but with Goldring Lenco GL68 Transcription unit and CS90 Cartridge. Cover included. Inc. carr. **28Gns.**
Various other types with Magnetic P.U. Cartridges and 'Lift off' or 'Roll over' transparent covers at lowest prices.

R.S.C. PLINTHS

for Record Playing units. Teak finish cut for Garrard 1000, 2000, 3000, AT6, AT60, SP25 etc. etc. **59/9** Available with Transparent plastic cover. Inc. carr. **6 Gns.**
1 Watt Transistor Amplifiers. Min. size battery operated. For 3-5Ω L/speakers. Brand new boxed. **37/9**

BRADFORD 10 North Parade (Half-day Wed.). Tel. 25349
BLACKPOOL (Agent) O & C Electronics 227 Church St.
BIRMINGHAM 30/31 Gt. Western Arcade, opp. Snow Hill Station 021-236 1279. Half-day Wed.
DERBY 26 Osmaston Rd. The Spot (Half-day Wed.). Tel. 41361
DARLINGTON 18 Priestgate (Half-day Wed.). Tel. 68043
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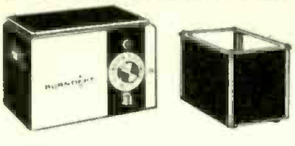

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(Burndept B.E.352) 60 watt model. Supplied Brand New complete with stainless steel tank 9¾ × 6½ × 4½ in. **£60.** Carr. 20/-.

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SPEAKER BARGAINS. E.M.I. 13 × 8 in. with double Tweeters 15 ohm, **65/-**, P.P. 5/-. As above less tweeters 3 or 15 ohm, **45/-** ea., P.P. 5/-.

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100 c.f.m. 4½ × 4½ × 2 in. 2800 r.p.m. Wonderful buy at **50/-** ea. 240v. A.C.

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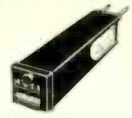

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High stability, carbon film, low noise. Capless construction, molecular termination bonding.
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Leads: 35
10% ranges; 10 Ohms to 10 Megohms (E12 Renard Series).
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		each	10 off	25 off	100 off
¼W	10%	2d.	1/6	3/3	10/4
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CAPACITORS
Subminiature Polyester film. Modular for P.C. mounting. Hard epoxy resin encapsulation. Radial leads.
±10% tolerance. 100 Volt working.
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0·001, 0·002, 0·005, 0·01, 0·02	6d.	4/3	8/4	30/-
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0·2	1/2	10/-	20/10	68/6

Polystyrene film. Tubular. Axial leads. Unencapsulated ±5% or ±1pf tolerance. 160 Volt Working.
Prices—per Capacitance value (μμF)

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10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82, 100, 120, 180, 220, 270, 330, 390	5d.	3/7	7/9	24/-
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2,200, 3,300, 4,700, 5,600	7d.	5/-	10/10	33/4
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POTENTIOMETERS (Carbon)
Superior grade enclosed controls. Low rotational noise. Body dia., 1in. Spindle, 2in. × ¼in. Tolerance, 20%.
Linear: 1K to 2M. (½W at 40°C).
Logarithmic: 5K to 2M. (¼W at 40°C).

Prices per ohmic value	each	10 off	25 off	100 off
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GANGED STEREO POTENTIOMETERS (Carbon)
¼W at 70°C. Long Spindle.
Logarithmic and Linear: 5k + 5k to 1M + 1M.

Prices per ohmic value	each	10 off	25 off	100 off
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High quality pre-sets suitable for printed circuit boards of 0·1in. P.C.M. 100 ohms to 5 Megohms (Linear only). Miniature: 0·3W at 70°C. ±20% below ½M, ±30% above ½M. Horizontal (0·7in + 0·4in. P.C.M.) or Vertical (0·4in. × 0·2in. P.C.M.). Subminiature: 0·1W at 70°C. ±20% below 2·5M, ±30% above.

Prices—per ohmic value	each	10 off	25 off	100 off
Miniature (0·3W)	1/-	8/9	18/9	66/8
Subminiature (0·1W)	10d.	7/1	14/7	46/8

ELECTROLYTIC CAPACITORS (Mullard.) —10% to +50%.
Subminiature (all values in μF)

4V	8	32	64	125	250	400
6·4V	6·4	25	50	100	200	320
10V	4	16	32	64	125	200
16V	2·5	10	20	40	80	125
25V	1·6	6·4	12·5	25	50	80
40V	1	4	8	16	32	50
64V	0·64	2·5	5	10	20	32
Price	1/4	1/3	1/2	1/-	1/1	1/2

Small (all values in μF)

4V	800	1,250	2,000	3,200
6·4V	640	1,000	1,600	2,500
10V	400	640	1,000	1,600
16V	250	400	640	1,000
25V	160	250	400	640
40V	100	160	250	400
64V	64	100	160	250
Price	1/6	2/-	2/6	3/-

POLYESTER CAPACITORS (Mullard)
Tubular 10%. 160V: 0·01, 0·015, 0·022μF, **7d.** 0·033, 0·047 μF, **8d.** 0·068, 0·1 μF, **9d.** 0·15 μF, **11d.** 0·22 μF, **1/-.** 0·33 μF, **1/3.** 0·47 μF, **1/6.** 0·68 μF, **2/3.** 1 μF, **2/8.**
400V: 1,000, 1,500, 2,200, 3,300, 4,700pF, **6d.** 6,800pF, 0·01, 0·015, 0·022 μF, **7d.** 0·033 μF, **8d.** 0·047 μF, **9d.** 0·068, 0·1 μF, **11d.** 0·15 μF, **1/2.** 0·22 μF, **1/6.** 0·33 μF, **2/3.** 0·47 μF, **2/8.**

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PRINTED CIRCUIT BOARD (Vero).
0·15in. Matrix: 3¾in. × 2½in., **3/3.** 5½in. × 2½in., **3/11.** 3¾in. × 3¾in., **3/11.** 5in. × 3¾in., **5/6.**
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a complete stereo system for 28 gns

The new Duo general-purpose 2-way speaker system is beautifully finished in polished teak veneer, with matching vynair grille. It is ideal for wall or shelf mounting either upright or horizontally.

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The Duetto Integrated Transistor Stereo Amplifier 9 GNS. +7/6 p. & p.

The Duetto is a good quality amplifier, attractively styled and finished. It gives superb reproduction previously associated with amplifiers costing far more.

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R.M.S. power output: 3 watts per channel into 10 ohms speakers.
INPUT SENSITIVITY: Suitable for medium or high output crystal cartridges and tuners. Cross-talk better than 30dB at 1Kc/s.
CONTROLS: 4-position selector switch (2 pos. mono & 2 pos. stereo) dual ganged volume control.
TONE CONTROL: Treble lift and cut. Separate on/off switch. A preset balance control.

