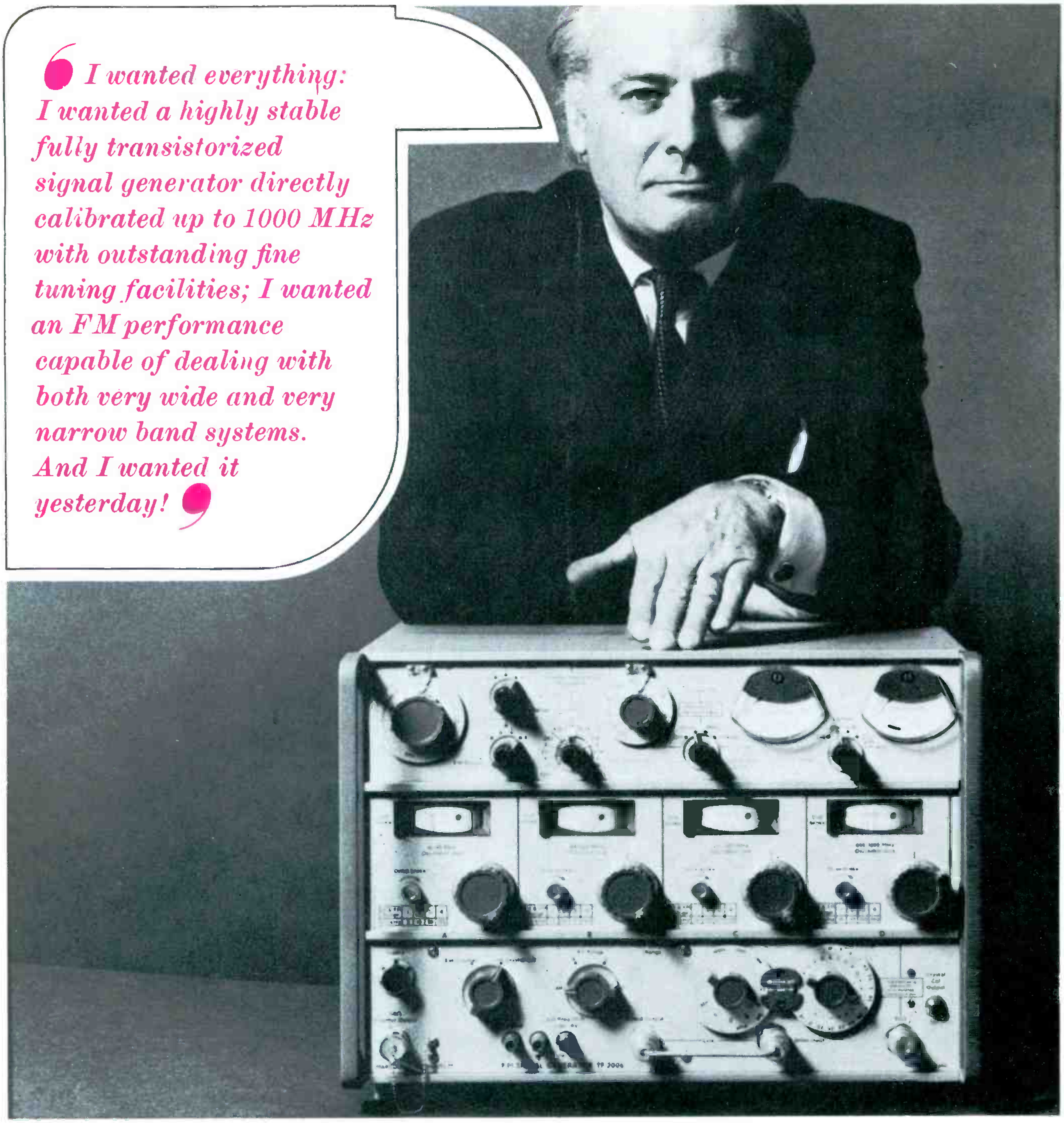
Wireless World

July 1971 17½p

S.S.B. receiver module

Audio sweep generator



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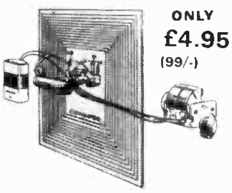
READY BUILT AND TESTED

TREASURE LOCATOR MODULE



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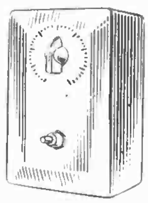
RELAXATRON



CUTS OUT NOISE POLLUTION—SOOTHES YOUR NERVES! Don't underestimate the uses of this fantastic new design—the RELAXATRON is basically a pink noise generator based on avalanche operated transistors. Besides being able to mask out extraneous unwanted sounds, it has other very interesting properties. For instance many people find a rainstorm mysteriously relaxing, a large part of this feeling of well-being can be directly traced to the sound of falling raindrops!—a well-known type of pink noise. A group of dentists have experimented on patients with this pink noise—NO ANAESTHETICS WERE USED! The noise ostensibly created a most definite reaction on these patients' nervous systems with the results that their pain systems were blocked. IF YOU WORK IN NOISY OR DISTRACTING SURROUNDINGS, IF YOU HAVE TROUBLE CONCENTRATING, IF YOU FEEL TENSED, UNABLE TO RELAX—then build this fantastic Relaxatron. Once used you will never want to be without it—pocket sized. Uses standard PP3 batteries (current used so small that battery life is almost shelf-life!) CAN BE EASILY BUILT using our unique, step-by-step, fully illustrated plans. All parts including case, a pair of crystal phones, components, nuts, screws, wire, etc., etc. Send only £2.25 + 25p p. & p. (45/- + 5/-). (Parts available separately.)

ONLY **£2.25** (45/-)

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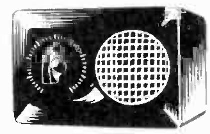

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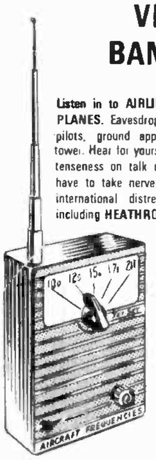
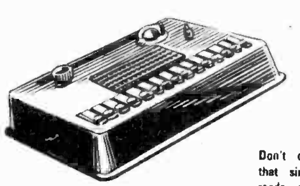


Real Working ELECTRONIC ORGAN



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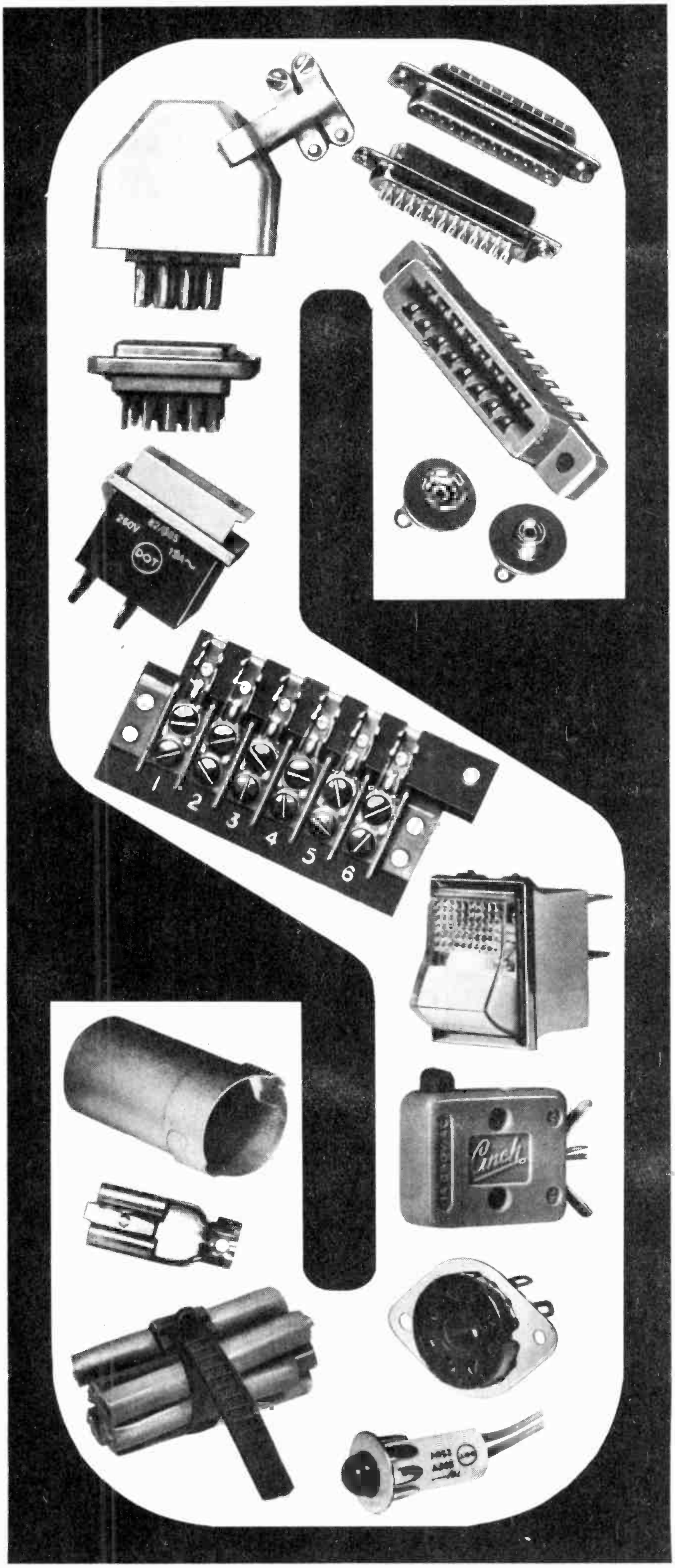

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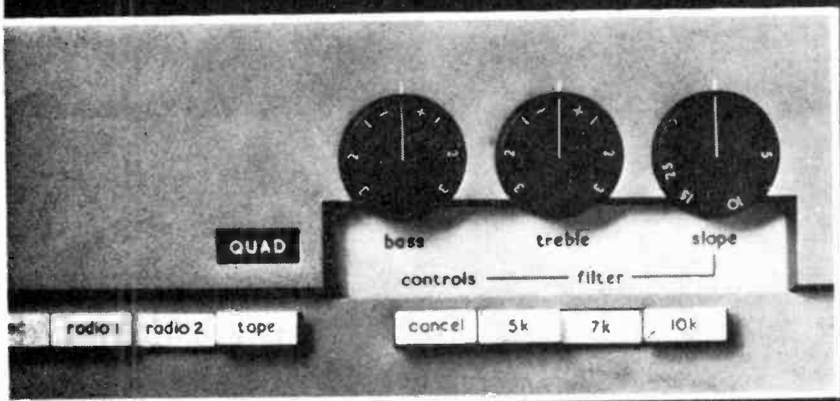

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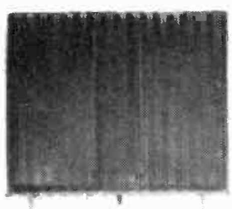

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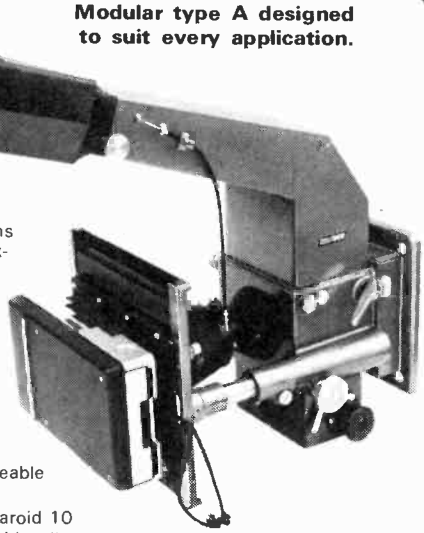

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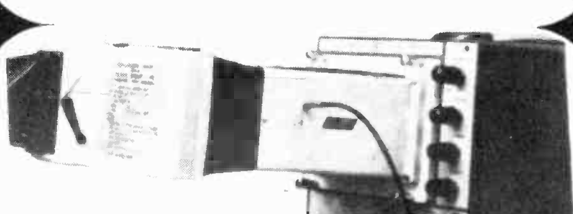

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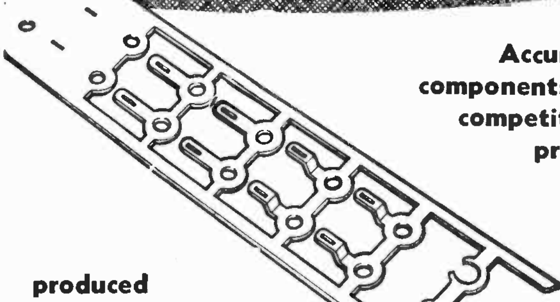

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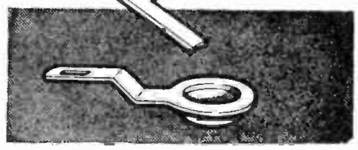

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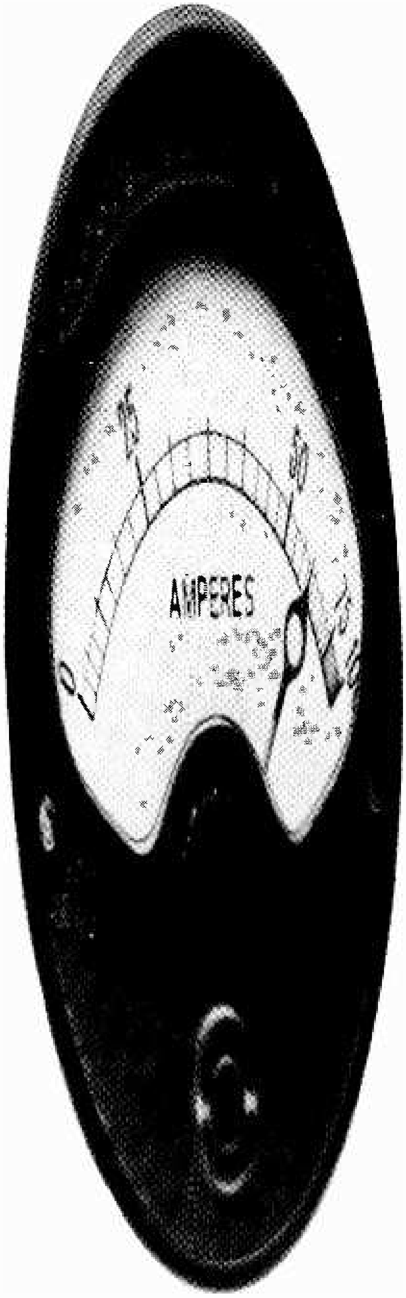
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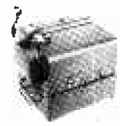

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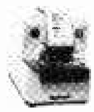

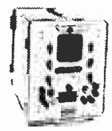

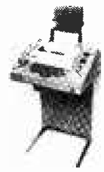

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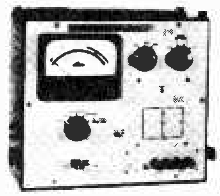
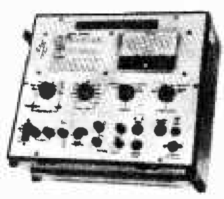


The Hatfield range of Transmission Test Equipment includes the Psophometer Type 1000 which is specified by the Post Office. This rugged battery operated unit incorporates solid state circuitry throughout and is designed for measuring flat or weighted wide-band noise.



The Milliwatt Test Set Type 747 gives laboratory accuracy in portable form making it unnecessary for more than one instrument to standardise signal levels on 75, 140 and 600 ohm circuits. *Send for full details of Hatfield Transmission Test Equipment and a copy of our Short Form Catalogue.*

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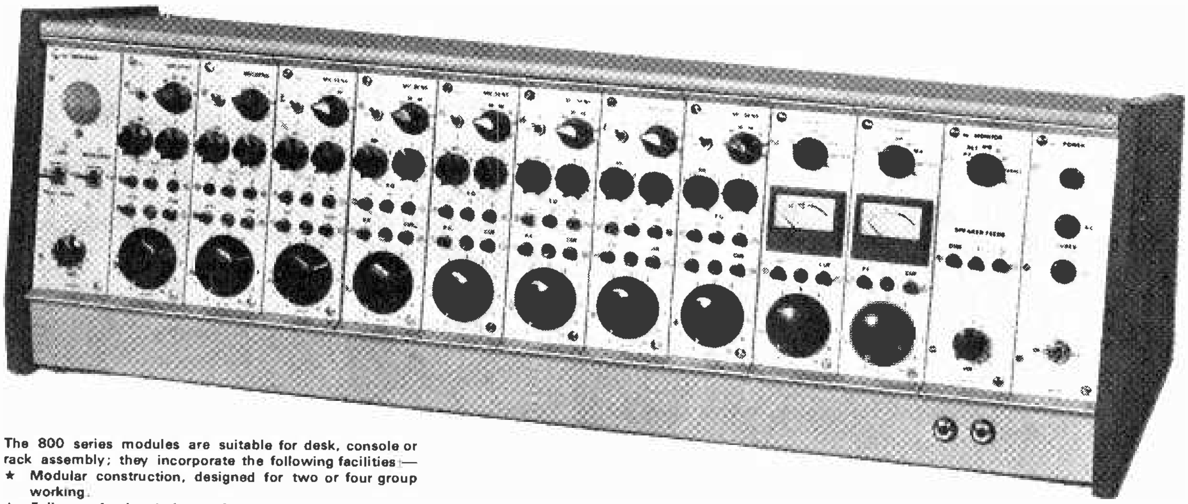

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* A single plug in board per module includes all active components.

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Microphone channels (2 & 4 group working): Line Channels: Group modules (including V.U. & P.P.M. metering): Monitor module: Talkback module: Power supply module Echo channel: Tone generator module. Limiter compressor module: Line equaliser module.

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Subsidiary of Felten & Guilleaume Kabelwerke AG KÖLN-MÜLHEIM

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"BNC" "N"

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A wide range of N, C, BNC, 83UHF, VMP, SM and MINI types. Crimp types in N, BNC & 83 UHF produced in addition to standard cable clamps. Other types for special applications.

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These are screened containers for attenuators etc. fitted with coaxial connectors.

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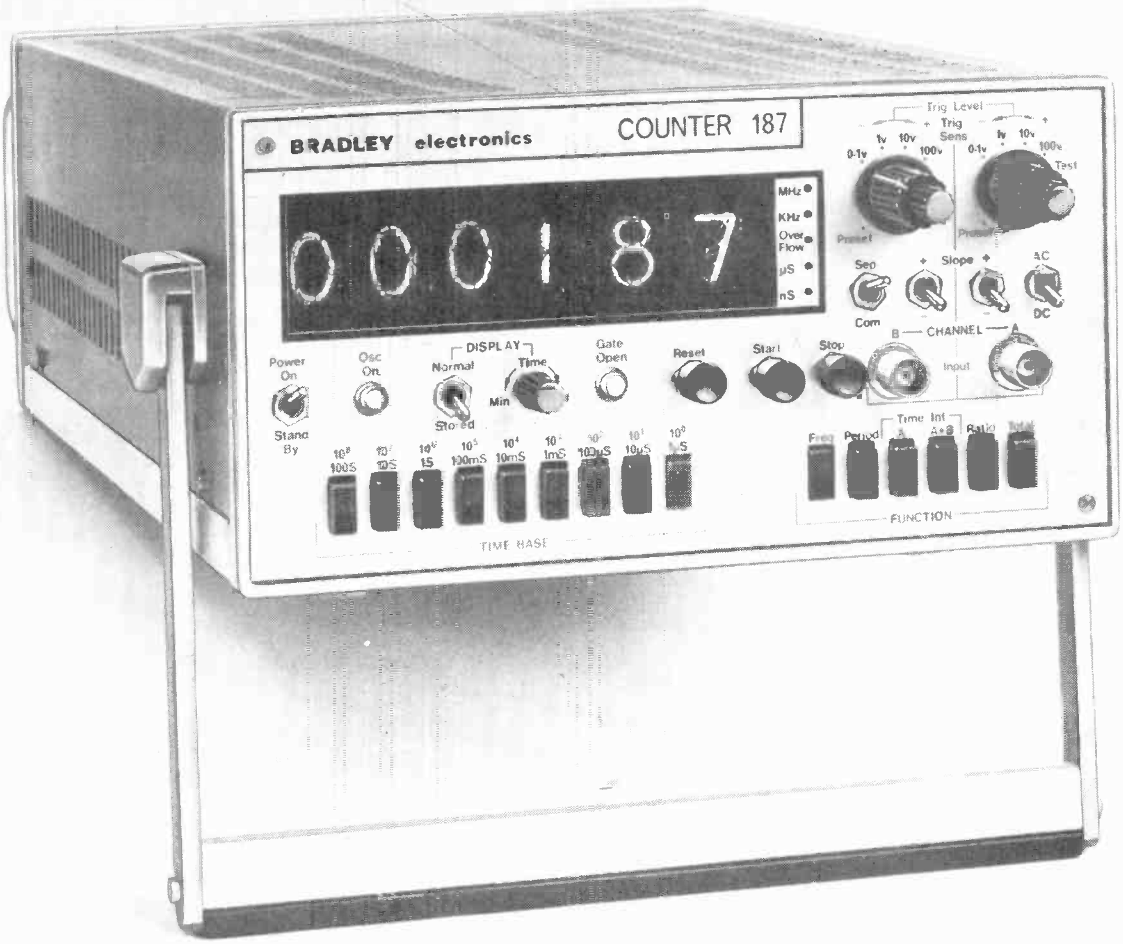

From Bradley. Real time interval measurement on the new 60MHz counter timer.