The Classic Teak finished case $8\frac{1}{2}$ GNS. plus 7/6 p. & p.

SPECIFICATION: Sensitivities for 10 watt output at 1 KHz. Tape Head: 3mV (at $3\frac{3}{4}$ i.p.s.) Mag. P.U.: 2 mV. Cer.P.U.: 80 mV. Radio: 100mV. Aux. 100 mV. Tape/Rec. Output: 100 mV. Equalisation for each input is correct to within +2dB (R.I.A.A.) from 20 Hz to 20KHz. Tone Control Range: Bass ±13 dB at 60 Hz. Treble ±14 dB at 15 KHz. Total Distortion: (for 10 watt output) <1.5%. Signal Noise: < −60dB. AC Mains 200-250v. Size $12\frac{1}{2}$" long. $4\frac{1}{4}$" deep. $2\frac{3}{4}$" high. **Built and tested.**

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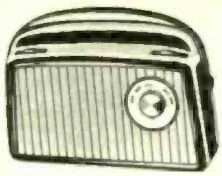
OUTPUT: 10 watts per channel into 3 to 4 ohms speakers (20 watts) monoral.
INPUT: 6-position rotary selector switch (3 pos. mono and 3 pos. stereo). P.U., Tuner, Tape and Tape Rec. out. Sensitivities: All inputs 100mV into 1.8M ohm.
FREQUENCY RESPONSE: 40Hz-20KHz ± 2dB.
TONE CONTROLS: Separate bass and treble controls. TREBLE 13dB lift and out (at 15KHz) BASS 15dB lift and 25dB cut (at 60Hz).
VOLUME CONTROLS: Separate for each channel.
AC MAINS INPUT: 200-240v. 50-60Hz.
SIZE: $12\frac{1}{2}$" x 6" x $2\frac{3}{4}$" in teak-finished case. Built and tested. p & p 7/6d.
Viscount Mark II for use with magnetic pick ups specification as above. Fully equalised for magnetic pick ups. Suitable for cartridges with minimum output of 4mV/cm/sec. at 1kc. Input Impedence 47k. **15 gns** plus 7/6 p&p.



THE DORSET (600mW Output)

7-transistor fully tunable M.W.-L.W. superhet portable—with baby alarm facility. Set of parts. The latest modulized and pre-alignment techniques makes this simple to build. Sizes: 12" x 8" x 3".

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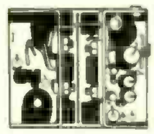
X101 10w. SOLID-STATE HI-FI AMP WITH INTEGRAL PRE-AMP.

Specifications: Power Output (into 3 ohms speaker) 10 watts. Sensitivity (for rated output): 1mV into 3K ohms (0.33 microamp) Total Distortion (at 1 KHz): At 5 watts 0.35%: At rated output 1.5%. Frequency Response: Minus 3 dB points 20 Hz and 40 KHz. Speaker: 3-4 ohms. (3-15 ohms may be used). Supply voltage: 24v D.C. at 800 mA. (6-24V. may be used).



Price **69/6** plus 2/6 p. & p.

CONTROL ASSEMBLY: (Including resistors and capacitors). 1. Volume: **Price 5/-**. 2. Treble: **Price 5/-**. 3. Comprehensive bass and treble: **Price 10/-**. The above 3 items can be purchased for use with the X101. **POWER SUPPLIES FOR X101:** P101 M (mono) **35/-** p. & p. 4/6: P101 (stereo) **42/6** p. & p. 4/6.

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An extremely reliable general purpose valve Amplifier—with six electronically mixed inputs. Suitable for use with: mics, guitars, gram, tuner, organ, etc. Separate bass and treble controls. Output impedance 3, 8 and 15 ohms.

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Solid State General Purpose Amplifier

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MIKE TO SUIT (CRYSTAL): 12/6d. + 1.6d. p. & p.
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CYLDON 2 TRANSISTOR U.H.F. TUNER

Brand new. Complete with circuit diagram.
£2.10 +1/- p. & p.

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(by famous manufacturer)

For 6 volt or 12 volt positive earth systems. Comprising: special high voltage working hermetically sealed silicon transistor mounted in finned heat-sink, high output ignition coil, ballast resistor and hardwear (screws, washers, etc.)

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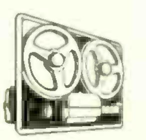

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3 Speed 2 track Tape Deck complete with heads, takes 7in. spool. Incorporating 3 motors. A.C. mains, 240 volts, listed at £21.0.0.

Our Price **£9.19.6** plus 10/- p. & p.

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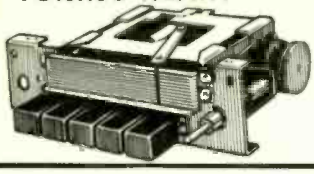
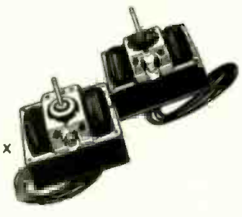
PYE CAR-RADIO PUSH BUTTON TUNING HEART



25/- + 3/- p. & p. This PRESTOLOCK 5 station Push-Button Tuner Heart with Manual Over-ride is an ideal basis for a quality AM car radio. Size 6½" x 4" x 2".

GARRARD TAPE MOTORS

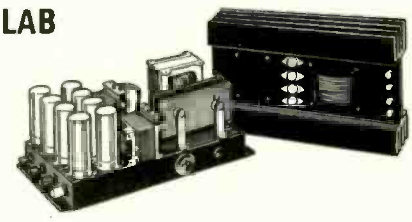


39/6 per pair + 7/6 p. & p.
Fast forward and fast re-wind motors, as used by famous manufacturer. Size 3" x 2½" x 2¾". Spindle 5/32" AC Mains 250v.

ADVANCE CONSTANT VOLTAGE TRANSFORMER

Price **22/6** p. & p. 7/6. Output 7.5 volts at 1 amp and 30v. at 100 MA. Mains input 125 volts (2 can be used in series for 250 volts).

LIVINGSTONE LAB



50 watt RMS Base Transistor Amplifier **27 Gns.** plus 20/- p. & p. This amplifier is designed and manufactured by L.L. using the best quality components, thus making it an extremely reliable and almost indestructible. Size (Power supply) 16" x 9¼" x 6½" (Amplifier) 14½" x 9" x 4" sensitivity for rated output 1 volt.

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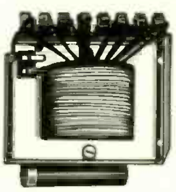

35/- p. & p. 7/6. Input 250 volts. OUTPUT (All RMS values) 4 windings of 11.5 volts connected in series total 46 volts at 4.5 amps (conservatively rated). The following combinations may be used.

1. 23—0—23 volts
2. 46 volts

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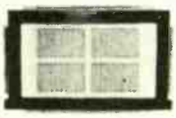

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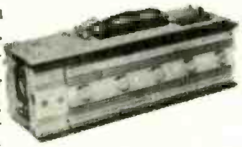

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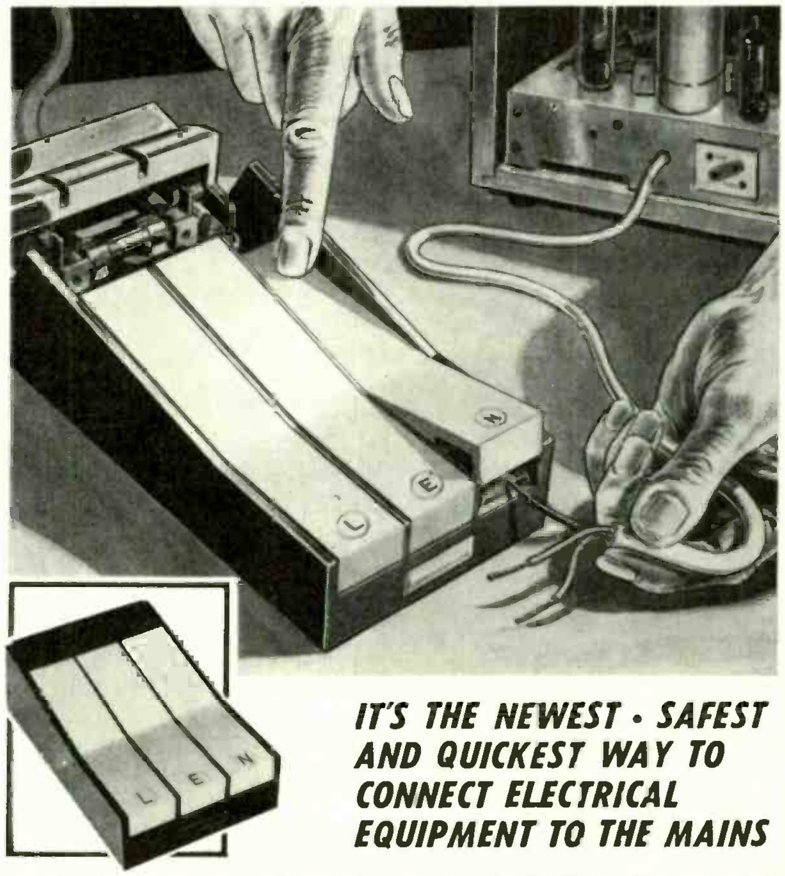

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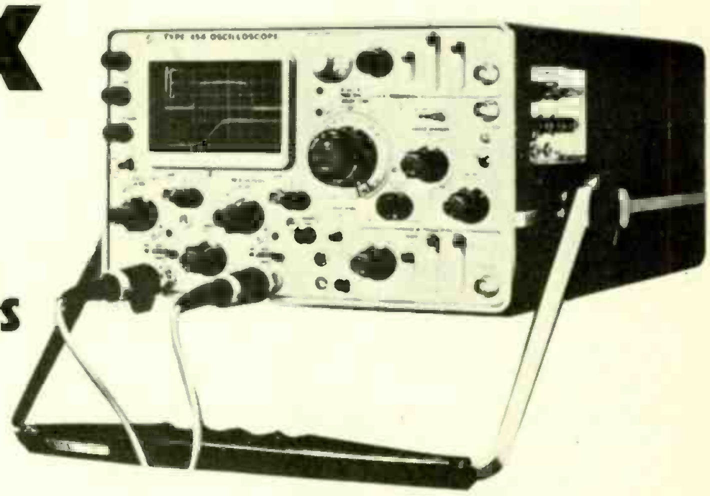

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To assist with the maintenance of broadcasting equipment in a large studio complex including sound mixers, programme routing equipment, automated programme equipment, tape and disc recording and playback units. Some shift work will be required.

The Corporation offers annual increments and bonus on merit and has a pension fund, medical aid scheme and group life assurance scheme of which membership is compulsory. Attractive commencing salaries, salary scales and a settling allowance are offered. Travelling expenses to the Republic of South Africa will be borne by the S.A.B.C.

Applications should be addressed to Mr. G. L. A. Jensen, Administrative Supervisor, S.A.B.C., C/o Agence France Presse, 43, Shoe Lane, London E.C.4, to reach him not later than 15th August 1969. Interviews will be conducted in London.

2303

Government of MALAWI

REQUIRES

Radio Engineer

[Police Department]

to serve on contract for one tour of 24—36 months in the first instance. Salary according to experience in scale £574—1223 a year (basic) plus Overseas Addition £401—612 a year. A further allowance of £196—244 a year is paid directly to the officer's bank in the U.K. Gratuity (free of Malawi tax) 25% of basic salary plus Overseas Addition provided minimum tour of 30 months is served. Liberal paid leave. Outfit and education allowances. Furnished accommodation. Free passages. Contributory pension scheme available in certain circumstances.

Candidates, up to 45 years, should have at least 5 years practical experience in radio, preferably in a Police Force or the Armed Forces. Preference will be given to candidates possessing the City and Guilds Intermediate Telecommunications Certificate or equivalent. A good knowledge of transistor circuitry, multi-channel carrier telephone equipment and/or diesel plant and petrol/electric alternators would be an advantage.

Apply to CROWN AGENTS, 'M' Division, 4 Millbank, London, S.W.1., for application form and further particulars stating name, age, brief details of qualifications and experience and quoting reference number M2K/64949/WF

2349

Work as a RADIO TECHNICIAN attached to Scotland Yard

You'd be based at the Metropolitan Police Wireless Station, Thornton Heath. Your job would be to maintain the portable VHF 2-way radios, tape recorders, radio transmitters and other electronic equipment, which the Metropolitan Police must use to do their work efficiently.

We require a technical qualification such as the City & Guilds Intermediate (telecommunications) or equivalent.

Salary scale: £1,032 (age 21), rising by increases to £1,379. Promotion to Telecommunication Technical Officer will bring you more.

For full details of this worthwhile and unusual job, write to: Metropolitan Police, Room 733 (RT), New Scotland Yard, Broadway, London, S.W.1.

2350

Planning Engineer DATA TRANSMISSION SYSTEMS

THE POST is in the Systems Planning Department of our Head Office at Southall, and will involve the planning of national and international data transmission systems. These can either be self-contained networks or systems allied to computers.

THE MAN to fill this post must be an engineer with a broad knowledge of communication systems and practical experience of the problems associated with the transmission of data at low, medium and high speeds. He should possess specialised knowledge in two or more of the following fields.