All Bradley instruments can be supplied with a British Calibration Service Certificate from our own B.C.S. approved standards laboratory.

Now Bradley introduce an advanced 60MHz instrument with a big range of facilities in a compact package. For only £450 in the UK.
Total performance of the 187 is wider than that of competitive equipment at a similar price.
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AUDIO MEASURING INSTRUMENTS

Two instruments having a superior performance than any others of this type regardless of price. Now accepted as standard equipment by Broadcasting Authorities, recording studios, magazine equipment test laboratories, and audio research and development laboratories all over the world.

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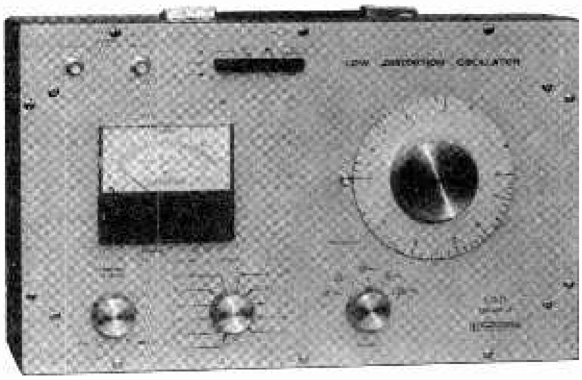
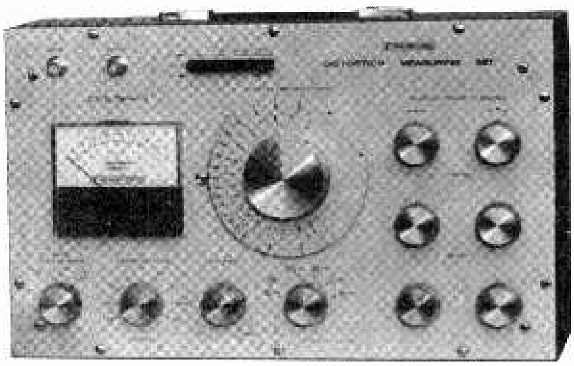


An instrument of high stability providing very pure sine waves, and square waves, in the range of 5 Hz to 500 kHz. Hybrid design using valves and semiconductors.

Specification

Frequency Range:	5 Hz-500 kHz (5 ranges).
Output Impedance:	600 Ohms.
Output Voltage:	10 Volts r.m.s. max.
Output Attenuation:	0-110 dB continuously variable.
Sine Wave Distortion:	0.005% from 200 Hz to 20 kHz increasing to 0.015% at 10 Hz and 100 kHz.
Square Wave Rise Time:	Less than 0.1 microseconds.
Monitor Output Meter:	Scaled 0-3, 0-10, and dBm.
Mains Input:	100 V.-250 V. 50/60 Hz.
Size:	17¼ × 11 × 8 in
Weight:	25 lb.
Price:	£150

DISTORTION MEASURING SET



A sensitive instrument for the measurement of total harmonic distortion, designed for speedy and accurate use. Capable of measuring distortion products as low as 0.002%. Direct reading from calibrated meter scale.

Specification

Frequency Range:	20 Hz-20 kHz (6 ranges).
Distortion Range:	0.01%-100% f.s.d. (9 ranges).
Sensitivity:	100 mV.-100 V. (3 ranges).
Meter:	Square law r.m.s. reading.
Input Resistance:	100 kOhms.
High Pass Filter:	3 dB down at 350 Hz. 30 dB down at 45 Hz.
Frequency Response:	±1 dB from second harmonic of rejection frequency to 250 kHz.
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Size:	17¼ × 11 × 8 in.
Weight:	15 lb.
Price:	£120.

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LTA15 15 WATT AMPLIFIER

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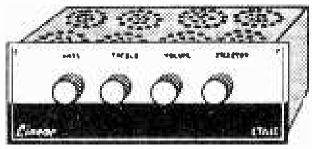
Frequency Response 10-40,000cps—3dB.
Bass Control + 17dB to − 16dB at 40 cps.
Treble Control + 17dB to − 14dB at 14 Kcs.
Hum and Noise − 80dB.
Harmonic Distortion 0.2% at rated output.
Output for 3-8-15 ohm Loudspeakers.



Recommended Retail price **£19**
Size 9½x3¾x5¼ in. approx.

If required an attractive wood cabinet with veneer finish can be supplied for any model. Prices from £3·50

PTA30 HI-FI PUBLIC ADDRESS AMPLIFIER

A successor to our popular Conchord 30 watt unit.

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Output Sockets for Loudspeaker or combination of Speakers with total impedance between 3 ohms and 30 ohms.
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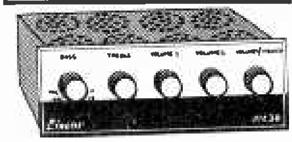

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Size 12x3¾x6 in. approx.

Available from your Local Hi-Fi Dealer

Please send a stamped addressed envelope for full descriptive details of above units.

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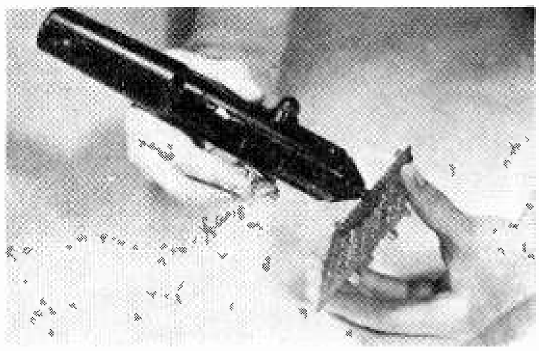

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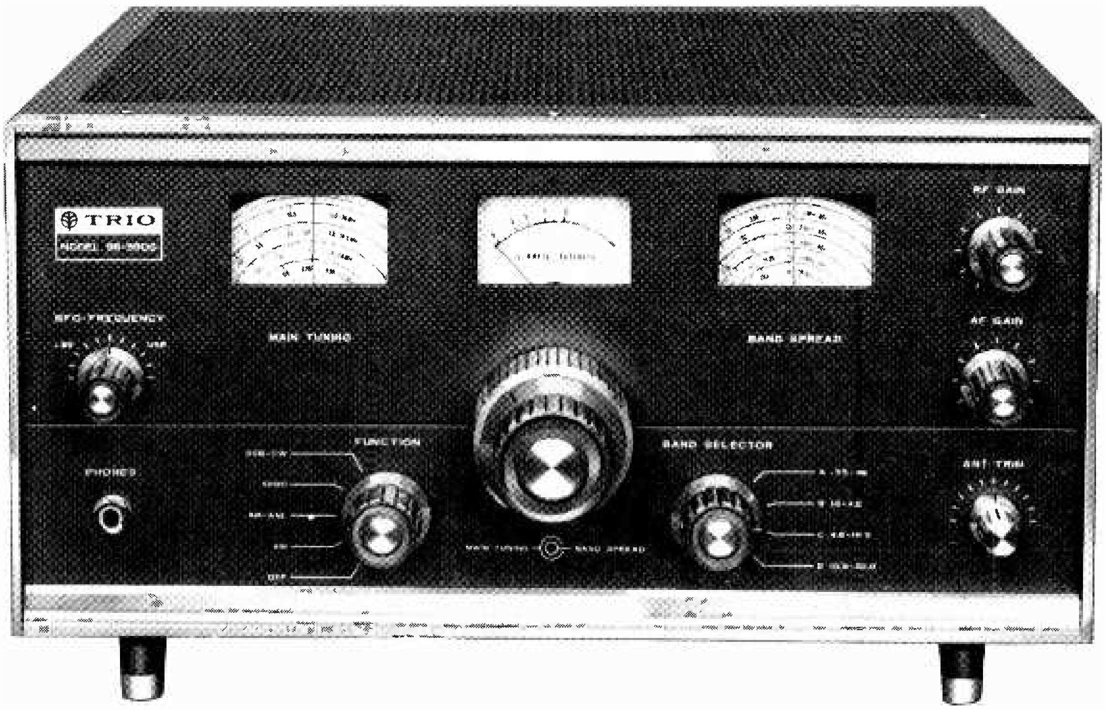
Model 9R-59DS BUILT IN MECHANICAL FILTER 8 TUBES COMMUNICATION RECEIVER



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The thrills of amateur short wave communication can be a joy forever. With TRIO's 9R-59DS communications receiver you can be assured of repeated adventure. TRIO's modern engineering techniques are especially apparent in its mechanical filter which achieves amazingly superior selectivity. For the thrill of a lifetime tune in with TRIO's 9R-59DS.

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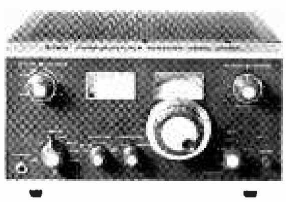
ALL BAND COMMUNICATION RECEIVER JR-599



SSB COMMUNICATIONS RECEIVER JR-310

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Three speeds.

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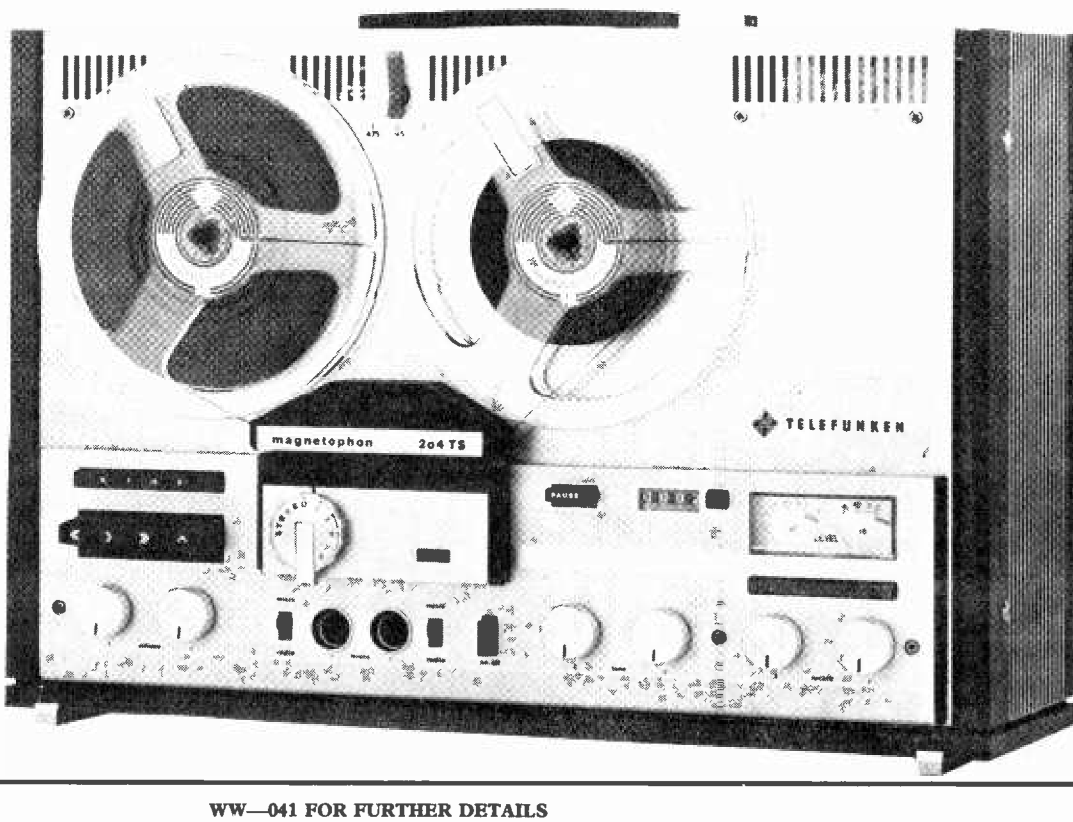

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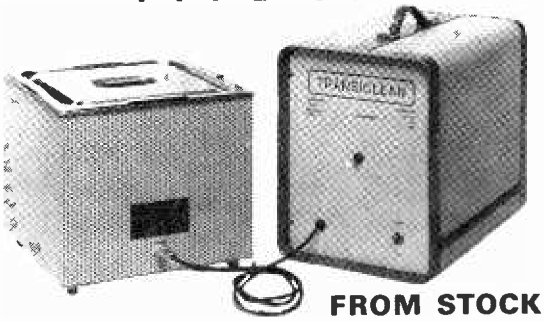
TYPE 66



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RESISTANCE BRIDGE TYPE P.W.3/E

RANGE.
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HIGH RESOLUTION WITH ELECTRONIC NULL DETECTOR

PRICE £78.50
DELIVERY EX-STOCK

A robust general purpose bridge for D.C. resistance measurements with a practical measuring range of from 1 ohm to 10 Megohms when used with its own built in supply and null detector. It has been designed to work under adverse factory or field conditions and the control functions are logically arranged and will be quickly understood by personnel not familiar with this type of measurement.

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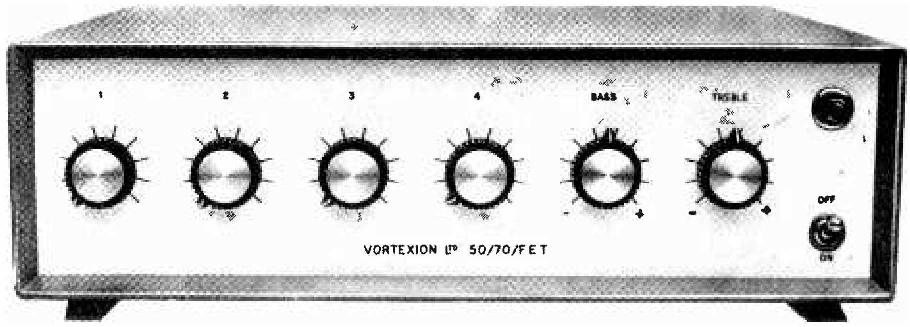
Vortexion

50/70 WATT ALL SILICON AMPLIFIER WITH BUILT-IN 4-WAY MIXER USING F.E.T.s.



This is a high fidelity amplifier (0.3% intermodulation distortion) using the circuit of our 100% reliable 100 Watt Amplifier with its elaborate protection against short and overload, etc. To this is allied our latest development of F.E.T. Mixer Amplifier, again fully protected against overload and completely free from radio breakthrough.

The mixer is arranged for 2-30/60Ω balanced line microphones, 1-HiZ gram input and 1-auxiliary input followed by bass and treble controls. 100 volt balanced line output or 5/15Ω and 100 volt line.

50/70 WATT ALL SILICON AMPLIFIER WITH BUILT-IN 5-WAY MIXER USING F.E.T.s
This is similar to the 4-way version but with 5 inputs and bass cut controls on each of the three low impedance balanced line microphone stages, and a high impedance (10 meg) gram stage with bass and treble controls plus the usual line or tape input. All the input stages are protected against overload by back to back low noise, low intermodulation distortion and freedom from radio breakthrough. A voltage stabilised supply is used for the pre-amplifiers making it independent of mains supply fluctuations and another stabilised supply for the driver stages is arranged to cut off when the output is overloaded or over temperature. The output is 75% efficient and 100V balanced line or 8-16Ω output are selected by means of a rear panel switch which has a locking plate indicating the output impedance selected.

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

THE 100 WATT MIXER AMPLIFIER with specification as above is here combined with a 4 channel F.E.T. mixer, 2-30/60Ω balanced microphone inputs, 1-HiZ gram input and 1-auxiliary input with tone controls and mounted in a standard robust stove enamelled steel case. A stabilised voltage supply feeds the tone controls and pre amps, compensating for a mains voltage drop of over 25% and the output transistor biasing compensates for a wide range of voltage and temperature. Also available in rack panel form.

CP50 AMPLIFIER. An all silicon transistor 50 watt amplifier for mains and 12 volt battery operation, charging its own battery and automatically going to battery if mains fail. Protected inputs, and overload and short circuit protected outputs for 8 ohms–15 ohms and 100 volt line. Bass and treble controls fitted.
Models available with 1 gram and 2 low mic. inputs, 1 gram and 3 low mic. inputs or 4 low mic. inputs.

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

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Telephone: 01-542 2814 and 01-542 6242/3/4 **Telegrams: "Vortexion, London S.W.19"**

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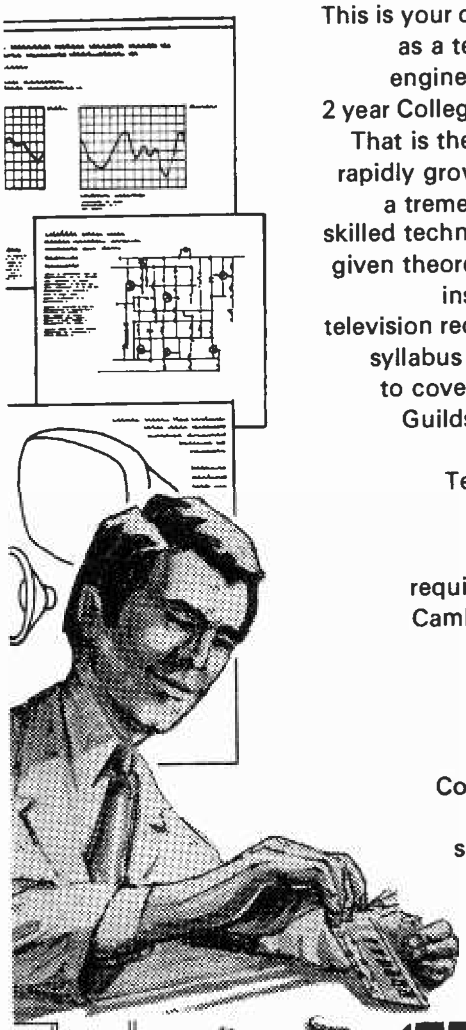

This is your opportunity to train as a television and radio engineer on our full-time 2 year College Diploma Course. That is the way to get into a rapidly growing industry with a tremendous demand for skilled technicians. You will be given theoretical and practical instruction on colour television receivers, following a syllabus specially designed to cover the new City and Guilds Radio, Television and Electronic Technicians' Course.