(a) Data modem and international standards for modulation and interface parameters.
(b) Commissioning, equalising and subsequent quantity control of long distance circuits handling data.
(c) Distribution of high speed data from computers to video display terminals.
(d) Low speed data switching systems handling telegraph signals including polling systems.
(e) The use of G.P.O. datel services and the problems of demarcation between G.P.O. and lessee's equipment.
(f) Operation of long distance leased circuits carrying data with particular reference to reliability of different sections of route.

It is unlikely that the successful applicant will be less than 30 years old. He should preferably have membership of a professional institution or qualification leading to such membership.

OUR OFFER will carry a starting salary to be negotiated in the range of £1,800-£2,100, membership of an excellent Contributory Pension and Life Insurance Scheme and benefits also include substantial concessions on holiday air fares to most parts of the world after 1 year's service. The post offers very good career prospects.

Please apply stating briefly details of age and qualifications to date, to:

Personnel Officer (R),
International Aeradio Limited,
Aeradio House, Hayes Road, Southall, Middlesex.

IAL **INTERNATIONAL AERADIO LIMITED**
AERADIO HOUSE · HAYES ROAD · SOUTHALL · MIDDLESEX

2359

The Stock Exchange require two

Television Service Engineers

Later this year, as the Stock Exchange continues its programme of modernisation, a closed circuit television system is being installed for the display of market prices.

To maintain this system, two experienced Television Service Engineers are required. Appropriate Television and Radio servicing certificates are essential, and applicants must be able to prove their ability as competent Service Engineers by suitable trade test.

Attractive salaries are offered in the region of £1,500–£1,600 p.a. with these positions and fringe benefits include a non-contributory pension scheme.

Applications giving brief details of qualifications and experience should be sent to: The Personnel Officer, Council of the Stock Exchange, 61 Threadneedle Street, EC2.

V.H.F. TELEVISION RELAY & COMMUNAL AERIAL SYSTEMS

We are planning a considerable expansion of our activities and have the following vacancies:

I. A SENIOR ENGINEER

to have control of all aspects of systems design, planning, estimating, installation and commissioning.

II. ENGINEERS

capable of undertaking either:

(*a*) System planning and estimating.

(*b*) control of installation work.

or (*c*) test and commissioning duties.

Candidates for these appointments must have a good background of practical experience in this field of work, and an up-to-date knowledge of techniques and equipment.

Applications, which will be treated in strict confidence, should be sent to:

BRITISH RELAY

The General Manager,
Special Services Division,
British Relay House,
41, Streatham High Road, S.W.16

2342

THE HANNAH DAIRY RESEARCH INSTITUTE

An

ASSISTANT EXPERIMENTAL OFFICER

required to assist in operation and further development of calorimeter for studying heat losses from animals. A man interested in using physical and engineering techniques for biological measurements would be particularly suitable. Previous experience in animal calorimetry not essential. Minimum qualifications ordinary B.Sc. or a Higher National Certificate or its equivalent in general science or electrical engineering. Salary on the A.E.O. grade with entry according to age (£770 at age 20; £1,150 at age 26 or over; rising to maximum £1,385). Superannuation. Applications, with the names of two referees, to the Secretary, The Hannah Dairy Research Institute, Ayr, by 14th July, 1969.

2311

EXPERIMENTAL OFFICER

required to assist in the setting up and running of a technologically biased laboratory in electronic tubes. The laboratory forms part of postgraduate training scheme for electrical engineers in the tube manufacturing industry. Qualifications should be HNC, HND, degree or equivalent in electrical engineering. Experience in vacuum technology, electronic tubes, microwave systems or gas-filled tubes will be an advantage. Appointment in the first instance is for three years after a suitable probationary period.

Salary—£1455 to £1865 per annum. Superannuation. Application to Departmental Superintendent, Electrical Engineering Department, Imperial College, South Kensington, S.W.7. 2296

digital

COMPUTERS · MODULES

Digital is maintaining its position as the leading manufacturer of small, medium and large scientific computers and continuing expansion during 1969 has created further opportunities.

We offer:—

A challenging career

Excellent promotion prospects

Opportunity to exercise initiative and imagination.

Responsibility.

We require the following:—

Experienced

Electronics Engineer

Qualifications B.Sc., H.N.D. H.N.C. or equivalent. Preferably with 2 tc 5 years of experience in the repair and maintenance of Electronic Equipment, Instruments, Circuits etc. down to component level. Further experience in Test Equipment design would be an advantage.

Responsibility to be the upgrading of a Module Repair Department by (a) Organising fault data collection and analysis; (b) Improving the test methods; (c) Development test equipment to increase the range of modules repaired.

Module Repair Technician

To assist the above Engineer. Qualifications are O.N.C. or equivalent with at least one year's relevant experience with Integrated Circuits and transistorised circuits.

Please write or telephone Personnel Department Ref. WW103

DIGITAL EQUIPMENT CO. LIMITED,

ARKWRIGHT ROAD, READING, BERKS. TEL: ORE 4-85131

EW 104

ELECTRONIC SERVICE ENGINEERS

required to work in this country and overseas, to maintain airborne navigational equipment. Ex-service Radar or Television and Radio Engineering experience an advantage.

Apply:

THE DECCA NAVIGATOR COMPANY LIMITED
SPUR ROAD, FELTHAM, MIDDX.

Telephone: 01-890 4898

2301

UNIVERSITY OF SURREY

EXPERIMENTAL OFFICER

Experimental Officer required, qualified and experienced in modern electronics to support the research groups in the Department of Electrical and Control Engineering.

The three major research groups are working in the fields of:

Ion implantation into semiconductor materials.

The applications of lasers and telecommunications.

Control and computers.

The work includes design of special equipment and apparatus and assistance with experimental work. The contract of employment would be for three years in the first instance.

Salary in the range of £1,338 to £1,766 per annum.

Applications should be sent to the Staff Officer, University of Surrey, Guildford, Surrey. 2327

NORWICH CITY COLLEGE DEPARTMENT OF ELECTRICAL ENGINEERING

Applications are invited for the position of

ELECTRONIC WORKSHOP TECHNICIAN

Applicants should have appreciable practical experience in electrical workshop practice and especially in the electronics field. Opportunities exist for study in order to obtain recognised qualifications.

Salary: Technical scale 2/3 (£765—£1,055 per annum). Additional payments for recognised qualifications.

Application forms may be obtained from the Registrar, Norwich City College, Ipswich Road, Norwich, Norfolk. NOR 67D. 2305

ELECTRONICS TECHNICIAN

Required to work in well equipped Electronics Department. Experience with Medical or Industrial Electronics or Nucleonic Equipment an advantage.

Salary according to age and experience

Applications to:

THE DIRECTOR,
NEUROPSYCHIATRIC RESEARCH UNIT,
MEDICAL RESEARCH COUNCIL LABORATORIES,
WOODMANSTERNE ROAD, CARSHALTON, SURREY

2326

Computer Engineering

NCR requires additional ELECTRONIC, ELECTRO-MECHANICAL ENGINEERS and TECHNICIANS to maintain medium to large scale digital computing systems in London and provincial towns.

Training courses will be arranged for successful applicants, 21 years of age and over, who have a good technical background to ONC/HNC level, City and Guilds or radio/radar experience in the Forces.

Starting salary will be in the range of £900/£1150 per annum, plus bonus. Shift allowances are payable, after training, where applicable. Opportunities also exist for Trainees, not less than 19 years of age, with a good standard of education, an aptitude towards and an interest in, mechanics, electronics and computers.

Excellent holiday, pension and sick pay arrangements. Please write for Application Form to Assistant Personnel Officer NCR, 1,000 North Circular Road, London, N.W.2, quoting publication and month of issue.

Plan your future with NCR

Government of ZAMBIA

ZAMBIA BROADCASTING SERVICES

Requires

TECHNICAL OFFICER

(STUDIOS AND TRANSMITTERS)

on contract for one tour of 36 months in the first instance. Commencing salary according to experience in Scale Kwacha 1644 (£Stg.959) rising to Kwacha 3216 (£Stg. 1876) a year, plus an Inducement Allowance of £Stg.237–£Stg.615. Gratuity 25% of total salary drawn. A direct payment of £Stg.233–£Stg.291 is also payable direct to an officer's home bank account. Both gratuity and supplement are normally TAX FREE. Free passages. Quarters at low rental. Children's education allowances. Liberal leave on full salary or terminal payment in lieu.

Candidates preferably between 23 and 45 years of age, must possess the City and Guilds Intermediate Certificate in Telecommunications, or the equivalent and have at least four years experience in a recognised Broadcasting Organisation on maintenance duties in:

(a) Sound Transmission and recording studios, or
(b) Television studios, or
(c) Transmitting stations.

The officer will be required to undertake routine operational shift duties and to assist with the maintenance and installation of equipment.

Apply to CROWN AGENTS, 'M' Division, 4 Millbank, London, S.W.1., for application form and further particulars stating name, age, brief details of qualifications and experience and quoting reference number M2Z/680905/WF.

2352

MID-HERTS COLLEGE OF FURTHER EDUCATION
THE CAMPUS, WELWYN GARDEN CITY, HERTS.

DEPARTMENT OF ELECTRICAL ENGINEERING

LECTURER, before January 1970 if possible to teach on Electrical and Telecommunication Technician courses up to Pt. II level. Specialist in G.P.O. work subjects particularly suitable.

Minimum qualifications—H.N.C. Elec. with practical telecomm. industrial experience, Teacher training or experience an advantage, but training course available on day-release in the County.

Salary £1,035-£1,835 dependent on qualifications and experience in industry. For a candidate able to organise all telecomm. courses an extra £175 allowance may be paid. Assistance with housing and removal in certain cases.

Forms and further details from Principal at the College. Closing date 25th July.

2316

Electronics Technician or Junior Technical Officer

required to develop and build solid state equipment for the cyclotron control system embodying current computer techniques. Some relevant experience essential. Opportunities for day release study. Age under 25. Starting salary up to £1169 according to qualifications and experience. *Write with full details to:*

THE DIRECTOR,
Medical Research Council Cyclotron Unit,
HAMMERSMITH HOSPITAL,
DUCANE ROAD, LONDON, W.12.

2317

GEC-Marconi Electronics

ELECTRONIC TECHNICIANS

Marconi can offer you

Attractive salary. Annual salary reviews

Good working conditions. 37-hour working week

Non-tied housing in a new town in certain circumstances

At Basildon we have a number of vacancies for technical test staff to work on advanced aeronautical electronic systems, maintenance and building of test equipment and other major projects. These positions will be of particular interest to men with experience of transmitters, receivers, aerials, closed circuit T.V. or digital systems.

Marconi

THE QUEEN'S AWARD TO INDUSTRY 1966 1967 1968 1969

Please telephone or write for an application form to: Mr. R. McLachlan, Personnel Officer, The Personnel Dept, The Marconi Company Limited, Christopher Martin Road, Basildon, Essex. Phone: Basildon 22822.

Member of GEC-Marconi Electronics Limited

2345

communications technicians

Air Force Department

The Air Force Department now has *two* levels of entry for men as Telecommunication Technical Officers. Both involve work on the installation, calibration, repair, maintenance and inspection of airborne and ground radio and radar equipments at R.A.F. stations in the United Kingdom. Opportunities for overseas service.

Age: At least 25 for Grade II.
At least 21 for Grade III.

Starting salary: (National) Grade II £1,601 which rises with yearly increases to £1,853 (£1,975 after 1.1.70.)
Grade III. According to age, e.g. £1,086 at 21, £1,178 at 23, £1,418 at 28 or over. Rises to £1,601 (£1,735 after 1.1.70.)
Promotion can take you to posts carrying at least £2,825.

Working conditions: 5 day working week. Over 3 weeks annual holiday from the start. This rises to 6 weeks. Non-contributory pension.

Qualifications: City & Guilds Technical Intermediate (No. 49) plus Certificates in Mathematics B, Telecommunications Principles B and Radar and Line Transmission B, or O.N.C. or equivalent in appropriate subjects. *Grade II candidates must also have had experience of supervising staff engaged on radio, radar, or other electronic work.*

*Fuller details of acceptable qualifications supplied on request.
Write to: Civil Service Commission, Savile Row, London W1X 2AA; or telephone 01-734 6010, Ext. 229 (after 5.30 p.m. 01-734 6464 "Ansafone" service) for application form, quoting S/7225/A. Closing date 9th Sept. 1969.

THE COLLEGE OF AERONAUTICS

The following appointments are to be made in the High Frequency Section of the DEPARTMENT OF ELECTRICAL AND CONTROL ENGINEERING and are open to candidates who have experience in waveguide techniques.

TECHNICAL OFFICER
TECHNICIAN

The vacancies are in the high frequency and radar laboratories which are concerned with postgraduate teaching and research in radar, radio and microwaves. Experience in the aviation field is not an essential requirement.

The TECHNICAL OFFICER will supervise the day-to-day activities in the laboratories and be responsible for the construction of specialised experimental equipment. Candidates should have passed the graduateship examination of the I.E.E., I.E.R.E., or possess a H.N.C. or equivalent qualification. Salary in scale rising to £1,517 p.a. (under review).