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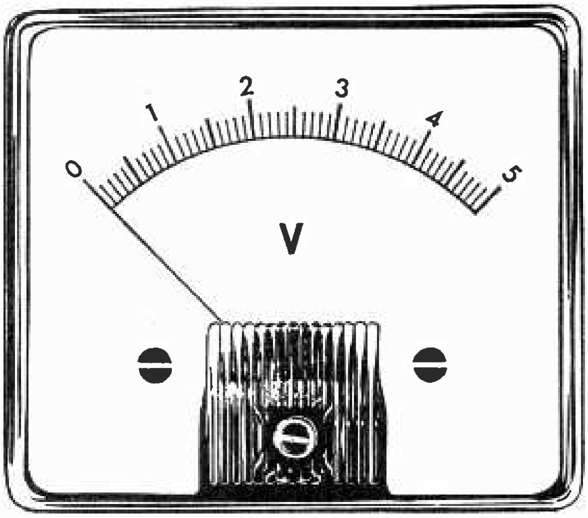

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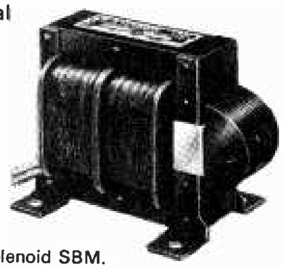

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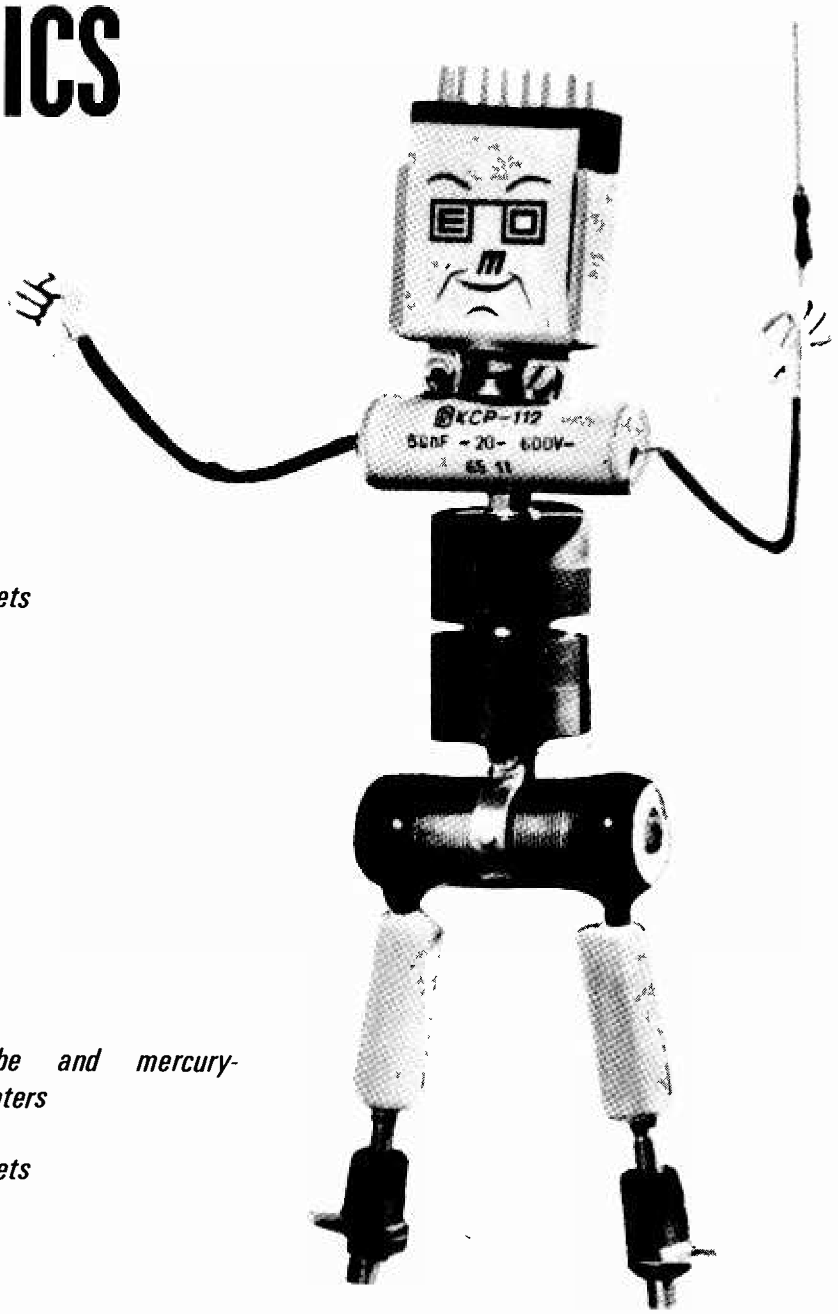

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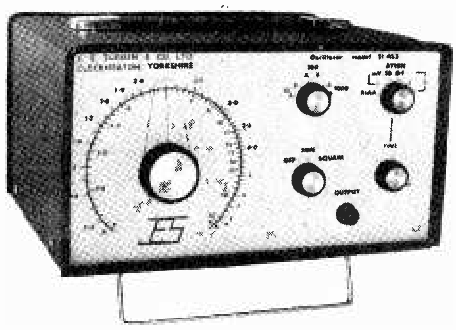

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SPECIAL FEATURES:

★ very low distortion content—less than 05%
★ an output conforming to RIAA recording characteristic
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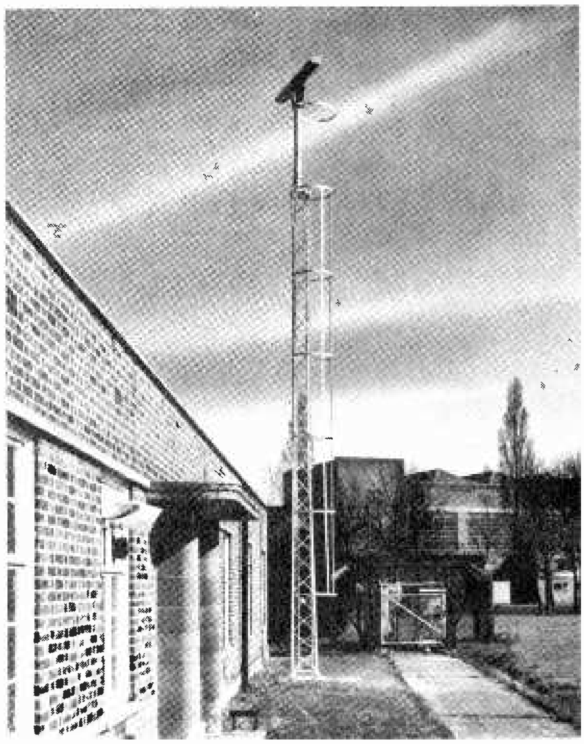

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"IMPEX". Manufacturers of the MS7, high quality Magnetic Pickup Preamplifier

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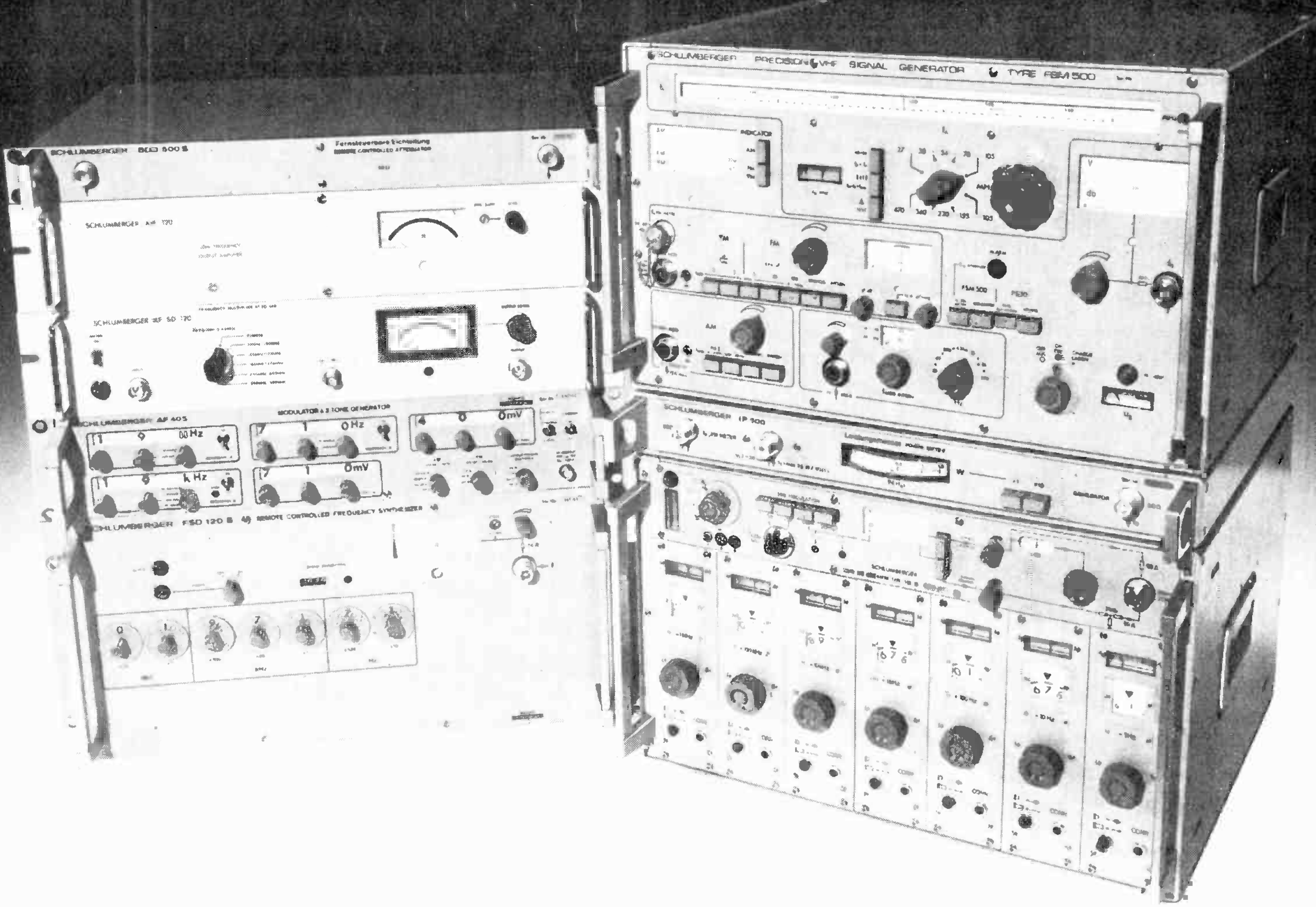
Set it and forget it!



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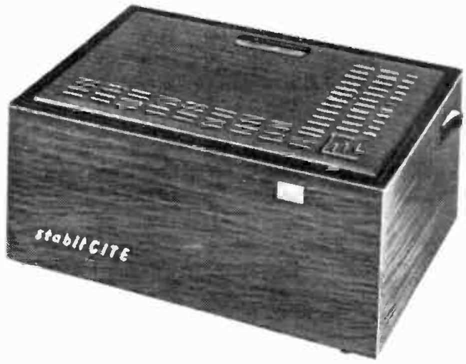

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Wireless World

Electronics, Television, Radio, Audio

Sixty-first year of publication **July 1971** **Volume 77 Number 1429**

This month's cover. Not a fly's eye but an array of silicon photodiodes in a Siemens vidicon tube, developed for videophone use. This sensitive tube, type XQ1200, is resistant to high target illumination and has low lag – residual signal is 10% after only 50ms.

Contents

IN OUR NEXT ISSUE

Source-follower circuits. Ten f.e.t. circuits covering virtually every possible configuration.

Crosshatch and dot generator. Inexpensive TV pattern generator using t.t.l. employing the barest minimum of components. Its main application would be as a 'built in' test equipment for colour receivers.

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Wireless World

Imbalance of trade in U.K. electronics

Figures issued by the Department of Trade and Industry reveal that in 1970, for the first time, U.K. imports of electronic equipment exceeded exports. This was in spite of a growth of exports for the whole electronics industry of 22%. The comparative figures for imports and exports are £339M and £320M. It is, incidentally, interesting to recall that the 1970 import-export deficit is more than the total value of capital goods exported in 1957!

The industry's imbalance was due mainly to the large increase in imports of computers and computer peripherals. Whereas exports and re-exports in this sector rose from £47.5M in 1968 to £74.4M last year the comparative import figures are £74.9M and £148.4M. Indeed the export-import performance of the electronic capital equipment industry as a whole has been reversed over the past few years. Whereas it was the major contributor to the industry's balance of trade a few years ago—in 1968 the sector's surplus was £16.8M—it last year added £7.8M to the deficit. Why is this? It is certainly not because of a reduction in the overall output of the whole industry; last year's figure was about £650M—an increase of 21%. It does, however, indicate, as the Electronic Engineering Association points out in its 1970 report, that there is a substantial demand in the computer market both in this country and overseas, "which the relatively infant U.K. computer industry is as yet unable to satisfy".

Perhaps it is unfair, therefore, to saddle the industry with this problem child which is unlikely to grow to the stature of a man despite the Government's paternal interest.

Lest it should be assumed that all the computer imports come from the U.S.A. it is worth recording that about 33⅓%, approximately £50M worth, came from E.F.T.A. and E.E.C. countries last year. How many of the 'European' companies supplying us are 'offshore' establishments of American concerns is unknown.

Another area of the capital goods sector which is weakening is avionics, the fortunes of which are linked so closely to the country's aircraft industry.

While it is true, as the E.E.A. says in its report, that "in all other areas the industry has maintained its usual surplus balance of trade" it is no time for complacency. The need to go into the market place (however "common"!) is greater than ever. The old idea of a pathway being beaten to our doors by those anxious to buy our wares has long since past. It is encouraging therefore to see the very active part being taken by the E.E.A. in promoting the industry's participation in overseas exhibitions. An outstanding example of this is the number of companies joining in the composite display at the Geneva exhibition, Telecom '71, being held this month during the World Radio Conference For Space Telecommunications.

The increasing complexity of electronics in, for instance, space projects or supersonic aircraft, necessitates multi-national participation to sustain the scale of research, development and investment required. It is therefore essential, if we are going to maintain our position in the world electronics market, that in any multi-national collaborative projects the U.K. should get its fair share. In the aerospace field avionics has tended to come a poor third in priorities; after aero-engines and airframes.

S.S.B. Receiver Module

Integrated circuits are employed in the module which is an s.s.b. receiver less frequency selection components

*by R. C. V. Macario**, *B.Sc., Ph.D., M.I.E.E.*

Nearly all h.f. radio transmissions have gone over, quite rightly, to single-sideband working. This is because the product detectors and low-level narrow-band transmissions of s.s.b. systems provide a near optimum voice transmission system when looked at in terms of spectrum occupancy and signal range for a given transmitter power. Experiments and discussions have taken place on the feasibility of s.s.b. transmission for m.w. broadcasts[1]. If the latter took place it is probable that the remaining h.f. a.m. broadcast transmissions would be changed too, so that the design of s.s.b. receivers would be of interest on a very wide scale.

Receivers for s.s.b. are complex and expensive, mainly on account of the frequency stability necessary. This means some sort of standard frequency reference has to be built into—or alongside—the receiver because product detection needs to be almost coherent. That is, the phase and frequency of the demodulating carrier must be close to that of the transmitted signal carrier, whether it be present or totally absent. Yet, unless special transmissions and corresponding receiver circuits are employed, no help can be derived from the incoming signal.

If the frequency standard reference is separated from the rest of the circuits of the receiver the remaining sections of the receiver become much simpler. This remaining circuitry may be used for many apparently differing receiver systems. Before considering such a package, or module, it is helpful to briefly review some of the variations of s.s.b. receiver design.

There is considerable literature on s.s.b. operation[2,3], but in order to assist later discussion let us quickly note certain features. Consider signal A, shown in Fig. 1, which will be amongst other signals at the receiver input. The usual process is to arrange suitable mixing with a locally generated carrier F_{01} so that signal A falls neatly into a crystal filter passband at F_I also shown in Fig. 1. However, there is an immediate complexity, depending on which sideband signal A is, and whether one mixes with a carrier above or below the signal frequency. Table 1 assists here.

Thus in Fig. 1, where A is shown as a lower sideband signal (l.s.b.) an inversion occurs, and the product detecting carrier F_{02} [second local oscillator (l.o.)] needs to be below the nominal i.f. passband as indicated. The second channel signal (B for example) would correspond to an upper sideband signal (u.s.b.) if it were to be demodulated satisfactorily. If on the other hand A was also u.s.b. and referred to the same frequency of 2.0 MHz—shown dotted in Fig. 1—one must either change the crystal filter or one or both of the l.o. frequencies. In order to least disturb the receiver module described here we have shifted the first local oscillator to below the i.f., as indicated in Fig. 1. The frequencies shown in the diagram are written as seven figure numbers to stress the need for accurate frequency generation necessary for satisfactory s.s.b. demodulation.

For various reasons the s.s.b. receiver structure shown in Fig. 2 has almost universally become adopted. Gain is necessary in the mixer—not immediately obvious

TABLE 1
Sideband inversion and non-inversion on mixing

Incoming signal F_A	Mix* with carrier above F_A (inverts)	Mix* with carrier below F_A (non-invert)	Direct conversion
l.s.b.	product detect carrier below i.f. passband	product detect carrier above i.f. passband	product detect carrier just below F_A
u.s.b.	product detect carrier above i.f. passband	product detect carrier below i.f. passband	product detect carrier just above F_A

* Local oscillator above i.f.—reverse result for local oscillator below i.f. passband frequency.

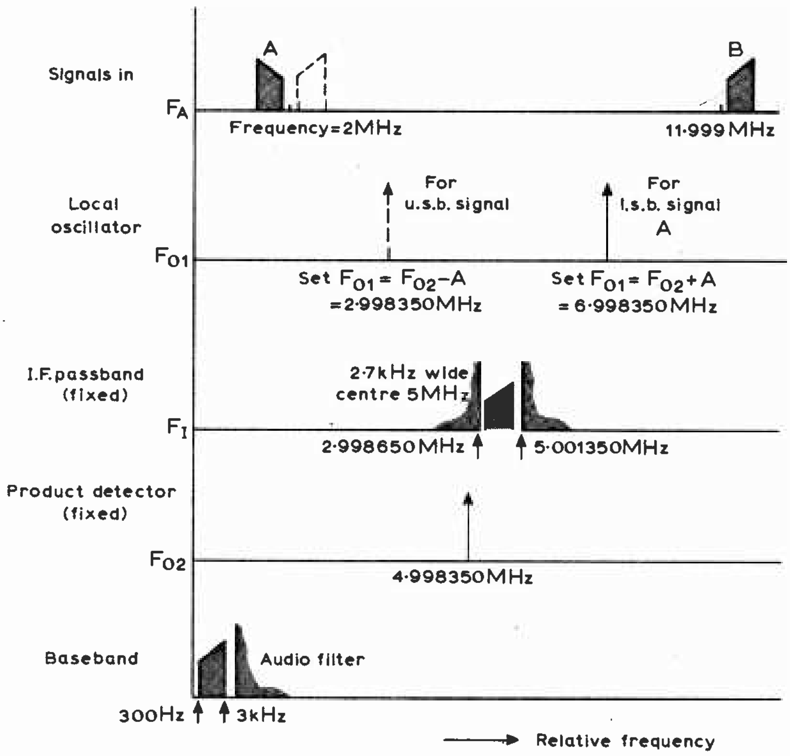

Fig. 1. Frequency chart for s.s.b. demodulation.

*University College of Swansea

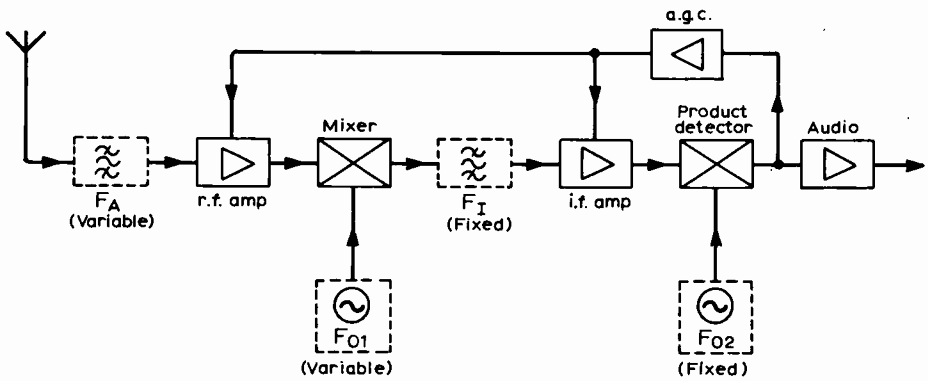

Fig. 2. Basic block structure of an s.s.b. receiver.

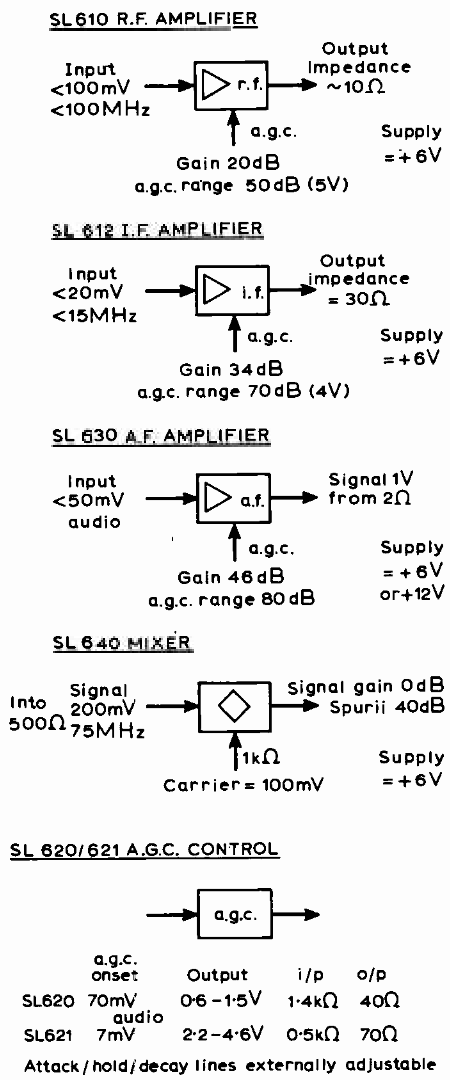

Fig. 3. SL600 characteristics summary.

from the ratio of input and output signals —to achieve an output signal of similar amplitude to the input signal and to raise the reference signal (F_{01}) to a sufficiently high level.

For ease of design the sections of the receiver dotted in Fig. 2 should be frequency independent. Integrated circuits are largely designed to be frequency independent; they are not expensive and also give repeatable performance. In other words design with integrated circuits is almost mandatory. With this approach it is also practical to contemplate remaking amateur receivers using a module of the type described; with one part of the receiver out of the way, more time can be spent on the design of the frequency generating circuits, for example, digital frequency synthesis [4].

A particularly convenient integrated device family is the Plessey Microelectronics SL600 communication series. Fig. 3 summarises the devices and some of their characteristics of interest to the present article. From these, one can recognise the position each device might occupy in the receiver module. For example, the SL610 is much more suitable as the gain controlled r.f. amplifier than the SL611/612 because it will withstand the maximum input signal level with no a.g.c. applied, i.e. it should have better blocking characteristics.

In the i.f. section, where the signal level is more constant, one may as well use a device with the maximum gain, i.e. SL612, unless an i.f. frequency above 10MHz is required.

The most critical characteristic however is one belonging to the a.g.c. device, SL621; namely the input audio signal level versus a.g.c. (d.c.) voltage level. This determines the gain needed ahead of the a.g.c. pick-off point in order that signal levelling occurs as soon as the input signal rises sufficiently above the receiver or aerial noise, i.e. above 1μV. Even so, a.g.c. operation must not occur due to receiver noise, otherwise the receiver noise figure is impaired.

Receiver design

Fig. 4 shows the undotted parts of Fig. 2 redrawn with an integrated circuit device number marked in its appropriate position. Underneath, the expected gain per stage is marked as well as the signal level and a.g.c. range available.