The TECHNICIAN, who will have received relevant training and experience, will be remunerated in a scale rising to £1,077 with a supplementary allowance of £50 p.a. for possession of a H.N.C. or equivalent qualification.

37 hour week of five days, generous holidays, staff superannuation and sick pay schemes.

Application form from Staff Records Officer, The College of Aeronautics, Cranfield, Bedford.

2309

ELECTRONICS ENGINEER

to design solid state circuits of high reliability in control, power supply and computer type applications. Pass degree or H.N.C. required. Some experience essential. Technical Officer category. Starting salary up to £1,518 p.a. Apply with career particulars to **THE DIRECTOR, MEDICAL RESEARCH COUNCIL CYCLOTRON UNIT, HAMMERSMITH HOSPITAL, LONDON, W.12**

2337

FOR HIRE OR SALE

CLOSED CIRCUIT TELEVISION EQUIPMENT

23in. PYE Monitors and single channel 625 lines polished teak cabinets. PYE Lynx Cameras, working tubes 1in. lenses: suitable for surveillance, education and general applications.

For details and prices contact Television Applications Limited, 9/11 Windmill Street, London, W.1. 01-636 3521.

2334

ELECTRONIC ENGINEER

required for development of apparatus for medical research purposes. The applicant should have a general knowledge of electronic instruments such as amplifiers, cathode ray tube displays and pressure measuring apparatus. Some workshop experience would be an advantage. The Salary is in the range £1,120-£1,455 as a Medical Physics Technician III according to age, qualifications and experience.

Applications, giving these details, and the names of two referees to: Geoffrey A. Robinson, Secretary to the Board of Governors, The National Hospital, Queen Square, London, W.C.1.

2298

TELEVISION ENGINEER

One-inch helical scan VTR and CCTV experience. Prospects of working in colour television.

Must be willing to travel occasionally through U.K. and Europe.

Salary approx. £1,500 per annum.

Telephone Mr. PANNAMAN 01 580 2283

2304

ROYAL FREE HOSPITAL

167 GRAYS INN ROAD, LONDON, W.C.1

MEDICAL ELECTRONICS DEPARTMENT

Technician required to assist in the development, construction and maintenance of medical research equipment. Previous experience in this field would be an advantage. Whitely Council rates. Please write, or telephone Mr. J. Green, Tel. No. 01-837 6411, Ext. No. 158, for further information.

[2331

Government of ZAMBIA

General Post Office

Professional Engineers

required for telecommunications on contract for one tour of 36 months in the first instance. Commencing salary according to experience in scale. Kwacha 2784 rising to Kwacha 4464 a year (£Stg.1624–£Stg.2605) plus inducement allowance of £Stg.348–£Stg.429 a year. Gratuity 25% of total salary drawn. A direct payment of Stg.£233–£Stg.350 is also payable direct to an officer's home bank account. Both gratuity and supplement are normally TAX FREE. Free Passages. Quarters at low rental. Children's education allowances. Liberal leave on full salary or terminal payment in lieu.
Candidates should have a recognised degree in telecommunications or electrical engineering or equivalent qualification. This should be followed by several years of experience with a telecommunications organisation. The duties of the posts are varied. They include planning of trunk and telegraph multiplex systems and radio systems, also the technical and economic evaluation of local and trunk line development policy in the field of underground cables and open wire lines.

Apply to CROWN AGENTS, 'M' Division, 4 Millbank, London, S.W.1., for application form and further particulars stating name, age, brief details of qualifications and experience and quoting reference number M2Z/61610/WF.

2353

TECHNICAL OFFICER
HOME OFFICE POLICE RESEARCH AND DEVELOPMENT BRANCH

Unestablished vacancy for a Technical Officer Grade III with knowledge and experience of workshop practice and electronic equipment. The successful candidate will work in the equipment group, which is concerned with assessment, trials and development of a wide range of equipment for police use, and will carry out construction, modification and test work in co-operation with police officers.

Qualifications: Ordinary National Certificate or evidence of an equivalent standard of technical education, together with a five year apprenticeship and at least three years' practical experience.

Salary: £1,114 (age 21)—£1,395 (age 28 or over on appointment)—£1,543.

Applications should be made to the Principal Establishment Officer, Room 327, Home Office, Whitehall, London, S.W.1, by 4th August, 1969.

2330

UNIVERSITY OF SURREY
INSTITUTE FOR EDUCATIONAL TECHNOLOGY

A TECHNICIAN is required in the Institute of Electronic Technology to service a range of electronic equipment including audio visual aids. This will be a three-year appointment concerned with work for the Leverhulme Research Fellowship. Good holidays and conditions. Salary on a scale £773 to £1,077 p.a.

Applications should be forwarded to the Staff Officer, University of Surrey, Guildford.

2297

ATV NETWORK LIMITED
has vacancies in Birmingham for

4 ASSISTANT ENGINEERS
in their Telecine Section

required for operation and maintenance duties in this section of their Central Technical Department. This will involve working with modern 35 mm. and 16 mm. telecine projection equipment, caption and slide scanners and associated electronic equipment.
We would like to hear from applicants possessing a good knowledge of television electronics and who are interested in working in this particular field.

PLEASE QUOTE VACANCY No. 68.

SOUND ASSISTANT "A" or "B"

APPLICANTS should have wide experience of television sound techniques including boom operation and the use of disc and tape recording and reproducing equipment.

PLEASE QUOTE VACANCY No. 49.

APPLY fully in writing stating age, knowledge and experience, to

Head of Staff Relations Television
ATV NETWORK LIMITED
150 Edmund Street, Birmingham, 3
(quoting the appropriate vacancy No.)

2336

circuit design engineers

for COLOUR TELEVISION

RANK BUSH MURPHY already occupy a leading position in the field of domestic radio and television. The brand names Bush and Murphy are synonymous with technical excellence and high reliability, and the current products continue to set the pace in technical design, aesthetic appeal and quality of reproduction.

The growth of the market in colour television creates further outstanding opportunities for electronics design and development engineers to join in this success and enjoy a future career with rewards matched to abilities and successful contribution to the business.

Our present need is for development engineers who have previous *successful experience of circuit design* in this or related fields such as communication systems or data processing.

The successful applicants will join our Advanced Development group at Chiswick and be concerned with examining the relevance and suitability of the latest techniques in electronics for inclusion in the design of our products. They should be around 27-30, qualified by degree and/or membership of I.E.E./or I.E.R.E., and earning a salary at present of around £1,800 per annum. Additional benefits on joining the Company include free life assurance, pension scheme and assistance with removals and relocation expenses in appropriate cases.

Applications should be addressed to:

BUSH MURPHY DIVISION

Divisional Personnel Manager,
Rank Bush Murphy Ltd.,
Power Road, London, W.4.

The Rank Organisation

Holders of The Queen's Award to Industry for 3 successive years.

ELECTRONICS TECHNICIAN

required, to be responsible to the Group Engineer for the maintenance, calibration and installation of a wide range of electronic equipment used in the medical and engineering field of hospital work. Qualifications required are to the level of H.N.C. with wide experience in the maintenance and calibration of electronic equipment. Salary range £1,030 to £1,365 p.a. Good applicants with reasonable prospects of acquiring the stated qualification will be considered. This post offers an ideal opportunity for a man to join a vital and growing service with prospects for advancement. Application forms from

GROUP ENGINEER,
READING & DISTRICT HOSPITAL MANAGEMENT COMMITTEE,
3 CRAVEN ROAD, READING

2325

FIELD SERVICE ENGINEER

For public address and audio amplification equipment.
Based from our **Glasgow office.**
Experience essential.
Company vehicle or vehicle allowance provided.
Write: **Service Manager, Magneta (B.V.C.) Ltd., Parson's Green Lane, London, S.W.6.**

2300

BRAND NEW

Cossor pocket vhf transmitter/receivers, CC2/8, Mark 2. Two sets for 156.4mc (Chan 8, intership), also two sets 157.85 (Marinas and Yacht Clubs). All complete, reduced price of £100 each, or all four for £390. Hudson R/t a.m. base station, 50 watt tx, 25 kc rx, excellent condition, £200. Marconi TF 995/A5 Sig. Gen., as new, £275 "Telecomm" all-transistor Sig. Gen., 70/95mc, as new, £70. Carriage and packing extra on all above. Box. W.W. 2318, Wireless World.

2318

AIR FORCE DEPARTMENT

Vacancies at — RAF Sealand, near Chester — RAF Henlow, Bedfordshire and RAF Carlisle, Cumberland.

Interesting and vital work on RAF Radar and radio equipment for

RADIO TECHNICIANS

Minimum qualification, 3 years training and practical experience in radio engineering.

Starting pay according to age, up to £1130 p.a. (at age 25) rising to £1304 p.a. with prospects of promotion.

5-day week — good holidays — help with further studies — opportunities for pensionable employment.

Write for further details to:
Ministry of Defence CE3h (Air)
Sentinel House
Southampton Row
London, WC1

Applicants must be U.K. residents.

2307

ENTHUSIASTS

have you considered a career in Technical Authorship? If you have sound experience in electronics or communications and ability to write clear concise English we would train you. The vacancies are in the Home Counties and the Midlands and salaries range from £1,600 to £1,900 p.a. depending on experience. Box W.W. 5056

2332

ATV NETWORK LIMITED

require an

ENGINEER

for their Technical Services Department (OB Vision Engineers Section). Applicants should have a thorough knowledge of Colour Television principles and practice, together with experience of modern 3 or 4 tube plumbicon television cameras.

Duties will include setting up, maintaining and controlling modern colour cameras and associated equipment on Outside Broadcast units, using advanced test equipment. Deputising for Vision Control Supervisor when necessary.

Salay £1900+.

Applications giving full details of age and experience should be sent to:

**Head of Staff Relations,
150 Edmund Street, Birmingham 3.**

Please mark on the envelope VACANCY 63 (E).

2324

LEC

RADIO & TELEVISION SERVICING
RADAR THEORY & MAINTENANCE

This private College provides efficient theoretical and practical training in the above subjects. One-year day courses are available for beginners and shortened courses for men who have had previous training.

Write for details to: The Secretary, London Electronics College, 20 Penywern Road, Earls Court, London, S.W.5. Tel.: 01-373 8721.

84

Telecommunications Superintendent

Required by the GOVERNMENT OF THE GAMBIA to serve on contract for one tour of 18-24 months in the first instance. Salary according to experience in scale £G.1026-1266 a year plus Inducement Pay normally tax free, of £816-900 a year paid direct into officer's bank in U.K. Gratuity 25% of total emoluments. Generous paid leave. Furnished accommodation. Education and Outfit Allowances. Free passages. Contributory pension scheme available in certain circumstances.

Candidates, up to age 50, must possess a City and Guilds Intermediate Telecomms. Certificate (Radio) or equivalent plus 10 years' experience in telecommunications engineering, 5 of which should preferably have been in Africa. Experience of automatic telephone exchanges would be an advantage.

The officer selected will be responsible for:

(A) the operation and maintenance of a V.H.F. multi-channel radio telephone and telegraph system throughout the Gambia.

(B) the maintenance of Police V.H.F. and H.F. fixed and mobile system and signals vehicle.

(C) general workshop practice including the repair and maintenance of miscellaneous equipment, i.e. tape recorders, public address equipment, etc.

He should be prepared to travel extensively in the Provinces.

Apply to CROWN AGENTS, "M" Division, 4 Millbank, London, S.W.1, for application form and further particulars, stating, name, age, brief details of qualifications and experience and quoting reference number M2K/690526/WF.

2295

NORTHERN POLYTECHNIC

Holloway Road, London, N.7.

Principal:
J. Leicester, M.Sc., M.Sc. Tech., Ph.D., F.R.I.C.

Department of Electronic and Communications Engineering

Head of Department:
J. C. G. Gilbert, C.Eng., F.I.E.R.E., F.T.S., F.B.K.S.

Full-time 3-year course in preparation for the Northern Polytechnic Diploma in Electronics and Telecommunications. This course is recognised by the Institution of Electronic and Radio Engineers and gives full exemption from the Graduateship examination.

Part-time day release and evening courses for Section B of the Graduateship examination of the Institution of Electronic and Radio Engineers covering:—

Applied Electronics
Computer Engineering
Television Engineering
Advanced Telecommunication Principles

Advanced Short Courses on:—
Colour Television Engineering
Modern Network Theory
Pulse Techniques
Basic Microwave Techniques
Transistor Engineering
Medical Electronics
Audio Engineering Measurements.

Full-time, 3-year course leading to exemption from Part 1 of the Council of Engineering Institutions (C.E.I.) examination, and the Higher National Diploma (H.N.D.) in electronic engineering.

Full-time, 2-year course for Radio, Television and Electronic Technicians in preparation for the City & Guilds of London Institute and the Radio Trades Examination Board's Certificates. Part-time day release and evening classes for Electronic Technicians for the Electronic Servicing Certificate of the City & Guilds of London Institute (Subject 47).

All the above courses include practical laboratory and workshop experience (where applicable). London fees: £40 per year, plus £5 10s. registration fee, for all full-time courses. (No fee for students under 18 years of age.)

Evening class fees range from 50/- to 110/- per session.

Enrolment for day classes by appointment.