The following considerations indicate how the choice of module was made. Suppose we require the receiver to operate with a more-or-less constant response from about 1μV (e.m.f.) input, then approximately 7 mV is needed after the second mixer so as to just reach the a.g.c. threshold —see SL261 characteristics. This suggests a gain of 77 dB. Using a SL610 as the r.f. amplifier, and a SL612 as the i.f. amplifier clearly does not provide sufficient gain and a second i.f. module is required. A second SL612 allows a good margin for loss elsewhere in the receiver and costs little in terms of power consumption as it is a low current unit. However, a.g.c. need not be applied to the second SL612 since a range of nearly 120 dB (1μV to 1V) is available by simply controlling the SL610 and the first SL612 as shown. An SL630 a.f. amplifier working from the SL621 input (audio) conveniently raises the output to the 0dBm level. The output change of level with input signal will therefore be the same as that of the SL621, namely about 4 dB, (7-11 mV).

The complete receiver electronics now becomes a matter of connecting these modules together. These connections are shown in the complete receiver circuit diagram, Fig. 5. Frequency generation and filter modules are shown dotted. A prototype printed card layout is illustrated with Fig. 6. This shows a single fixed-frequency receiver centred on the marine distress frequency of 2.182 MHz. Adaption to other frequencies, etc., is described below; a few notes on the interconnection of the devices (Fig. 5) may be helpful at this point.

With pins 5 and 6 of the SL610 strapped together internal bias is available. The input impedance is approximately 3kΩ at 3 MHz, but this must be connected capacitively to the aerial tuned circuit. The a.g.c. line is connected directly to pin 7, with some r.f. decoupling. The +6V pin 2 should also be decoupled to pins 4 and 8, earth. Provided the aerial tuning available is sufficient, the SL610 output can be directly connected to the first mixer, SL641. This device needs an output load from the output pin 5 to the +6V supply. An optimum d.c. load appears to be 2kΩ, as the device is then quietest. A further a.c. load, the resistors to ground can then be used to match the crystal filter, if necessary. A convenient list of crystal filters is to be found in reference five. The base decoupling pin 2 needs a 0.1 μ F for radio frequencies.

The two SL612 i.f. devices are connected the same as the SL610, except that pin 7

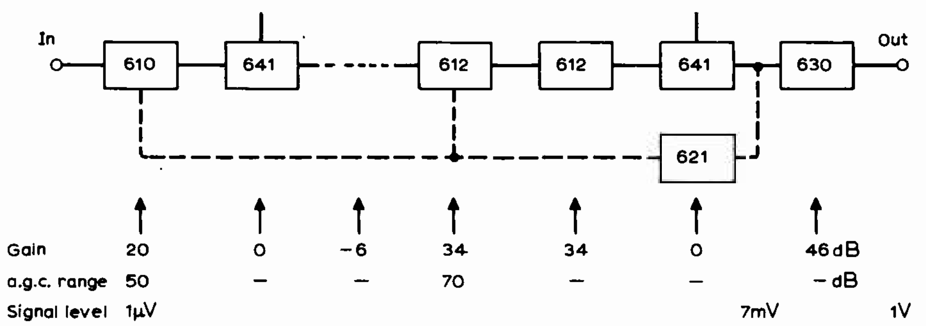

Fig. 4. Device and gain structure of receiver module.

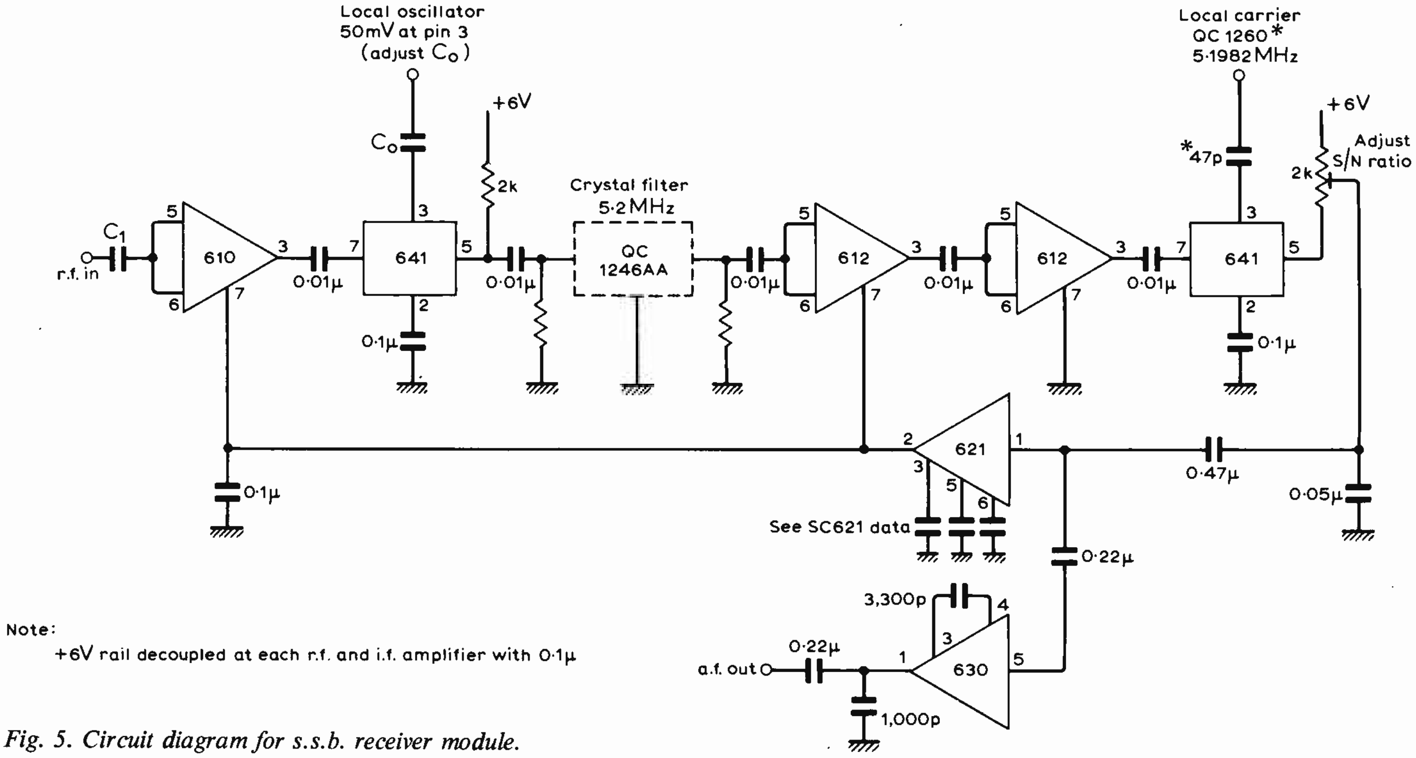

Fig. 5. Circuit diagram for s.s.b. receiver module.

(a.g.c.) of the second i.f. device is connected directly to earth; a.c. coupling, because of biasing, is necessary between all devices, however.

The second mixer is very similar to the first SL641. Again the decoupling on pin 2 only applies to r.f. and so can be 0.1μF. The local carrier supply to each product detector should be adjusted to be about 50mV. Note the output of the second SL641 is a preset $2k\Omega$ pot.

This allows the receiver to be adjusted for optimum signal-to-noise ratio by taking up gain variations in the preceding modules as described above. The a.g.c. device, SL621, is a unit designed specifically for s.s.b. receiver operation. It operates directly off an audio input, and not d.c. Its action is such that if the input to it drops faster than 20 dB/sec, it holds its output d.c. control voltage at whatever level it happens to be at, for a time, depending on the value of the electrolytic capacitor connected to pin 6. At the same time its response is not too fast (C on pin 5) so that speech, rather than noise spikes control the a.g.c. The audio input signal range is nominally 7-11 mV (pin 1). The d.c. output (pin 2) goes from 0 to about 4V (output impedance 40Ω) so making a level meter reading point.

The audio amplifier SL630 makes use of the same audio signal as the SL621. The r.f. is decoupled by 0.05μF. The capacitances, between pins 3 and 4, and across the output, give further low-pass filtering. The output voltage level, about 1V, is available from about a 2Ω source. This is more than sufficient to drive directly an integrated power amplifier circuit of which there are a number of types available for 2 to 5 watt operation. A single +6V supply of about 50 mA drives the entire module.

Receiver performance

The layout illustrated in Fig. 6, although this by no means determines the performance, it can be expected that the performance of any reasonable layout of the circuit of Fig. 5 will be the same as now discussed.

The measurements were all made with no aerial input tuning, i.e. a signal generator, or generators connected to the input terminal. Usually a 2.7 kHz i.f. bandwidth centred at 5.2 MHz was employed. The first local oscillator was derived from an external frequency synthesizer; the product detector frequency was usually as illustrated in Fig. 6.

Sensitivity and a.g.c. characteristic: This is given in Fig. 7 for 2.182 MHz. The pre-set gain control was adjusted so that the a.g.c. 'took off' at 1μV (e.m.f.). One notes the output remains within 3 dB for a change in input of 100 dB from a 3μV reference level, whilst a 20 dB signal-to-noise ratio for a 1kHz signal is available from about 2μV.

Cross modulation: With a wanted signal 60dB above 1μV the interference pro-

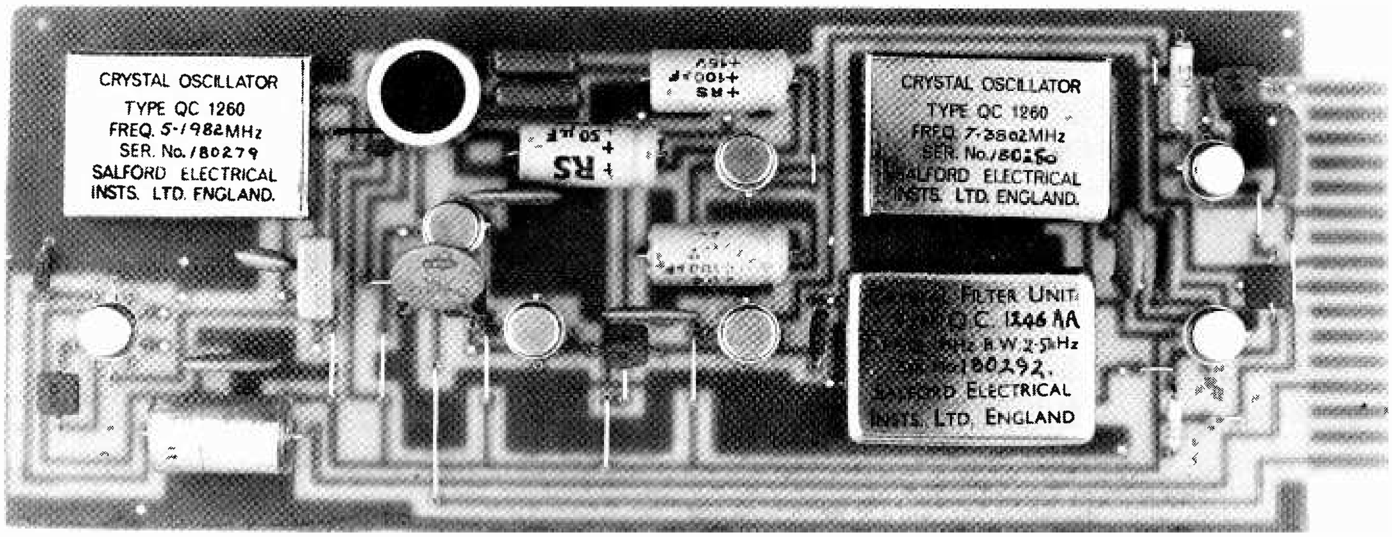

Fig. 6. A printed circuit board construction.

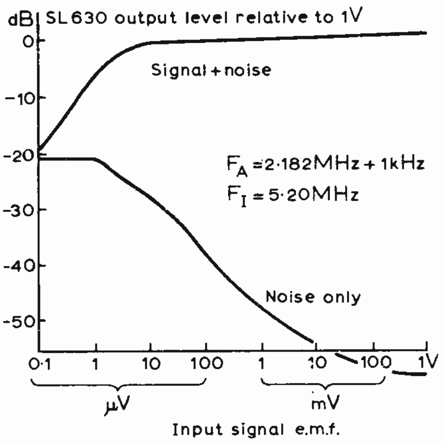

Fig. 7. Signal-to-noise and a.g.c. performance of circuit of Fig. 4.

duced by an unwanted a.m. (50%) signal 20 kHz off-tune, 100 dB above 1μ V, was 30 dB below standard output.

Blocking: With a wanted signal 60 dB above 1μ V, an unwanted carrier 20 kHz off tune reduced the wanted output by 3dB when its level was 112 dB above 1μV.

Intermodulation: With the wanted signal 40 dB above 1μV, two unwanted signals whose difference frequency equalled that of the wanted signals had to be 80dB above 1μV to produce standard output. The level of inband intermodulation was measured as −32 dB with reference to the two wanted signals.

I.F. rejection: The measurement here refers to the carrier suppression in the first SL641. At 5.2 MHz this was 24 dB. This can be improved by forward biasing the SL641, or using a SL640, but normally one does not run one's aerial frequency at one's i.f.!

Other i.f. frequencies may be used. The following data is of interest:

i.f. frequency	relative output (Input 10μ V, no a.g.c.)
500 kHz	0 dB
1.4 MHz	0 dB
5.2 MHz	0 dB
9 MHz*	−1 dB
10.7 MHz	−3 dB

*See reference 6

Using a 10.7 MHz i.f. suggests using the module for v.h.f. operation. Again the following data is of interest:

aerial frequency* (Local oscillator adjusted accordingly)	sensitivity μV (pd) for 20 dB s/n at 1 kHz
1 MHz	1.4
3	1.4
10	1.4
30	1.6
70	2.0
100	3.6
120	4.0

*i.f. passband at 5.2 MHz

The fall in performance is mainly due to the mixer characteristics. Some selection of devices for the best operation at 100 MHz may be necessary.

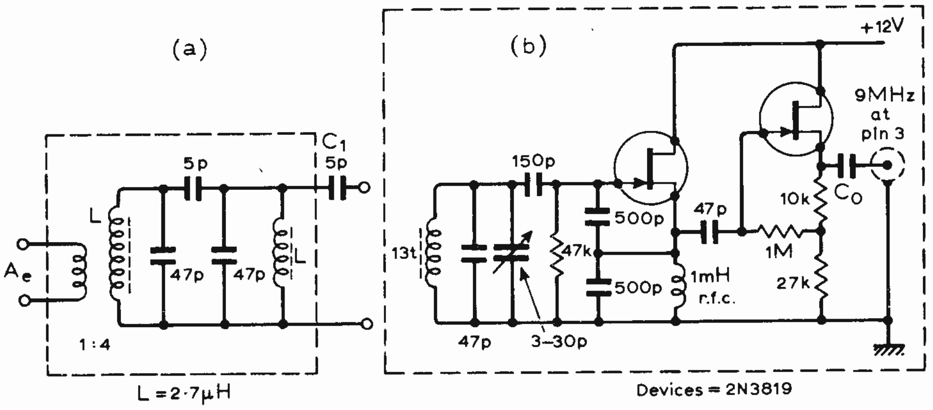

Fig. 8. Aerial pre-selection and local oscillator for 20-metre band.

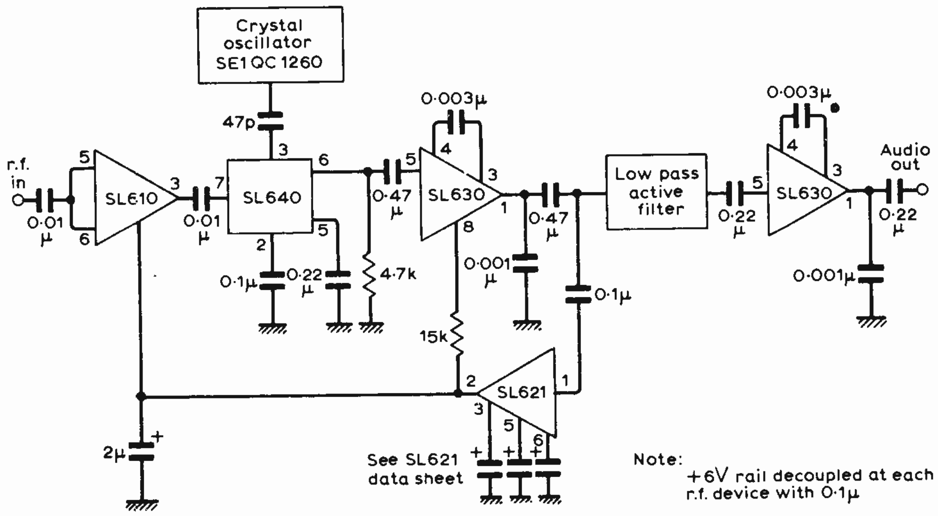

Fig. 9. Circuit diagram for direct conversion s.s.b. receiver.

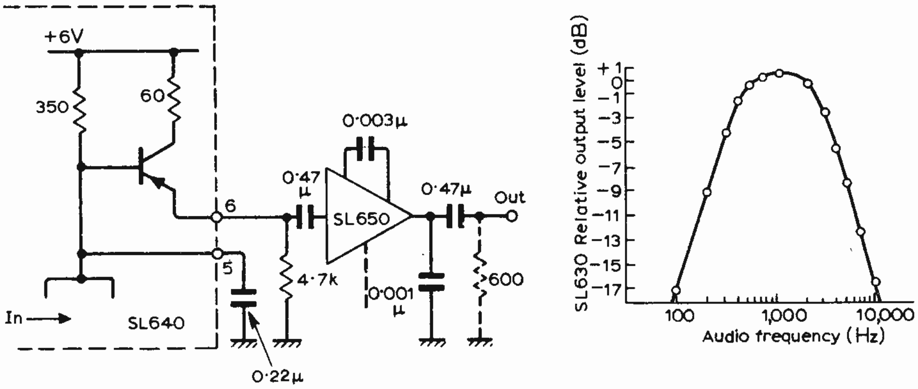

Fig. 10. Audio filtering within circuit of Fig. 9.

Application

To adapt the module to on-the-air operation one needs to supply a pre-selection (aerial) filter and a stable local oscillator source as indicated in Fig. 2. Thus Fig. 8 gives some information for adapting the module to one of the h.f. amateur bands, e.g. 14 MHz (20 metres). A fixed tuned aerial selection circuit is sufficient, unless extremely severe local transmissions are evident. The f.e.t. local oscillator circuit[7] tunes over 200 kHz and on one such model it remained within ±25 Hz of the set frequency, sufficient for general purpose radio telephony. For other bands switching-in other similar and appropriate units is advised.

The receiver module has also been employed to monitor medium-wave experimental s.s.b. transmissions[1] on 1.438 MHz (u.s.b.). Since m.w. signals are usually of the order of millivolts some 20 dB of attenuation was inserted ahead of the module and a single coil front end was employed—see Fig. 8. A local frequency generator was set to 6,638,200 Hz, corresponding with the other frequencies shown in Fig. 5. An accurate oscillator is needed for listening here as one must remain within approximately ±4 Hz if reception is to be satisfactory. Amplitude modulated signals can also be demodulated. At v.h.f. a lumped aerial filter may again be used similar to that of Fig. 8(a), but the local oscillator would need to be something special—beyond the scope of this article. The module nevertheless operates satisfactorily though with a decrease in the sensitivity as discussed earlier.

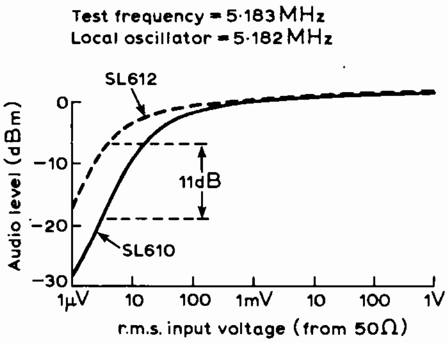

Fig. 11. A.G.C. performance of circuit of Fig. 9.

Avoiding the crystal filter

S.S.B. can also be directly demodulated. That is, instead of selecting the wanted s.s.b. signal with an i.f. crystal filter, and then product detecting down to audio, both steps can be carried out at the first mixer, i.e. the local carrier is practically coincident with the input signal frequency. With direct conversion receivers [8,9] one can save both the crystal filter and corresponding crystal oscillator. In doing this, however, one introduces the following problems,

(1) i.f. gain has to be replaced by audio gain (noisier),
(2) the s.s.b. signal must be free from a second channel (i.e. not compatible with a.m., i.s.b., etc.), and
(3) it is very susceptible to harmonics of the local (first) oscillator.

Nevertheless, it is very easy to adapt Fig. 5, to a direct conversion form: Fig. 9. Thus one notes the front end SL610/SL640 is retained together with the a.g.c. device SL621. The i.f. amplifier has been replaced by a single high-gain SL630, while the second SL630 is as before. Audio filtering prior to a passive, or active, low-pass audio filter is practical by capacitively loading the SL640 and SL630 device respectively, as shown in Fig. 9. The a.g.c. performance of this circuit is as good as the previous module because both the r.f. and first a.f. amplifier can be controlled by the SL261 as shown in Fig. 10.