Enrolment for part-time day release and evening classes: 23rd & 24th September 1969 between 5.30 and 7.30 p.m.

New session commences 29th September 1969. Prospectus free on application to Secretary.

2310

Become a RADIO TECHNICIAN

and work at the nerve centres of civil aviation

The National Air Traffic Control Service, a Department of the Board of Trade, needs Radio Technicians to install and maintain the very latest electronic aids at Civil Airports such as Heathrow, Gatwick and Stansted, Air Traffic Control Centres, Radar Stations and specialist establishments.

This is responsible demanding work (for which you will get familiarisation training) involving communications, computers, radar and data extraction, automatic landing systems and closed-circuit television and it offers excellent prospects with ample opportunities to study for higher qualifications in this fast-expanding field.

If you are 19 or over, with practical experience in at least one of the main branches of telecommunications, fill in the coupon now.

Starting salary varies from £869 (at 19) to £1,130 (at 25 or over); scale maximum £1,304 (higher rates at Heathrow), and some posts attract shift-duty payments. The annual leave allowance is good and there is a non-contributory pension scheme for established staff.

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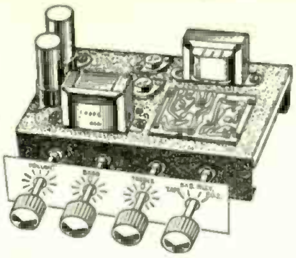

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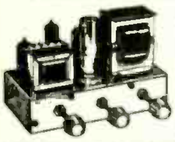

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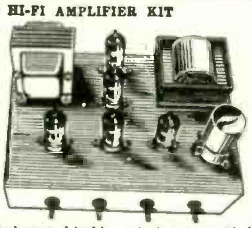

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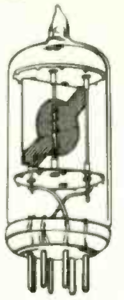

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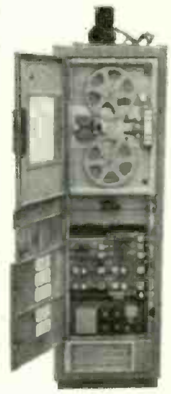

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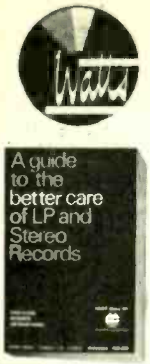

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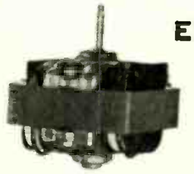

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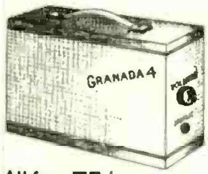

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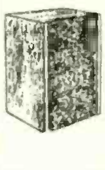

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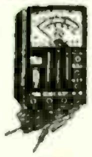

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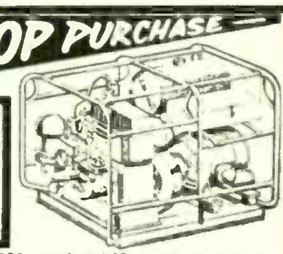

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★ THREE DAY REPAIR SERVICE ★ INTERCHANGEABLE BITS—STOCK ITEMS ★ SPECIAL TEMPERATURES AVAILABLE AT NO EXTRA COST.

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ERSIN

Multicore

5 CORE SOLDER

SAVBIT

THIS EXCLUSIVE ERSIN MULTICORE ALLOY IS SATURATED WITH COPPER AND WILL NOT DISSOLVE COPPER FROM COPPER WIRES, CIRCUIT BOARDS AND SOLDERING IRON BITS.

Melting Point 215°c Recommended Bit Temperature 275°c

	Before Soldering	During Soldering	After Soldering
In soldering with straight tin/lead alloys . . .	Tin/Lead Solder / Copper Tip — Solder contacted by copper tip . . .	Molten Tin/Lead/Copper / Copper Tip — absorbs tip metal to saturation . . .	Tin/Lead/Copper Joint / Copper Tip — and wears out tip rapidly!
Whereas . . . In soldering with SAVBIT ALLOY . . .	Tin/Lead/Copper Solder / Copper Tip — Copper-saturated SAVBIT solder . . .	Molten Tin/Lead/Copper / Copper Tip — cannot borrow copper from the iron . . .	Tin/Lead/Copper Joint / Copper Tip — which receives hardly any wear.

THIS EXPLAINS HOW SAVBIT ALLOY STOPS THE WEARING OUT OF COPPER TIPS

Ersin Multicore Savbit Solder is used throughout the world by leading electronic manufacturers to overcome the rapid pitting and wear of copper soldering iron bits. Savbit is a soldering alloy to which copper has been added, thus preventing the copper of the soldering iron bit being absorbed into the solder alloy.

By the use of Savbit Alloy, the bit life is prolonged by up to ten times, eliminating the need for frequent resurfacing of the copper bit, and, by keeping the copper bits in good condition the soldering speed and efficiency are increased. Also by using Savbit Alloy the diameter and strength of soldered copper wire will not be reduced.

Laboratory investigation and full-scale tests carried out by many manufacturers on their own production lines have proved the claims made for Savbit Alloy.

FOR FACTORY USE

7 lb. REELS

Available in standard wire gauges from 10–22 swg., on strong plastic reels.

1 lb. REELS

Available in all standard wire gauges from 10–34 swg., on unbreakable plastic reels. (From 24–34 swg. only ½ lb. is wound on one reel.)

FOR MAINTENANCE AND SERVICE ENGINEERS

SIZE 1 CARTONS

In 14, 16 and 18 swg. Packed in a coil, so it can be drawn out through the top of the carton.

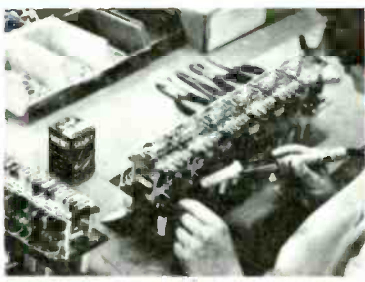
SIZE 5

Contains 10 ft. of 18 swg., packed in a unique handy dispenser.

SIZE 12

90 ft. of 18 swg. on a plastic reel, packed individually in a carton.

USED THROUGHOUT THE WORLD



HOLLAND

Ersin Multicore Savbit Alloy is used by Bull Nederland of Amsterdam, Holland for the assembly of administration and statistics machines.

NEW ZEALAND

Ersin Multicore Savbit Alloy is seen being used at the factory of Bell Radio Television Corpn. Ltd., Auckland, New Zealand.

For further details, please apply on your Company's notepaper to:
MULTICORE SOLDERS LTD., HEMEL HEMPSTEAD, HERTS. Telephone: HEMEL HEMPSTEAD 3636