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Letters to the Editor

The Editor does not necessarily endorse opinions expressed by his correspondents

Ceramic pickup equalization on the stereo mixer

I have used the gramophone pickup amplifier, Fig. 3, described by Mr. Walker in his article 'Stereo Mixer' in the May issue, but have obtained rather poor results with the ceramic pickup facility. Discussions with the author have revealed that part of the trouble was due to the input resistance changing at low frequencies. With the present value of C_6 in the emitter of Tr_2 there is a small signal voltage fed back at low frequencies via R_4 to the base of Tr_1. This has the effect of modifying the input resistance and thus affects the performance with ceramic pickups, giving a rise of 3 to 4dB below 100Hz. A simple solution is to increase C_6 to say 50μF but this gives a rather extended low-frequency response with magnetic pickups. A better solution is to put a 68kΩ resistor in series with R_4 and connected to the junction of R_9 and R_{10}. The junction of R_4 and this 68kΩ resistor is decoupled to ground with a 10μF/16V capacitor. The input resistance will now be constant at 220kΩ throughout the audio range.

Mr. Walker has also pointed out that as stated in the text the equalization in Fig. 3 is suitable for a source capacitance of 600pF. This includes the capacitance of the connecting cable as well as that of the cartridge; the input time constant formed by this source capacitance and R_4 is about 135μs. If the cartridge had a capacitance of 800pF, for example, and was connected to the mixer with a cable of about 200pF capacitance, this would require an effective input resistance of 135kΩ. In practice a 360kΩ could be connected between the 'ceramic' position of the input switch and ground. Likewise for other source capacitances.

C. R. WHITELEY,
Cambridge.

Recording characteristics

In his first article (May '71) on a stereo mixer, H. P. Walker repeats J. L. Linsley Hood's "suspicion" that the R.I.A.A. recording characteristic is not accurately followed below 50Hz by most record manufacturers.

While it is true that most records contain very little material below this frequency, the major disc cutting systems (Westrex, Neumann, and Ortofon) are very carefully equalized to the R.I.A.A. curve, and if a full-range signal were to actually reach the cutting amplifier, the resulting disc would come very close (±1dB) to the R.I.A.A. curve.

To minimize several technical and operational problems, however, most microphones, recording consoles, and mastering channels incorporate some type of high-pass filter operating in the 30-60Hz region. This filtering, which is applied to the signal before it reaches the cutting amplifier, is the reason for the lack of very low-frequency signals on a typical disc.

It should be mentioned that, within the current decade, quieter studios, better microphones and microphone suspensions, better plating, and significant improvements in mass-market Hi-Fi equipment should enable the recording system designer to include 10 more clean-and-quiet hertz on his final product.

CHARLES NAIRN,
Detroit,
Mich., U.S.A.

Pickup self-capacitance

I read with interest the letter from Mr. Burrows in your June issue, on the subject of the frequency response of ceramic pickup cartridges used with a circuit such as my simple pre-amp. There may be circumstances in which what he says is correct. However, there is another side to this argument, and in fairness to the designers of pickup cartridges (and amplifier circuits) it should be stated.

To recapitulate Mr. Burrows' argument, a ceramic (piezo-electric) pickup cartridge can be considered as a generator in series

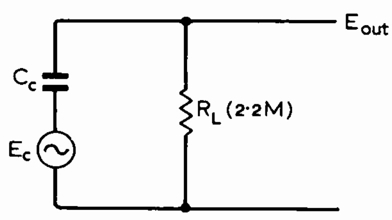


Fig. 1

with a capacitance of equivalent value to its own self-capacitance. When this is used in conjunction with a high value load resistance as shown in Fig. 1, and driven from a constant displacement system, as may be supposed to be the case with R.I.A.A. recording characteristic records below some 500 Hz, the output should be predictable from the attenuation characteristics of the pickup self-capacitance and load resistance. In the case of one well known and highly regarded ceramic cartridge, used with the recommended 2.2 megohm load the output response characteristics, at l.f., should be as shown by curve (a) in Fig. 2.

In addition, since the amplitude characteristics of the recording suffer a 12 dB fall between 500 Hz and 2 kHz the treble response will be as shown by (b) in Fig. 2.

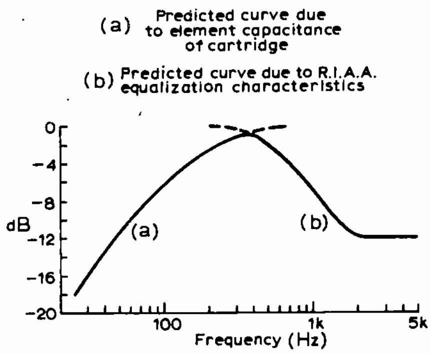


Fig. 2

However, the makers show a response curve under these conditions which is substantially flat within the range 50Hz—10kHz. This astonishing (?) circumstance arises as a result of the electro-mechanical design of the head in which the compliance of the cantilever mechanism, the visco-elastic mounting of the ceramic elements and the known and presumed resonant characteristics of the cartridge, stylus and arm are utilized to modify the final frequency response characteristics of the system. If this were not so, the final performance of the simple ceramic pickup valve amplifier combination would be far less satisfactory than it is, and the manufacturers of piezo-electric transducers might no longer be in business.

Unfortunately, piezo-electric elements are inherently more affected by the small amplitude, low velocity and low frequency lateral and vertical displacements which constitute turntable 'rumble' than their electromagnetic transducer counterparts. This problem is worsened by the fact that such inexpensive pickup cartridges are likely to be used, mainly, with relatively inexpensive turntables in which rumble can be expected to be more of a problem. For this reason, the satisfactory use of a ceramic cartridge with an inexpensive turntable and loudspeaker units having reasonable bass response demands the use of some form of high-pass rumble filter, and to be effective this requires an attenuation slope of at least 18 dB/octave —with a turnover frequency of some 35-40 Hz. If a lesser slope is used a proportionately higher turnover frequency will be required (with consequent greater loss of bass) in order to achieve the same desired attenuation of the rumble frequencies.

The most convenient means of achieving the suggested −18dB/octave characteristic is by using an active filter having a double *RC* 'lead' element within the loop, and a gain adjusted to give a *Q* of 1.4. A single *RC* element external to the loop, and having an attenuation of 0.71 at the transition frequency of the filter, will then remove the characteristic hump of the filter and convert the −12dB characteristic of the active element into the desired −18dB slope. In performing this function it matters not one bit whether the passive *RC* element is before or after the active section although for optimum overload characteristics it is preferable that it should be before.

If this passive attenuator is omitted or modified as Mr. Burrows suggests the residual l.f. hump of the active filter element will certainly augment the bass response of the pickup but at the expense of the slope of the filter characteristic, which will be reduced to −12dB/octave (plus any l.f. attenuation due to cartridge characteristics).

Finally, if I may make a point which will perhaps put matters in perspective, the effective value of two capacitors in series is readily calculable, and in the case of the Connoisseur SCU1, which Mr. Burrows quotes, the effect of the 1500 pF series capacitor will be to make this cartridge appear to have an internal capacitance of 176 pF instead of 200 pF. If the bass response of this unit into 2MΩ with such an effective element capacitance is as bad as Mr. Burrows suggests the effect of restoring it to its original 200 pF by omitting the series capacitor is not going to work many miracles either.

J. L. LINSLEY HOOD,
Taunton,
Som.

Audio amplifiers

I have just completed making up the modular pre-amplifier and the 20-watt class AB amplifier (in stereo) described in *Wireless World* July 1969 and July 1970 and I am writing to express my thanks and appreciation for the pleasure Mr. Linsley Hood, and *Wireless World,* have given me in reading about and constructing these amplifiers. I get my parts from U.K., hence the delay.

I suppose I have been constructing audio amplifiers for myself and friends at odd times over twenty years. It took Mr. Hood to sell me the idea of transistors equalling valves. Frankly all commercial transistor audio amplifiers I had heard did not come up to a good valve design—like the Radford—that is, until I built Mr. Hood's design. Audibly, the *Wireless World* amplifiers are the best, valve or transistor, I have heard.

I was a sporadic reader of *W.W.* and came across Hood's class A by accident and read your April 1969 issue with avid interest. From then on I became a regular reader and was delighted to read, and profit by, your further articles on audio.

I hope Mr. Hood sees this, as I would certainly like my gratitude conveyed to him somehow. And thank you also. Articles such as these cannot fail to enhance your reputation.

E. MCSHERRY,
Wellington, N.Z.

Stereo techniques in Australasia

I was delighted to note an article by the esteemed E. J. Jordan on Loudspeaker Stereo Techniques in the February issue (received in New Zealand in May!) At last I feel I have read an article that looks at 'audible' stereo in the proper perspective. For many years we have taken mono speaker systems, doubled them, and reproduced stereo. And despite many theories, formidable or otherwise, aimed at improving the loudspeaker's reproduction, stereo remains largely unchanged in this respect. When a manufacturer sells a pair of speakers, he has no idea how the customer will place them. For many people stereo in its true sense does not exist.

The biggest objection to stereo must be its critical listening area. I am employed by a firm which manufactures largely 'middle class' fidelity equipment, using speaker units manufactured here, and, due in the main to the rather small size of our market in comparison to that in the U.K., these units lack some of the sophistication of imported ones.

Therefore it is the 'average' person who purchases our gear, and not dyed-in-the-wool Hi-Fi enthusiasts. Because of this fact, one regularly finds speaker enclosures set up in homes in most impractical positions for satisfactory listening.

To this end, I have for some time been experimenting with a single box method of providing stereo, guaranteeing the customer an adequate listening area in his living room.

Economy being paramount, the result was an 8ft long box (8ft being the standard length of a single sheet of veneered board), 6in deep, and 9in high.

Along this length and facing forward, were placed five 6½in high-compliance type speakers, with small centre cones. The total length was divided into five equal air suspension systems. A purely resistive division was used between each speaker. The result is one similar to the centre channel technique. The middle speaker's output is 50% left and 50% right, although this level is approx 25dB down on either the left or right. The second and fourth speaker then receive 75/25% L and R, and are also down on level, to some point between the centre and outside speakers. This then gives an amplitude 'curve' to your sound wall. In a way this gives increased 'width' to the inside of your polar characteristics, without altering the position from a frontal aspect. The effect of this system, though still not in my opinion the right approach to reproducing the original sound stage, is nonethe-less astonishing to listen to. As with Mr Jordan's phase delay technique it is possible to stand at one end of the enclosure and be 'run over' by the train. (I in fact used a track in which an American dragster commences at one end, and disappears completely through your wall, with surprisingly little damage). The most notable feature is the increase in 'breadth' and definition, when listening to a large orchestral piece.

Retail price is approximately $110 N.Z. (about £50 sterling). Although this was a modest unit, there is no reason why a larger system could not be built using superior units. Power handling is 15 watts r.m.s. per channel. Mounted on the wall, the system looks very attractive in today's modern, centrally heated living rooms, and can replace ye olde mantel-piece.

GARRY V. LAMBERT,
Waihi,
New Zealand.

F.M. tuner and stereo

I was most impressed with the f.m. tuner design by L. Nelson-Jones, published in the April *Wireless World,* but I feel compelled to query the tuner's suitability for stereo reception or, to be more specific, the suitability of the FM-4 filters.

I think it is now generally accepted that, for good stereo performance, an i.f. bandwidth of 250-300kHz is required (the good old rule of thumb formula 2 $(f_m + f_d)$ for bandwidth in f.m. systems gives a required bandwidth of 256kHz with a deviation of 75kHz and maximum baseband frequency of 53kHz). However, the manufacturer's data shows that the 3dB bandwidth of a single FM-4 could be as narrow as 200kHz and, if one was unlucky enough to obtain two filters which were at the minimum end of the bandwidth specification spread, the tuner would have a 6dB bandwidth of 200kHz, which would be ideal for mono, but virtually useless for stereo.

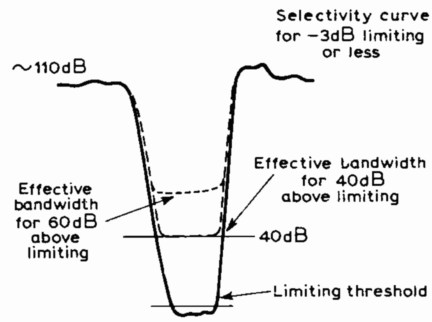
It could well be that the specification tolerances are wider than the actual production spread and the problem would then not arise, but I do feel that some assurance to this effect should be given, either by the author or by Vernitron, especially as the text of the article implies that the prototypes of the tuner have not actually been tried with a stereo decoder.

K. CLAYSON,
Redhill,
Surrey.

The author replies:

The quick answer is, yes the tuner is certainly suitable for stereo use, and since the script was originally written has been tested on stereo transmissions, on which it performs well.

The reason why would be more apparent had the second half of the article been available to Mr. Clayson, in that this contains the response curve of the i.f. amplifier together with a more thorough treatment of the mode of operation of the tuner. The figures of the requirements of a stereo tuner and of the performance of the FM-4 filters given by Mr. Clayson are essentially correct, but he has overlooked one important point, namely the good limiting performance of the tuner.



This results in an effectively wider bandwidth as shown in the graph, so that at the minimum signal strength at which stereo reception would give anything like an acceptable signal-to-noise ratio, the effective bandwidth is approximately 400 kHz, or more. It was partly for this reason that the limiting threshold of 0.18μV was set so low.

L. NELSON-JONES.

'High-quality tape recorder'

I should like to clear up two points which are causing confusion over my tape recorder design. (*W.W.*, Nov, Dec. 1970, Jan. '71).

The components list on p.591 December, gives the Plessey core number for T_1 as 905/1/01613/008μe; this should be 905/1/01613/108μe.

It is becoming difficult to obtain the Plessey cores in small numbers, however the requirement can be met from the new Mullard range as below:

L_1 6.25mH Plessey 905/1/01581/006μe; μ_{eff} 220, 41 turns/mH or Mullard LA1225 *and* LA1274, both numbers.

L_2 10.6mH Plessey 905/1/01581/009; μ_{eff}63, 84.5 turns/mH or Mullard LA1416 *and* LA1339.

T_1 Plessey 905/1/01613/108μe; μ_{eff} 300, 32 turns/mH. Nearest equivalent: Mullard LA1219 *and* LA1275.

If the Mullard core is used for T_1, C_{29} should be 400pF beehive trimmers.

I have given the inductance values for L_1 and L_2 at 1kHz and 100kHz respectively. Any cores capable of operating at the frequencies concerned may be used if wound to these values.

The tape heads specified were $\frac{1}{2}$-track Bogen UK202B record and replay and UL290 erase; quarter-track heads UK207B can be used without modification, although it is better to make C_{28} 100pF beehive trimmers.

The old quarter-track heads UK207 require more bias than the UK202B; for this the bias windings will need to be 120+120 turns and the oscillator run from about 11V, with C_{29} adjustable. The erase heads are all good substitutes in stereo.

J. R. STUART,
London, W.4.

Stereo decoder using sampling

We have been largely at cross purposes in our discussion about sample-and-hold stereo decoders. The discrepancy of 1000:1 in frequency characteristic* arose because one of us (T.P.) was considering the transmission of signals through the sampler while the other (D.E.O'N.W.) was referring to the spurious outputs caused by high-frequency signals applied to the input of the decoder. We are thus both correct in our assertions.

We have agreed that allowing the sampler to 'free-run' during mono reception can result in a degradation of the signal/noise ratio. However, changing the mark/space ratio of the sampling pulse to 1:1 can only, at best, give an improvement of 6dB. As this change would eliminate any advantages of using a sample-and-hold method for stereo decoding, it is not the answer to the problem. Instead, the modifications described† give a practical solution to the problem of noise during mono reception.

D. E. O'N. WADDINGTON,
T. PORTUS.

*See letter from T. Portus, June issue, p.283.
†See letter from D.E.O'N. Waddington, May issue, p.233.

Multi-core cables

Now that D.I.N. connectors are becoming standard on many items of equipment, would manufacturers make 5-core cables readily available, and 4-core individually screened cables available, at least on demand.

A few words, also, to users. How about creating a demand for these cables by using them whenever making up D.I.N. leads? It works out cheaper in the long run, instead of making up dozens of different single or twin-core leads.

R. WILLIAMS,
St. Albans,
Herts.

Ceramic Pickup Equalization

1—Myths against maths and measurements

by B. J. C. Burrows, B.Sc.

Almost every human endeavour accumulates a fund of information, fundamental understanding, rule-of-thumb methods, folklore and mythology. Sound reproduction has its share of all these. In particular, items like pickups and loudspeakers have a somewhat higher proportion of mythology than others.

There is one aspect of pickup operation which has more than its share of myths, but which allows an objective analysis. This is the question of the influence of the pre-amplifier input loading on magnetic and, more especially, ceramic pickups. A thorough reading of published reports, papers, books and manufacturers' operating instructions reveals a wide range of opinion. Many sources assert that the electrical loading on the pickup caused by the pre-amplifier input impedance affects the mechanical operation of the pickup by damping mechanical resonances! Thus:

'It is advantageous in all cases to apply negative feedback* to the pickup, whether electromagnetic or crystal. This may be accomplished in any conventional manner and the feedback reduces non linear distortion and the effect of mechanical resonances[1].

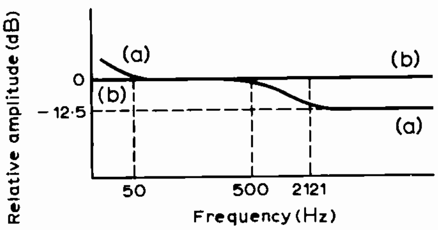


Fig. 1. Recording correction curves. (a) R.I.A.A. (b) constant amplitude.

'Now because of the (capacitative) nature of crystal and ceramic pickups it is only necessary to connect them into a sufficiently low electrical resistance for their inbuilt correction to be almost nullified'[2].

The inbuilt correction referred to is incorporated into most ceramic pickups to compensate for the difference between the real R.I.A.A. recording characteristic, Fig. 1 (a), and a true constant amplitude characteristic (b). This is achieved by allowing a broad mechanical resonance to occur in the high frequencies. The degree of equalization achieved in practice is quite good. Fig. 2 shows the output from a Sonotone 9TAHC when playing an R.I.A.A. test record.

Certain other myths on pickup operation concern the use of ceramic pickups with fully R.I.A.A. corrected magnetic input sockets on pre-amplifiers. Information on the Leak Varislope II stereo pre-amplifier includes 'For optimum results no additional resistors are required. The input loading (70-100kΩ) on the pre-amplifier forces this type of pickup to give approximately the same frequency characteristic as moving coil and variable reluctance pickups . . .'. Apart from one pickup only, the Connoisseur SCU1, this recommendation is totally wrong on two major factors! The Leak information, to compound its misdemeanour, goes on to say 'If more bass is desired you should insert a 100kΩ resistor in series with each live pickup input lead'. If for more bass one substitutes *treble cut starting at an even lower frequency than normally* this would be more accurate!

More recently, fashion has veered away from low impedance loading, bringing forth a welter of designs of f.e.t. pre-amps and other high input impedance circuits and converters, presumably because of dissatisfaction with the results of following advice such as that quoted above. In fact, now there are signs of a return to the belief that ceramic pickups (stereo and mono) must be operated into a high impedance for best results. Indeed, two recently published pre-amp designs 4, 5 in *Wireless World* tend to perpetuate the idea by providing an input impedance of 2-5MΩ for the ceramic pickup input (thus rigidly following the manufacturer's traditional recommendation).

Pickup design and operating recommendations remain almost unchanged from valve amplifier days when high input impedances were normally available. This has probably led to the belief that high impedance loading is necessary for best operation of the pickup because the manufacturers recommend it! Although this myth, too, is widespread, there nonetheless appears to be no truth in it and I think, along with the others, it can be classified as an 'old wives' tale'.

I should hasten to add that I am not saying that loading a pickup with a high impedance is bad or wrong, but there are disadvantages with high impedance loading. References 4 and 5 are the best original transistor pre-amp circuits as yet published in *Wireless World* for ceramic pickups†, but see also reference 3 for modifications to the Dinsdale Mk. I and Mk. II pre-amplifiers.

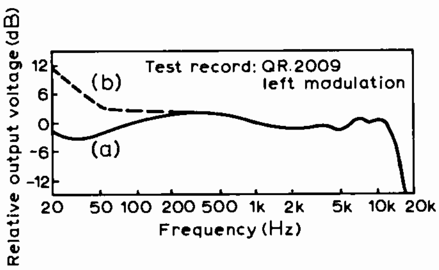


Fig. 2. Sonotone 9TAHC frequency response curve. (a) voltage across 2MΩ load shunted by 100pF. (b) internal pickup e.m.f. Curve (a) can be derived from (b) by calculating the bass cut due to the 2MΩ load—which gives 3dB down at 88Hz.

It seems rather a pity to spoil the fun of the advocates of a host of 'bolt-on' goodies (f.e.t. pre-amps, impedance converters, etc., etc.) which claim to provide the necessary high-Z load for best performance but the 'old wives' tale' appears to have no foundation. This is demonstrably true by maths, measurement and listening tests. In the past it is probable that many designers have erred on the safe side in their design philosophy, preferring the devil they know ($R_{load} > 2M\Omega$) to the devil they don't know (equalization problems with $R_{load} \ll 2M\Omega$). Since conventional (and *cheap*) bipolar transistors are most conveniently used in low input impedance circuits this seems a good time to try to form an understanding

* The negative feedback referred to here has the effect of providing a low impedance load for the crystal of approximately 1.5kΩ in series with 0.5 μF.

† The design of the rumble filter in both refs. 4 and 5 does not allow for the effect of the pickup capacitance, but see letter in June 1971 issue of *Wireless World* for suggested modifications.

of the effects of $R_{load} \approx 10k\Omega$ on ceramic pickups.

The existing mythology can be summarized in six main points. Low impedance loading is variously said to:

(1) affect the mechanical damping and transient response of the pickup;
(2) affect the built-in mechanical equalization which depends on broad mechanical resonances;
(3) reduce the distortion;
(4) affect the separation (i.e. crosstalk);
(5) provide correct equalization into a magnetic pickup input with so-called 'velocity loading'; and
(6) alter the needle tip mechanical impedance.

What is required then is an understanding of the interaction between the electrical and mechanical parts of the pickup.

A pickup is not a simple device mechanically[6]; whereas the equivalent circuit of the electrical part is simple—or is it? It is generally shown as in Fig. 3.

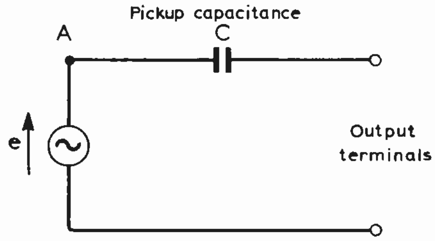


Fig. 3. Equivalent circuit of one channel of a stereo ceramic pickup.

This is an *equivalent* circuit. In the real thing C is the capacitance of the ceramic bimorph within which e, the pickup e.m.f., is generated. There is no physical access to point A in the actual pickup. The pickup capacitance, C, can be measured with a conventional a.c. bridge. Typical values of C and e for many stereo pickups are shown in Table 1.

The pickup e.m.f. is measured by connecting a very high input impedance voltmeter to the pickup terminals when tracking a known groove modulation. Fig. 2 shows the variation of e.m.f. against frequency for a mechanically compensated pickup (9TAHC).

So our simple equivalent circuit consists of just two elements: a voltage source and a series capacitance. But, e is produced by mechanical motion of the ceramic element, and is thus inextricably tied up with the mechanical constants—damping,

TABLE 1

Pickup type	Capacitance††	Output†
Acos GP94/1	900pF	100mV
BSR C1	—	110mV
Decca Deram	600pF	30mV
Garrard KS40A	600pF	200mV
Goldring CS90	900pF	50mV
Goldring CS91E	900pF	20mV
Sonotone 9TAHC	800pF	55mV
Connoisseur SCU1*	200pF	150mV

†at 1cm/sec at 1kHz, r.m.s. into $R_{load} > 1M$
*no mechanical compensation in this pickup.
††for each channel.

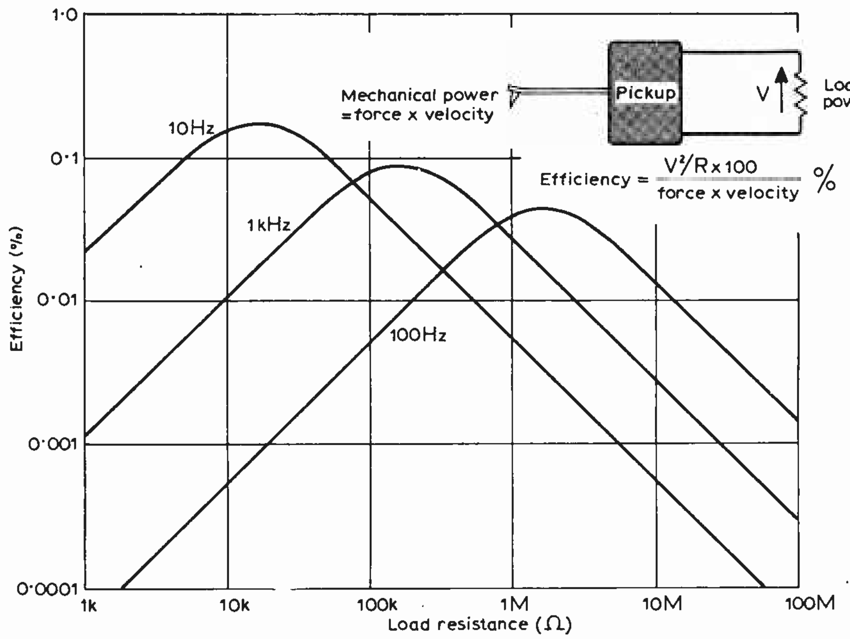


Fig. 4. Power conversion efficiency of a stereo ceramic pickup (9TAHC).

resonances, etc. To understand the six points mentioned above, what we need to discover is whether the electrical load across the output terminals in any way affects these mechanical constants, thus altering e. To be more specific.

(a) are e and C independent of loading?
(b) is the needle tip impedance independent of load?

Should e be affected by load this would imply that a much more complicated equivalent circuit is required involving both the mechanical and electrical equivalent circuits and the degree of coupling between them.

Pickup efficiency

Although it is plausible that the electrical load might affect mechanical resonances, it depends on the magnitude of the effect. A calculation of the efficiency would give a good clue to the likelihood of appreciable coupling within the pickup.

For a good ceramic stereo pickup*, at 1kHz with a fully modulated groove, 3g playing weight is needed.

Thus input power to pickup=

$$\frac{20\times3\times981}{10^7\times\sqrt{2}}\ \text{J/s} = 4.2\text{mW}$$

Its e.m.f. e is 1.1V r.m.s. in series with 800pF, and taking a load R of 160Ω, power into load

$$= \frac{e^2R}{X_C{}^2+R^2} = 3.8\mu W$$

Therefore tranducer efficiency is 0.091%. That is, less than 1/1000 part of the input power appears in the load. Higher and lower values of R give an even lower efficiency than 0.091%. Fig. 4 plots the variation of efficiency for three frequencies over a wide range of load. Even at 10kHz with the optimum load the peak efficiency is merely 0.18%, i.e. less than 1/500 of the input power.

This is an important result since it shows that ceramic pickups are inefficient devices when looked at from the energy conversion point of view. So also are magnetic pickups†, most microphones and a host of other transducers. With such a low overall efficiency is it reasonable to think that the mechanical damping will be affected by different values of load resistor? Obviously not, since a 1/1000th part represents an insignificantly small proportion of the total absorbed power.

It follows that the voltage generator e in the equivalent circuit depends only on mechanical factors and these are unaffected by electrical loading.

Although e is independent of the load resistance R, the voltage developed across R will depend on the values of R and the pickup capacitance, C, since they form a simple high-pass filter. *This effect is simple to calculate and very simple to correct in the pre-amplifier.* We may now review the six "myths" listed above.

(1) The transient response is unchanged.
(2) The mechanical equalization is unaffected.
(3) Distortion is unchanged.
(4) Separation is unaffected.
(5) Velocity loading does work with certain special precautions[3].
(6) Needle tip mechanical impedance is unchanged.

To some this may come as a surprise and some readers may find mere calculations unconvincing, and, like the author, prefer a practical demonstration to show that the theoretical model upon which the deductions were based was a valid representation of the real thing.

Measurements were carried out with two different pickups—a Sonotone 9TAHC and a Garrard EV26. The important differences between these pickups are that the 9TAHC has a high capacitance and low

*Calculation based on 9TAHC.

†The efficiency calculation, when performed for moving-magnet variable-reluctance and moving-coil pickups, reveals the same thing—efficiency about 0.01%.

output, but the EV26 has a low capacitance and a high output. The output from the pickup was fed to a microswitch so that it could be switched into an $R_{in} = 10M\Omega$ amplifier of gain -1 or straight into a resistor of $10k\Omega$ as in Fig. 5.

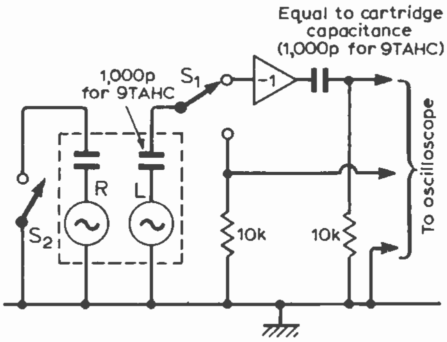


Fig. 5. Test circuit for high/low impedance loads.

With switch S_1 up, the pickup 'sees' the $10M\Omega$ amplifier input resistance but the amplifier output is fed to the 'scope via a *CR* circuit of 1000pF and $10k\Omega$. With the switch down, the pickup is directly loaded by a $10k\Omega$ resistor. Therefore, in each case the output to the oscilloscope is taken from *CR* circuits of $f_0 = 16kHz$ but in the first case the transducer is loaded by $10M\Omega$ and the second by $10k\Omega$. This method of comparison eliminated rumble, and accentuated the distortion and resonances because of the 6dB/octave rising frequency response up to 16kHz. An EMI test record TCS101 was used which consists of constant frequency bands of *L* only and *R* only at 20 spot frequencies from 30Hz to 20kHz. During the comparison tests, differences were looked for in the output voltage amplitude and waveform throughout the whole range of the audio frequency spectrum down to 60Hz* while S_1 was operated rapidly to change from high- to low-impedance loading.

The first clear fact to emerge from the comparison test was that mechanical equalization was completely unaffected when changing the load, and was also unaffected by making the other channel o.c. or s.c. The second clear fact was that the stylus mass/record compliance resonance dominated the distortion and it also was unaffected by the loading of either the test channel, or o.c. or s.c. on the other channel. Most ceramic pickups have a broad hump in the frequency response at about 8kHz caused by the piezoelectric element. On the face of it this resonance would be the most readily affected by electrical damping if electrical damping is significant since it is the actual ceramic element which is resonating thus giving the closest coupling to the output. But this too was unaffected. In fact no change in waveforms at all occurred on switching from high to low load.

This would have been a perfect experiment from which beautifully coincident oscillograms should have been produced, but for one thing. The distortion on any one test frequency varied continuously. Oscillograms would have shown this variation, and not the lack of it at the instant of load switching. Fig. 6(a), (b) and (c) show superimposed waveforms at 6, 18 and 20kHz respectively taken at different circumferential points on the record. Despite this difficulty, it was feasible by eye to check that no waveform change took place at the instant of load switching. Incidentally, the waveform fluctuations kept in step with the record rotation so they are probably caused by record pressing aberrations, warps or changes in the hardness of the vinyl.

These measurements have confirmed the calculation. However, a listening test is always the final deciding test with audio problems since subjective assessment often reveals unexpected shortcomings. Comparisons made over a period of many months in day-to-day usage of a record player using alternate high- and low-impedance loading revealed that there is no detectable difference. The amplifier was frequency corrected as given in Fig. 8(b) of ref. 3 when the low-impedance load configuration was used, i.e. bass lift of 6dB/octave starting at 500Hz was applied

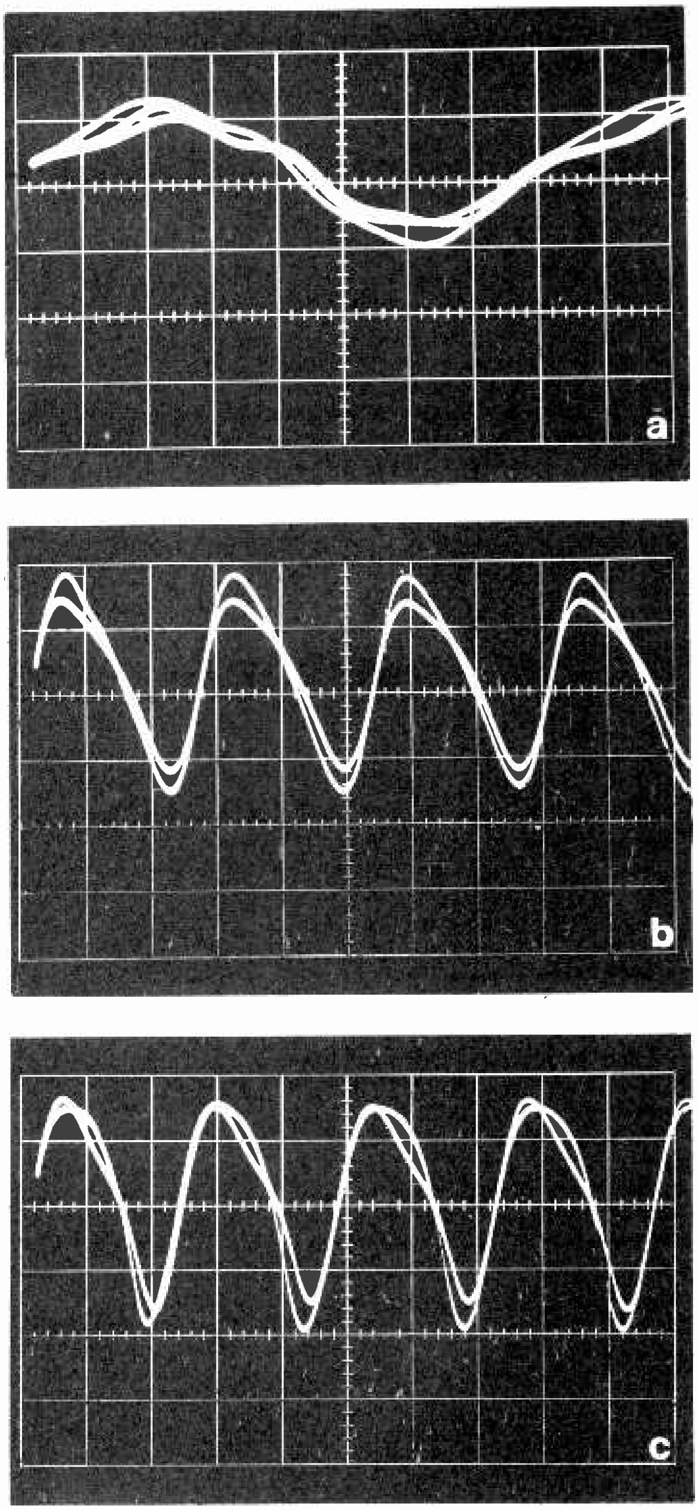


Fig. 6. Superimposed waveforms at 6kHz (a), 18kHz (b) and 20kHz (c) taken at different points on the test record and using the arrangement of Fig. 5.

*The reactance of the pickup capacitance can no longer be neglected in comparison with $10M\Omega$ at frequencies lower than 60Hz.

to compensate for the bass cut due to the 200kΩ input resistance.

Reasons for low efficiency

The calculations which produced Fig. 4 use the 'black box' approach, in which the 'innards' of the box (i.e. the pickup) are ignored, and only the input-output characteristics considered. The calculations show that whatever load is used the overall efficiency is very low. This fact allows many important deductions to be made without recourse to detailed knowledge of the contents of the box. For example, the needle tip impedance must be unaffected by electrical load and, with practically all magnetic pickups apart from sum and difference types, all the other factors mentioned earlier are unaffected. A plausible argument that might be raised at this point is that the low overall efficiency with ceramic pickups is caused by very weak coupling between the needle cantilever and the ceramic element, but the element might still be efficiently coupled to the electrical output terminals. But, the pickup series capacitive reactance precludes a high efficiency through limiting the current into the load, except at very high audio frequencies.

At these high frequencies, the ceramic element needs to be well damped to avoid pronounced resonances when the pickup is used with a high load resistance, and indeed the usual construction of ceramic pickups does include one or more damping blocks mounted directly on the bimorph, which makes it well damped, independent of any loading effects. It would be unworkable in any case to expect the electrical load to damp correctly the mechanical parts, such damping being inherently very frequency dependent. Thus, efficiency is low at high frequencies because of damping, and it is low at low frequencies due to the series reactance of the self capacitance. Tuning out the reactance at, say, 100Hz with a high-Q 2500H inductor might raise the efficiency to 4%, but give a very peaky frequency response!

The same type of argument can be used for magnetic pickups although different in detail. A magnetic pickup would be very inefficient at low frequencies owing to the very low e.m.f. and at high frequencies where the efficiency might be high, damping and the rising series reactance ($X_L \propto f$) once more work against this.

The requirement of aperiodic response from a vibrating system is in direct conflict with efficiency, and this is the main feature which automatically precludes high conversion efficiency from a gramophone transducer be it ceramic, moving-coil, variable reluctance or even strain gauge! Thus, interaction between electrical load and mechanical performance is to all intents and purposes negligible.

Choice of pickup operating conditions

Having established that the pickup loading has no influence on distortion, needle impedance, separation etc., the designer is free to choose the simplest and best operating circuit for the ceramic pickup.

High impedance circuits are very popular but there are many difficulties. All the pickups in Table 1 need at least 4MΩ to put the turnover frequency to 50Hz or below and the SCU1* needs 16MΩ! High input impedance transistor pre-amplifiers are inconvenient, prone to noise and hum pick-up and need f.e.ts or multi-transistor bootstrapped input stages. No conventional high-impedance circuit deals satisfactorily with the better quality ceramic pickups, particularly the Connoisseur SCU1, because the bass turnover frequency is too high. Also a "tone balance" type of tone control circuit is needed to provide the correct treble lift. Ceramic pickup input stage design will be more fully examined in Part 2 of this article.

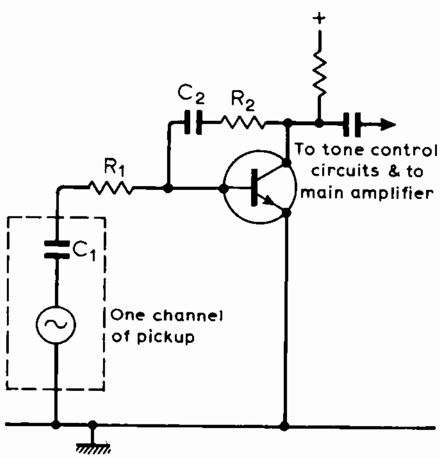


Fig. 7. Basic circuit for equalizing any ceramic pickup.

Low impedance loading suffers from none of these disadvantages. All equalization can be achieved around one transistor (see Fig. 7) and the circuit can be easily adapted for any of the pickups listed in Table 1. The pre-amplifier merely has to provide sufficient bass lift to counteract the bass cut due to the low input impedance, and the overall frequency response can be held flat to well below 50Hz; better than with a 1–2MΩ load in fact! Rumble filtering can be designed into the single stage as well to reduce the very low-frequency noise. Allowance can be made for the absence of mechanical compensation in the Connoisseur SCU1, since tone balance adjustment is a feature of the virtual earth feedback amplifier, and is achieved by varying one component—R_1.

Conclusions

1. Pickup load impedance has no effect on the in-built mechanical compensation, transient performance, distortion, separation, etc.

2. Much published information on this subject, including amplifier manufacturers' operating instructions, is often ill-informed to the point of absurdity.

3. High-impedance loading does not automatically cure all of the equalization problems particularly the low capacitance types and the SCU1.

4. Decompensation circuits as in ref. 3, (Figs. 12 and 13) arc needed when operating most pickups (except SCU1) into magnetically corrected pre-amplifiers.

*Really intended for operation into a 100kΩ load (or less) fully R.I.A.A. magnetically corrected it then gives overall flat response ±2dB.

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The Diagnosis of Logical Faults

by R. G. Bennetts, B.Sc., M.Sc.*

One of the problems that the designer and user of logical systems is confronted with, is that of testing the logical functioning of the circuits within the system. The procedure is usually split into two main processes—namely a simple go/no go test followed by, in the event of a no go decision, a more thorough analysis to determine the location of the fault. The former is known as fault detection whereas the full detection and location process is termed diagnosis. It is the purpose of this series of two articles to illustrate, through the use of examples, some of the techniques that have been developed to assist in determining the necessary tests and to comment on their advantages and disadvantages.

The processes for detection and location of faults occurring at circuit level, i.e. printed circuit board or sub-assembly level, have always been rather complex and the pre-1960 logic designer was usually left to his own devices when it came to their specification. This led to a number of *ad hoc* techniques such as exhaustive testing, special test rigs, the provision of test points positioned on the actual board, or as in the case of digital computers, special diagnostic programmes usually based on checking the order code and assuming that this would indicate full operational status of the central processor unit. As the complexity of the circuits increased, it became apparent that the techniques in use were not capable of providing full checkout of the system, or in the case of exhaustive testing, would take too long. Associated with this was areas of operational uncertainty leading to a lack of confidence in the finished design.

Fortunately, about this time (1960), the theory behind the design of logical networks was becoming consolidated and logic designers were beginning to realize the potential of formalizing their logic requirements and using the algorithmic reduction techniques. This increased use of switching theory, as it is now known, suggested ways in which the circuits could be fully tested without exhaustive testing. It was also found that algorithms that had been developed for minimizing the logical equations could be adapted and used in the selection of the minimal number of tests required to provide diagnostic information. Consequently, a number of formal techniques for determining the necessary tests for detection and/or location of faults has evolved and this paper seeks to explain how these techniques are applied and what their restrictions are. Some of the restrictions are common to all techniques and the next section contains details of these together with definitions of the terminology of diagnosis.

General restrictions and definitions

The type of faults that can occur within a logical circuit can be classified into two groups—logical and non-logical. Among the logical faults is included such types as signal lines being stuck a logical 1 or logical 0. These stuck-at-1, stuck-at-0 types are usually referred to as s-a-1, s-a-0 respectively and can result from open- or short-circuit connections, input transistor malfunction, etc. The logical fault group can be further sub-divided into single fault only, multiple faults or intermittent faults. In general, the diagnostic techniques are designed to cover single faults with limited coverage of multiple faults. The intermittent fault is extremely difficult to diagnose using automatic techniques, and the usual approach is to continually re-cycle the diagnostic test set until the fault recurs and is successfully diagnosed. Note that the occurrence of a logical fault causes the circuit to still function as a completely logical circuit, albeit incorrectly and it is usual to refer to the 'good' circuit and the many faulty circuits.

The non-logical fault group contains all those faults that are not included in the logical group and this includes power rail failure, ground plane incompatibilities, crosstalk, incorrect wiring etc. Such faults may give rise to a logical malfunction, but the diagnostic test set is limited to discovering the logical effect of the fault, and not its cause.

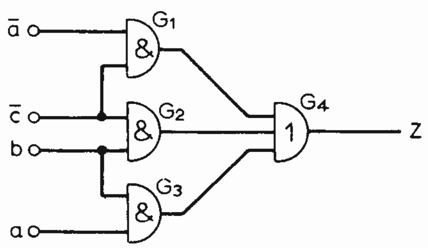

Fig. 1. Fault masking through redundancy.

A test on a logical circuit is a defined input configuration that will produce a defined output under the no-fault condition. If the output is not correct, this indicates the existence of a fault and in general, one test is not sufficient to completely cover all postulated faults. This implies therefore that one must seek a set of tests, called the diagnostic test set (d.t.s.) that will cover all the postulated faults and in the limit, all input configurations (exhaustive testing) may be used. There is an obvious disadvantage here in that for n input variables, there are 2^n tests and it is this exponential proliferation of tests that quickly leads to impractical diagnostic test sets.

A further general restriction is that the circuits should contain a minimal amount of redundant logic. In some cases such as in the avoidance of races and hazards, redundant logic is incorporated into the circuit and a fault occurring within the redundant logic may not be observable at an output terminal unless the signal lines in the redundant logic are brought out to an accessible observation post such as the edge connector of a printed circuit board or a test point. If these lines are not accessible, then the faults cannot always be detected, let alone located. A prime example of this occurs in majority voting circuits in which redundancy is deliberately introduced to increase the reliability and diagnosis techniques, for this class of circuit has to make use of extra test points or outputs.

A further effect of redundancy is that in some cases a fault occurring in the redundant element can mask other faults occurring in the non-redundant elements. This is illustrated in Fig. 1.

The function realized here is given by:

$$z = \bar{a}\bar{c} + b\bar{c} + ab$$

and either by Boolean manipulation or Karnaugh mapping, it becomes obvious that the $b\bar{c}$ term is redundant. This means that G_2 is a redundant gate. Consider now the effect of a s-a-1 fault on the output of G_2. This will cause the output z to always be 1 and will mask s-a-0 faults occurring on either G_1 or G_3 outputs. Note also that no input configuration can be found to diagnose the G_2 output s-a-1 fault since this would

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entail establishing a test that simultaneously set G_1, G_2 and G_3 outputs to $0: a = b = \bar{c} = 0$ will achieve this, but it is not known whether the s-a-1 fault is occurring on G_1, G_2 or G_3 output. This leads to the conclusion that s-a-1 faults occurring on G_1, G_2 or G_3 are indistinguishable in that there is no input configuration that is capable of differentiating between them.

One other feature of G_2 is that the other fault, G_2 output s-a-0, is completely undiagnosable since there is no input configuration that will simultaneously attempt to create a 1 on G_2 output and a 0 on G_1 and G_3 outputs.

Before leaving this section, it is as well to define the circuit classification terms *combinational* and *sequential.* The definitions are as follows:

Combinational circuit:

Logic circuit in which the output(s) obtained from the circuit is solely dependent on the present state of the input.

Sequential circuit:

Logic circuit in which the output(s) obtained from the circuit is not only dependent on the present inputs, but also the past inputs. This implies storage and feedback of previous input conditions.

These two types of circuit are illustrated diagrammatically in Figure 2.

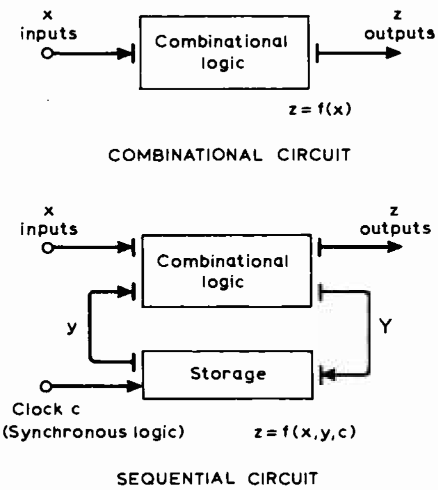


Fig. 2. Models for combinational and sequential circuits.

Testing procedures

There are two main approaches to the testing of logical circuits. The first, termed *multi-flow* uses the response of the $(j-1)^{th}$ test to determine the j^{th} test. This involves the use of certain criteria and these are enumerated in a later section (that dealing with partitioning).

The other approach, termed *single-flow* does not have this facility and consists instead of a pre-defined set of tests, all of which must be applied before any decision can be made. Generally, multi-flow procedures are more efficient and in some cases, can allow very rapid analysis as to the state of the circuit. Single-flow procedures are usually easier to implement, however, and provided an optimum set of tests can be derived, can often be more economical.

Both procedures lend themselves to *automatic test systems*, the basic configuration

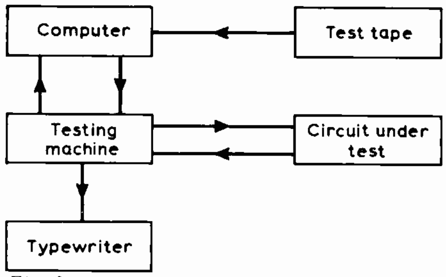


Fig. 3. Automatic test system.

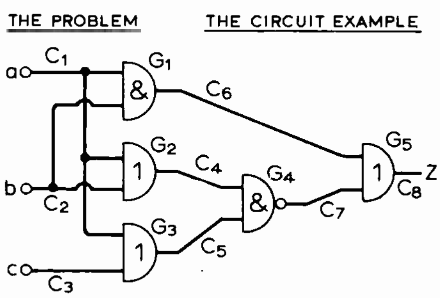
for which is shown in Fig. 3, and the testing tape will either contain the pre-defined set of tests (single-flow) or criteria details (multi-flow).

Alternatively for the multi-flow procedure, the test tape can contain tests that have been pre-determined from a computer simulation of the circuit-under-test. The idea of simulation has become quite useful as far as sequential circuits are concerned, but simulation does carry its own problems of course.

Discussion of the diagnosis technique

The remainder of this paper is concerned with a discussion of four techniques that are now in use. The aim of each is to produce a satisfactory set of tests that can be applied to a circuit and analysis of the output sequence enables either the detection or full diagnosis of a fault if it exists. Each technique will be discussed in general terms and then applied to an example—the same example being used in all cases. In this way, it is hoped that an effective comparison may be made. For the purpose of establishing the concepts behind the technique, the example is kept relatively simple, i.e. a pure combinational circuit, but the extension or otherwise into the sequential circuit field will be indicated. The postulated faults will be restricted to single s-a-1, s-a-0 type for all techniques. Again, this is so as to not obscure the conceptual detail, but bear in mind that this is usually a natural limitation of the technique anyway. The four techniques that will be studied are: Fault matrix; path sensitizing; boolean difference; and partitioning.

Of these four, the first three are primarily used to produce a test set suitable for use in single-flow testing procedures, whereas the fourth is more applicable to the multi-flow technique.



$$Z = \bar{a}\,\bar{b} + \bar{a}\,\bar{c} + a\,b$$
$$= \overline{(a+b)(a+c)} + a\,b$$

Fig. 4. The circuit used to illustrate the various techniques of diagnosis.

The problem is this: Given the circuit shown in Fig. 4, and assigning each signal transmission path $C_1 \rightarrow C_8$ as shown*, determine a minimal or near-minimal (optimal) set of tests that may be applied to the input terminals such that analysis of the resultant output sequence will successfully

(a) detect or

(b) detect and locate the single faults of s-a-1 or s-a-0 occurring on each connection.

The circuit itself does not contain redundant elements (although this results in a race on C_6 and C_7); it is not symmetrical and it contains a variety of gate types.

1: The fault matrix

The fault matrix F relates a set of tests to their associated faults and the entries within F are the output values resulting from the defined input conditions with the defined fault. In the case of the circuit of Fig. 4, there are three input terminals and therefore eight different tests, termed $t_0 \rightarrow t_7$. The 16 faults $f_1 \rightarrow f_{16}$ that are postulated are s-a-0, s-a-1 faults occurring on the eight connections $C_1 \rightarrow C_8$ and are referred to as $C_1/0$, $C_1/1$, $C_2/0$ etc. to denote C_1 s-a-0, C_1 s-a-1, C_2 s-a-0 etc. Thus the matrix in this case is an 8-row by 16-column matrix with an extra column (f_0) to denote the output under the no-fault condition. The entries within the matrix can be determined either by hand computation or more usually by means of a computer simulation of the circuit. The F matrix for the example circuit is shown in Fig. 5.

We will consider initially, the problem of fault detection. The F matrix as it stands is difficult to manipulate and a further matrix G_D is formed by comparing each fault mode with the no-fault column and entering a 1 if there is a difference between the entries on the same row. Expressing this more formally:

For all $0 \leqslant i \leqslant 7$, $1 \leqslant j \leqslant 16$, the $t_i f_j$ entry $= 1$,

if and only if $t_i f_0 \oplus t_i f_j = 1$

where $\oplus$ denotes the Boolean exclusive OR operator.

The G_D matrix for the example circuit is shown in Fig. 6 and the no-fault column is not now present.

Examining the G_D matrix, we see that for any one test, a number of faulty conditions is usually identified. For example, if we apply t_1 to the circuit and the output is incorrect, i.e. 0, then this indicates that a fault is present and that the fault is one of five—$C_1/1$, $C_2/1$, $C_4/1$, $C_7/0$ or $C_8/0$. Remembering that we are only interested in a go/no go check at this stage, we wish to select a minimal set of tests such that the outputs will, if correct, enable us to say that none of the faults $f_1 \rightarrow f_{16}$ are present. This problem of minimal covering is identical to the selection of prime inplicants in minimization of combinational logic and the solution to both problems is the same,

*The fact that input '*a*' for instance really travels along three physically separate connections does not really matter here at all, since it would only increase the number of assigned connections and consequently the number of postulated faults. In real life, there would be 11 assigned connections.

abc	test	f_0	f_1 $C_1/0$	f_2 $C_1/1$	f_3 $C_2/0$	f_4 $C_2/1$	f_5 $C_3/0$	f_6 $C_3/1$	f_7 $C_4/0$	f_8 $C_4/1$	f_9 $C_5/0$	f_{10} $C_5/1$	f_{11} $C_6/0$	f_{12} $C_6/1$	f_{13} $C_7/0$	f_{14} $C_7/1$	f_{15} $C_8/0$	f_{16} $C_8/1$
000	t_0	1	1	0	1	1	1	1	1	1	1	1	1	1	0	1	0	1
001	t_1	1	1	0	1	0	1	1	1	0	1	1	1	1	0	1	0	1
010	t_2	1	1	1	1	1	1	0	1	1	1	0	1	1	0	1	0	1
011	t_3	0	0	1	1	0	1	0	1	0	1	0	0	1	0	1	0	1
100	t_4	0	1	0	0	1	0	0	1	0	1	0	0	1	0	1	0	1
101	t_5	0	1	0	0	1	0	0	1	0	1	0	0	1	0	1	0	1
110	t_6	1	1	1	0	1	1	1	1	1	1	1	0	1	1	1	0	1
111	t_7	1	0	1	0	1	1	1	1	1	1	1	0	1	1	1	0	1

Fig. 5. The fault matrix F for Fig. 4.

	(f_0f_1)	(f_0f_2)	(f_0f_3)	(f_0f_4)	(f_0f_5)	(f_0f_6)	(f_0f_7)	(f_0f_8)	(f_0f_9)	(f_0f_{10})	(f_0f_{11})	(f_0f_{12})	(f_0f_{13})	(f_0f_{14})	(f_0f_{15})	(f_0f_{16})
t_0		1											1		1	
t_1		1		1				1					1		1	
t_2						1				1			1		1	
t_3		1	1		1		1		1			1		1		1
t_4	1			1			1		1			1		1		1
t_5	1			1			1		1			1		1		1
t_6			1								1				1	
t_7	1		1								1				1	

Fig. 6. The detection matrix G_D for Fig. 4.

i.e. the use of the Quine-McCluskey algorithm.

The first requirement is to determine the essential tests. These arise if a particular fault is detectable only by one test and this amounts to scanning G_D for single entry columns. If we do this, we see that f_5 ($C_3/0$) can only be tested by t_3. Similarly, we require t_2 for f_6, t_1 for f_8 and t_2 for f_{10}. The essential tests therefore are t_1, t_2 and t_3 and these will cover not only the faults already mentioned but also most of the other faults. In fact, f_1 and f_{11} are the only faults now requiring cover, and the addition of t_7 to the three essential tests will complete the cover. One possible detection test set therefore (in this case, the minimal) is $t_1t_2t_3$ and t_7 and in terms of the input/output values *abc/z*, the test set is 001/1, 010/1, 011/0, 111/1. When these input values are presented sequentially to the circuit, any deviation from the defined output sequence will indicate the existence of an error. The next step is to locate the error down to the actual gate and in order to determine this, a different matrix G_L is formed.

The G_D matrix was based on indicating differences only between the outputs of the no-fault circuit and all other circuits. For full diagnosis, we wish to be able to differentiate between all the circuits and this means that not only do we compare f_j, $1 \leqslant j \leqslant 16$ with f_0, but also with f_k, $1 \leqslant k \leqslant 16$ where $k \neq j$. This will create a much larger (column-wise) matrix, but subsequent treatment is the same as for G_D. Expressed formally;

For all $0 \leqslant i \leqslant 7$, $0 \leqslant j \leqslant 16$, $0 \leqslant k \leqslant 16, j \neq k$, the t_if_{jk} entry = 1 if and only if

$$t_if_j + t_{if_k} = 1$$

The G_L matrix is not shown here since it is rather large (8 rows × 136 columns*) but some initial degree of simplification can be applied by noting the indistinguishable fault sets from G_D. Referring to Fig. 6, we see that f_7, f_9, f_{12}, f_{14}, and f_{16} are all detectable with the same three tests t_3, t_4 or t_5. This means that we cannot tell which of the five has occurred and there is no point in forming the $\binom{5}{2}$ columns that they represent. Similarly with (f_6f_{10}) and usually the only means of differentiating between indistinguishable faults is by the use of extra test points or access via terminal pins. This does mean that allocation of test points can now be made on a definitive basis, and not intuitively as is sometimes the case.

The formidable size of the G_L matrix tends to severely limit its use in deriving full locational test sets and this also applies to a lesser extent to the G_D matrix. It is a useful approach, however, and does serve to illustrate quite clearly the concepts of essential tests and indistinguishable faults. The example chosen is of necessity very simple. A more sophisticated sequential circuit can be accommodated within the fault matrix framework provided the entries in F can be ascertained. This normally requires a full computer simulation and the entry will possibly be an output sequence rather than a single 1 or 0. Multi-output circuits can also be handled simply by writing the output set in binary (or decimal equivalent) into the F matrix and proceeding as before. In this case, the exclusive OR operation is applied to corresponding bits in the output word.

*The number of columns for n faults is given by

$$\binom{n+1}{2} = \frac{n^2+n}{2}.$$

2: Path sensitizing

The basic technique of path sensitization relies on three processes:

(a) The postulation of a known fault at a known location.

(b) The propagation of the fault from its location to one or more of the primary outputs via a *sensitive path*, i.e. one along which any change in the logical value of the fault will be reflected in a corresponding change at the primary output. This is called the *forward-trace phase.*

(c) Implicit in the forward-trace phase is the setting up of other elemental inputs and outputs and these can only be established by their predecessors—in the limit this being the primary inputs. This process is termed the *backward-trace phase* and the final set of primary inputs constitute the necessary test configuration for the postulated fault.

In order to clarify the technique, we will consider the fault C_4 s-a-1 in the example circuit of Fig. 4.

Forward-trace phase: The first step is to determine through which gates the fault may be propagated and initially $C_4/1$ can only affect the output of G_4. In order to do so, C_5 must be held at 1 such that if C_4 is s-a-1, C_7 becomes 0. If C_4 should be 0 and the fault is not apparent, then C_7 will be 1. The effect of the fault has now been propagated to C_7 and again a search is made to determine through which gates the effect may be further propagated. In this case G_5 is the only candidate and we note that if C_7 is 0, then provided C_6 is held at 0, the output C_8 will be 0, and will indicate the existence of the fault, since the output under the no-fault condition will be 1. The effect of the fault has now been driven to an observable primary output and this completes the forward-trace phase. Before proceeding with the backward-trace phase, a comment about the terminology is in order. A 'sensitive' input to a gate is usually termed the *control* input and the other inputs that are held at some level, the *static* inputs. In general, for an n input gate, there are $(n-1)$ static inputs and one control, but in some cases referred to as *reconverging fanout* cases, there may be more than one control input.

Backward-trace phase: The backward-trace phase is essentially the establishment of the static inputs that were determined during the forward-trace phase and in the limit this will involve the primary inputs. In the case of C_4 s-a-1, the static inputs were C_5 held at 1 and C_6 held at 0. Also required of course is that C_4 should be 0 in the correctly functioning circuit. Let us now examine the implications of these three requirements.

(1) C_5 held at 1.

Logically $C_5 = C_1 + C_3$, therefore the permissible alternatives are:

$$C_1C_3,\ \bar{C}_1C_3 \text{ or } C_1\bar{C}_3$$

(2) C_6 held at 0.

Logically $C_6 = C_1C_2$, therefore the permissible alternatives are:

$$\bar{C}_1\bar{C}_2,\ \bar{C}_1C_2 \text{ or } C_1\bar{C}_2$$

(3) C_4 to be 0.

Logically $C_4 = C_1 + C_2$, and there is only one valid alternative:

$$\bar{C}_1\bar{C}_2$$

It now remains to select a combination that is valid for all three circumstances and $\bar{C}_1\bar{C}_2C_3$ is the only one that satisfies this. Consequently 001 on $C_1C_2C_3$, i.e. t_1, is the only test that will detect $C_4/1$ and this can be verified by reference back to the G_D matrix of Fig. 6 and looking at the f_8 column. The sensitive path in this case is via G_2, G_4, and G_5, with G_1 and G_3 acting as staticizing gates as shown in Fig. 7.

Associated with this technique is an allied process that will determine what faults a particular test input will detect. It is not

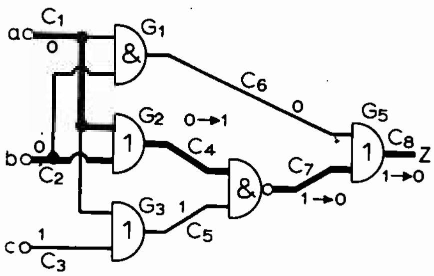


Fig. 7. The sensitive path and fully assigned circuit for C_4 s-a-1.

proposed to describe this in detail, but it consists basically of identifying the control and static inputs on the gates for a fully assigned circuit, i.e. one in which the true values of all the transmission lines under the defined input condition is known. From this knowledge, each line can be subjected to certain criteria to determine whether or not a fault will be successfully propagated to a primary output.

Also it is more usual to integrate the forward- and backward-trace phases such that if inconsistencies occur, i.e. if no valid combination can be found to suit all static requirements, then they may be recognized earlier, thus saving unnecessary computation.

In summary therefore, the process consists of postulating a fault, determining the necessary test input, deriving all other faults that such a test will detect and then repeating the process for another fault not yet covered until all faults are included. If this is conducted on the example circuit of Fig. 4 such that the first fault postulated is $f_1(C_1/0)$ then the three tests t_4, t_5 or t_7 will be identified. A decision must now be made as to which of these three to select and the only basis for this is to compute the number of faults each test will detect and select that one that detects the greatest number*. In this case t_4 and t_5 both detect seven faults whereas t_7 only detects four. If we arbitrarily chose t_4, the next fault (proceeding numerically from $f_1 \rightarrow f_{16}$) will be $f_2(C_1/1)$. Again, three tests are identified – t_0, t_1, and t_3 – and of these t_3 would be selected. Proceeding in this manner, the final test set would be $\{t_4, t_3, t_2, t_1, t_7\}$.

This result highlights one of the three major disadvantages of the sensitive path approach – namely that the essential tests cannot be predetermined and this can lead to a non-minimal test set. (In the case of the example circuit, the minimal test set is given by $\{t_1, t_2, t_3, t_7\}$). The second is that the process is only suitable for deriving a detection test set, rather than a full diagnostic set and the third is that it is very difficult to apply this technique to sequential circuits since the forward- and backward-trace phases tend to become rather complex due to the overall feedback that occurs.

*This is really a modified form of the checkout criterion that is used in the partitioning technique q.v.

(*to be concluded next month*)

60 Years Ago

July, 1911. This issue of *Wireless World's* predecessor, *The Marconigraph,* included an article (originally a lecture to the Royal Institution of Great Britain) entitled 'The Practical Development of Radiotelegraphy' in which Commendatore G. Marconi reviewed the current state of the art and Figs 1 and 2, reproduced photographically from the article, show a transmitter and receiver of the time. Also described in the article was a disc discharger (Marconi patent 1907) which allowed a much improved transmitter. Fig 3 shows the apparatus which was described by Marconi as follows:

"The apparatus shown consists of a metal disc *a* having copper studs firmly fixed at regular intervals in its periphery and placed transversely to its plane. This disc is caused to rotate very rapidly between two other discs *b* by means of a rapidly revolving electric motor or steam turbine. These side discs are also made to slowly turn round in a plane at right angles to that of the middle disc. The connections are as illustrated in the figure. The studs are of such length as to just touch the side discs in passing, and thereby bridge the gap between the latter.

"With the frequency employed at Clifden, namely 45,000, when a potential of 15,000 volts is used on the condenser, the spark gap is practically closed during the time in which one complete oscillation only is taking place, when the peripheral speed of the disc is about 600 feet a second. The result is that the primary circuit can continue oscillating without material loss by resistance in the spark gap. Of course the number of oscillations which can take place is governed by the breadth or thickness of the side discs, the primary circuit being abruptly opened as soon as the studs attached to the middle disc leave the side discs.

"This sudden opening of the primary circuit tends to immediately quench any oscillations which may still persist in the condenser circuit; and this fact carries with it a further and not inconsiderable advantage; for, if the coupling of the condenser circuit to the aerial is of a suitable value, the energy of the primary will have practically all passed to the aerial circuit during the period of time in which the primary condenser circuit is closed by the stud filling the gap between the side discs; but, after this, the opening of the gap at the discs prevents the energy returning to the condenser circuit from the aerial as would happen were the ordinary spark gap employed. In this manner the usual reaction which would take place between the aerial and the condenser circuit can be obviated with the result that with this type of discharger and with a suitable degree of coupling the energy is radiated from the aerial in the form of a pure wave, the loss from the spark gap resistance being reduced to a minimum.

"An interesting feature of the Clifden plant, especially from a practical and engineering point of view, is the regular employment of high-tension direct current for charging the condenser. Continuous current at a potential which is capable of being raised to 20,000 volts is obtained by means of special direct-current generators; these machines charge a storage battery consisting of 6,000 cells all connected in series, and it may be pointed out that this battery is the largest of its kind in existence. The capacity of each cell is 40 ampere hours. When employing the cells alone the working voltage is from 11,000 to 12,000 volts, and when both the direct-current generators and the battery are used together the potential may be raised to 15,000 volts through utilizing the gassing voltage of the storage cells.

"The potential to which the condenser is charged reaches 18,000 volts when that of the battery or generators is 12,000. This potential is obtained in consequence of the rise of potential at the condenser plates, brought about by the rush of current through the choking or inductance coils."

A paragraph in the editorial under the heading 'Man v Machine' starts 'The old bugbear of the machine being too far in advance of the man in charge of it has been trotted out again . . .' Need we say more!

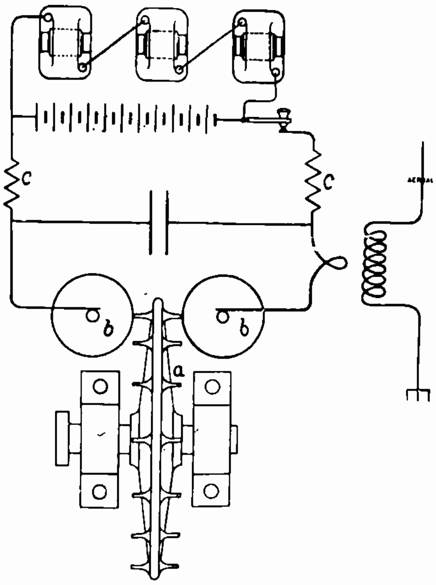


Fig. 3.

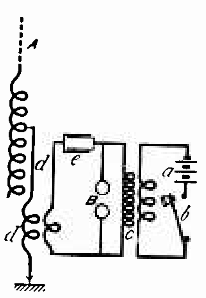


Fig. 1.

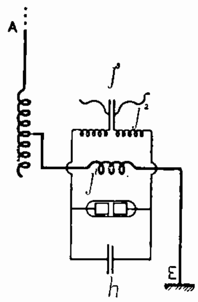


Fig. 2.

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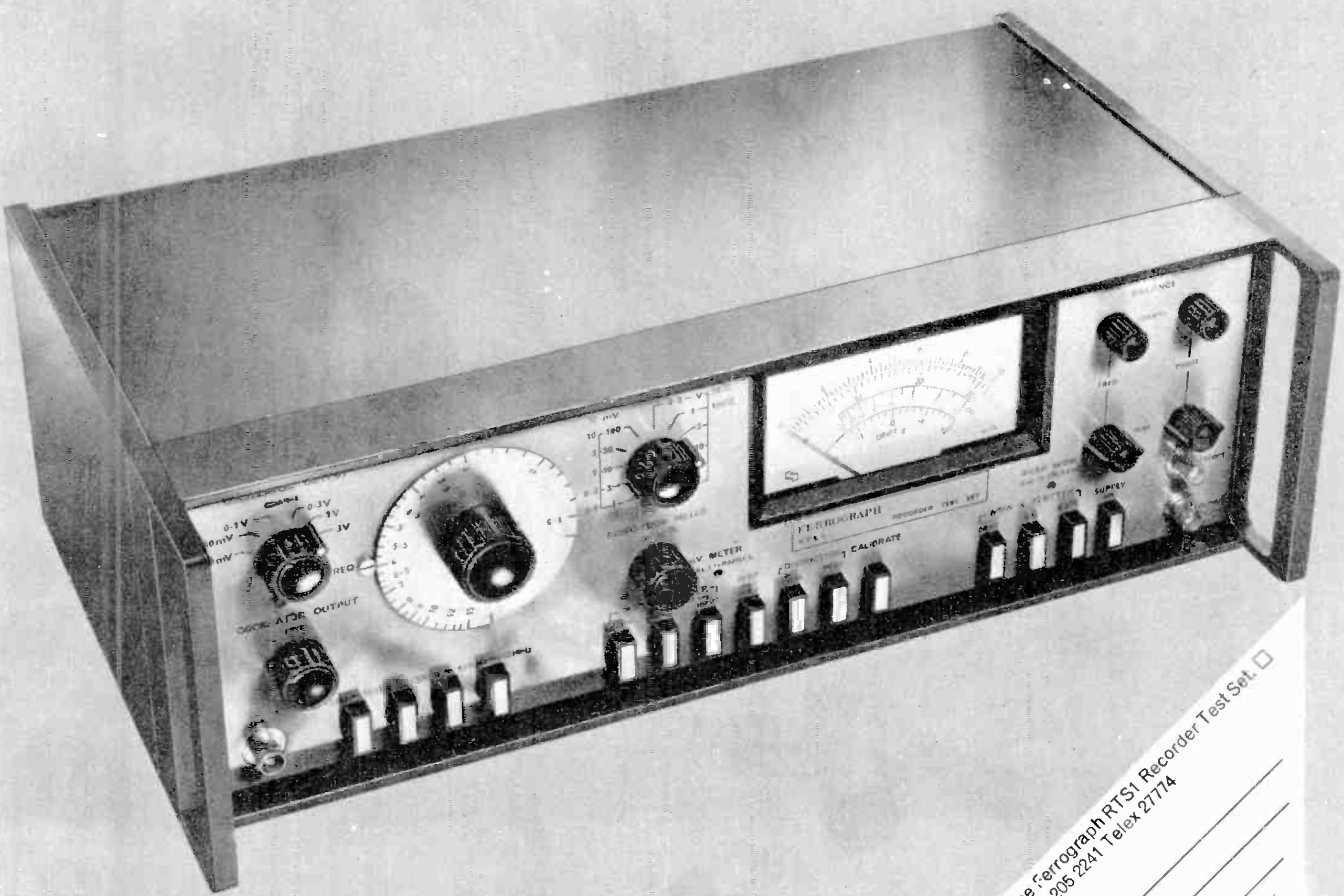

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New Approach to Transistor Circuit Analysis

by A. J. Blundell, M.I.E.E.*

Concluded from the June issue

The second and final article shows how the author's simple "voltage-control" transistor model is applied to the emitter-follower stage. It discusses accuracy of the model—compared to the hybrid-π circuit—and introduces d.c. and large signal versions of the model, applicable to Darlington and complementary pairs. It concludes by applying the model to the Lin output circuit and shows how simple modifications improve this circuit. Part 1 introduced the model from first principles and showed how to apply it to the common-emitter stage. The author proposed a correction term for evaluating internal emitter resistance of transistors and showed how to optimize voltage gain.

The second most important transistor circuit is the emitter follower or common-collector stage, Fig. 11(a). This is not as straightforward to analyse as the common-emitter stage because it is strongly bilateral. This means that G_V is not simply related to μ and equation (1) is not applicable. An amplifier made entirely of bilateral stages is complex with almost everything interacting; input and output impedances depending on load and source impedances respectively. Fortunately in transistor circuits an emitter follower usually precedes or follows a common-emitter stage which breaks the chain because it has definite input and output resistances.

*Lanchester Polytechnic, Rugby

Suppose R_l is known; then the total emitter resistance R_e' is the parallel combination of R_e and R_l, Fig. 11(b). The voltage gain must now be called A_V because the load is included. This is just the ratio of the potential divider consisting of r_e and R_e', i.e.

$$A_V = \frac{R_e'}{r_e+R_e'}$$

The input resistance is simply

$$r_1 = \beta_e(r_e+R_e')$$

so that

$$G_V = \frac{V_1}{V_s}\cdot\frac{V_l}{V_1} = \frac{r_1}{R_s+r_1}\cdot A_V$$

$$= \frac{\beta_e(r_e+R_e')}{R_s+\beta_e(r_e+R_e')}\cdot\frac{R_e'}{r_e+R_e'}$$

$$= \frac{R_e'}{\dfrac{R_s}{\beta_e}+r_e+R_e'}$$

If on the other hand R_s is the quantity known, we can work the other way. Let B_V be the driven open-circuit voltage gain analogous to A_V but with R_s included instead of R_l. From Fig. 11(c)

$$\mu = R_e/(r_e+R_e),\ r_1 = \beta_e(r_e+R_e)$$

$$\text{and } B_V = \frac{V_1}{V_s}\cdot\frac{V_2}{V_1} = \frac{r_1}{R_s+r_1}\cdot\mu$$

$$= \frac{\beta_e(r_e+R_e)}{R_s+\beta_e(r_e+R_e)}\cdot\frac{R_e}{r_e+R_e}$$

$$= \frac{R_e}{\dfrac{R_s}{\beta_e}+r_e+R_e}$$

Obviously if R_e' is substituted for R_e the result will be G_V as above and this would be the usual procedure, but to do the thing properly we will find r_2 and combine it with R_e and B_V in a formal way. The output resistance is usually the trickiest of the basic calculations. First make $V_s = 0$ because its value does not affect r_2, then apply V_2 at the output – Fig. 11(d). If I_2 can be calculated r_2 can be found. One current component is that flowing down R_e, the other flows up r_e as I_e, and down R_s as I_b. Thus the total voltage drop is $I_er_e+I_bR_s = I_er_e+I_eR_s/\beta_e = I_e(r_e+R_s/\beta_e)$, a result which implies that this part of the circuit acts as a resistance (r_e+R_s/β_e) so that the total resistance is simply the parallel combination of the two paths as shown in Fig. 11(e). Then

$$r_2 = \frac{R_e(r_e+R_s/\beta_e)}{R_e+r_e+R_s/\beta_e}$$

so that for any R_l

$$G_V = \frac{V_g}{V_s}\cdot\frac{V_e}{V_g} = B_V\cdot\frac{R_l}{r_2+R_l}$$

$$= \frac{R_e}{\left(\dfrac{R_s}{\beta_e}+r_e+R_e\right)}\cdot\frac{R_l}{\left[\dfrac{(R_e(r_e+R_s/\beta_e))}{(R_e+r_e+R_s/\beta_e)}+R_l\right]}$$

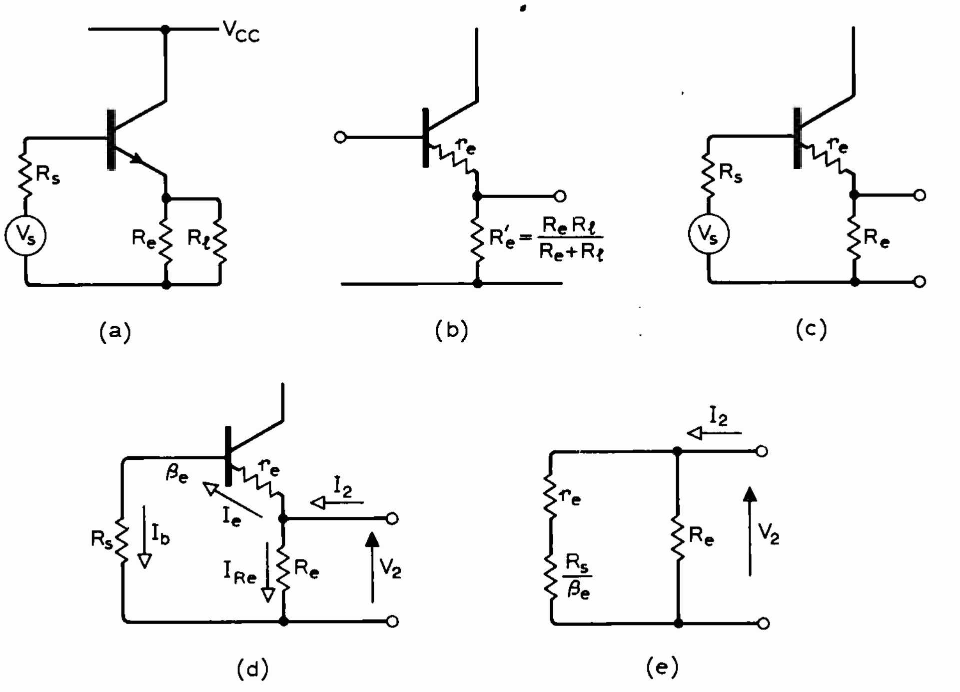

Fig. 11. In the common-collector stage or emitter follower (a), voltage gain is not simply related to μ because the stage is strongly bilateral, i.e. input and output impedance depends on load and source impedances respectively. Gain can be calculated knowing either R_e (b) or R_s (c). To find gain knowing R_s involves finding r_2 combining it with R_e and the driven open-circuit voltage gain. Resistance r_2 is found by putting $V_s = 0$ and applying V_2 at the output (d), which shows r_2 as the combination at (e).

$$= \frac{R_e R_e}{R_e(r_e+R_s/\beta_e)+R_l(r_e+R_s/\beta_e)+R_eR_l}$$

$$= \frac{R_e R_l}{(R_e+R_l)(r_e+R_s/\beta_e+R_eR_l/(R_e+R_l)}$$

$$= \frac{R_e'}{R_s/\beta_e+r_e+R_e'}, \text{ as before.}$$

Those who have read C. H. Banthorpe's article (*W.W.* August 1966) may have seen the one by G. Garside,[3] which was something of a sequel. Let us take the ring-of-three amplifier that he discussed as an example of the emitter follower analysis; we will assume that no feedback is used. Fig. 12 shows the circuit. There are two common-emitter stages separated by an emitter follower.

It is usually easier to marry the emitter follower to the following stage. Taking $\beta_e = 60$ for all the transistors the calculation proceeds as follows.

$r_{ec} = 26/2+3/\sqrt{2} = 15\Omega, \mu_c = -1100/15 \Rightarrow -73{\cdot}5$ and $r_{1c} = 60\times 15 = 900\Omega$. r_{1c} acts as load for Tr_b so $R_{eb}' = 900\times 22{,}000/22{,}900 = 864\Omega$. r_{eb} at 0·09mA is 299Ω so that $A_{Vb} = 864/(299+864) = 0{\cdot}742$. $r_{1b} = 60(299+864) = 69{,}800\Omega$. Thus Tr_b and Tr_c act as a single transistor with $\mu_{bc} = A_{Vb}\mu_c = 0{\cdot}742\times 73{\cdot}5 = -54{\cdot}5$ and $r_{1bc} = 69{,}800\Omega$.

It is now easy to combine this equivalent transistor with Tr_a for r_{ea} at 0·5mA is 56Ω and there is an emitter resistor of $1{,}000\Omega$ so that $\mu_a = -7{,}000/(56+1{,}000) = -6{\cdot}62$ and $r_{1a} = 60(56+1{,}000) = 63{,}360\Omega$.

Now we cannot work out the overall gain G_V because the source and load resistance for the complete amplifier are not known, so the overall gain we calculate is the open-circuit voltage gain of the amplifier

$$\mu_T = \mu_a \cdot \frac{r_{1bc}}{(r_{2a}+r_{1bc})} \cdot \mu_{bc}$$

$$= \frac{6{\cdot}62\times 69{,}800\times 54{\cdot}5}{7{,}000+69{,}800} = 328.$$

Finally $r_{2c} = 1{,}100\Omega$ so that the circuit is completely represented by

$$r_{1T} = 63{,}360\Omega,\ \mu_T = 328,\ r_{2T} = 1{,}100\Omega.$$

Now a source and load may be connected and off we go again!

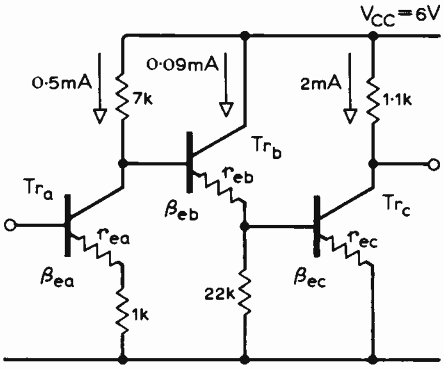

Fig. 12. Derivation of open-circuit voltage gain of ring-of-three amplifier used to illustrate emitter follower analysis. With no feedback and source and load unconnected gain is 328.

Referred resistances

Looking back at the work on the emitter follower there is no denying that the algebraic expressions are not so simple as those of the common-emitter circuit. It would be useful if some graphic aid could be developed, so that part of the manipulation could be displayed on a circuit diagram. In equation (11) it was found that the source resistance could be treated as being in series with r_e if it were first divided by β_e. On the other hand the resistances in the emitter appear in the base circuit as the input resistance if they are multiplied by β_e.

These are examples of a general rule which allows the effects of resistances to be transferred through the beta barrier. The rule leads to a more sophisticated technique for analysing transistor circuits which has, alas, its dangers and disadvantages. The danger is partly because the logic is more complicated and partly because the individual "internal" voltage drops may not correspond to the actual ones; this will not matter if "external" properties are all that are required. The disadvantage is that the coupling gains are not brought out specifically so negating one of the main points of the previous work.

To illustrate the technique let us calculate the overall gain of the common-emitter circuit in Fig. 13(a).

Figs 13(b) and (c) show the two possibilities for transferring the effects of the resistances. In (b) the two resistances in the base circuit are divided by β_e and added to the emitter circuit, while in (c) the resistances in the emitter circuit are multiplied by β_e and added in *parallel* with the base circuit. Although the effects are transferred, the resistances must still appear in their original positions and exert their usual influence in that part of the circuit. The effect of β_e has now been taken care of so its value can be set equal to infinity in the new circuit diagrams.

From Fig. 13(b) we see that the base voltage is equal to V_s because $\beta_e = \infty$ implies zero base current and therefore no voltage drop across R_s and R_b. The voltage gain between base and collector is the usual ratio of total collector resistance to total emitter resistance so that

$$G_V = \frac{-R_c'}{\left(r_e+\frac{R_s}{\beta_e}+\frac{R_b}{\beta_e}+R_e\right)}.$$

With this method the overall gain is found in one go straight from the modified circuit diagram.

Alternatively, transferring to the base circuit as in Fig. 13(c), the base current is again zero so that the base voltage is the output of the potential divider consisting of R_s, R_b, $\beta_e r_e$ and $\beta_e R_e$. The overall gain is then the gain of the divider multiplied by the gain of the transistor

$$G_V = \frac{(\beta_e r_e+\beta_e R_e)}{(R_s+R_b+\beta_e r_e+\beta_e R_e)}\cdot\frac{(-R_c')}{(r_e+R_e)}$$

$$= \frac{-R_c'}{\frac{R_s}{\beta_e}+\frac{R_b}{\beta_e}+r_e+R_e}, \text{ as before.}$$

Thus there are two ways of transferring the resistances depending on the requirements of the problem. The reader can check that the use of equations (4), (5), (6) and (1) will give the same results.

As an example the circuit of Fig. 12 will be recalculated. Fig. 14 shows the circuit in its referred form. As R_s is not known the total emitter resistance of Tr_a has been transferred to its base where it forms the input resistance of the amplifier, while the Tr_b and Tr_c base resistances have been transferred to their emitters. Notice that the collector resistor of Tr_a, which represents its output resistance, has been transferred first to the emitter of Tr_b by dividing by β_{eb}, and then, together with the resistance already in the emitter of Tr_b, to the emitter of Tr_c by dividing by β_{ec} i.e. $R_{ec}' = ((7{,}000/60+299)\|22{,}000)/60 = 6{\cdot}8\Omega$. Note that when β_e is put to infinity the resistance between the top end of r_e and ground is zero!

The coupling between each of the three stages is now unity and so

$$\mu_T = \frac{(-7{,}000)}{1{,}056}\cdot\frac{22{,}000}{22{,}416}\cdot\frac{(-1{,}100)}{21{\cdot}8} = 328$$

and $r_1 = 63{,}360\Omega$, $r_2 = 1{,}100\Omega$ as before.

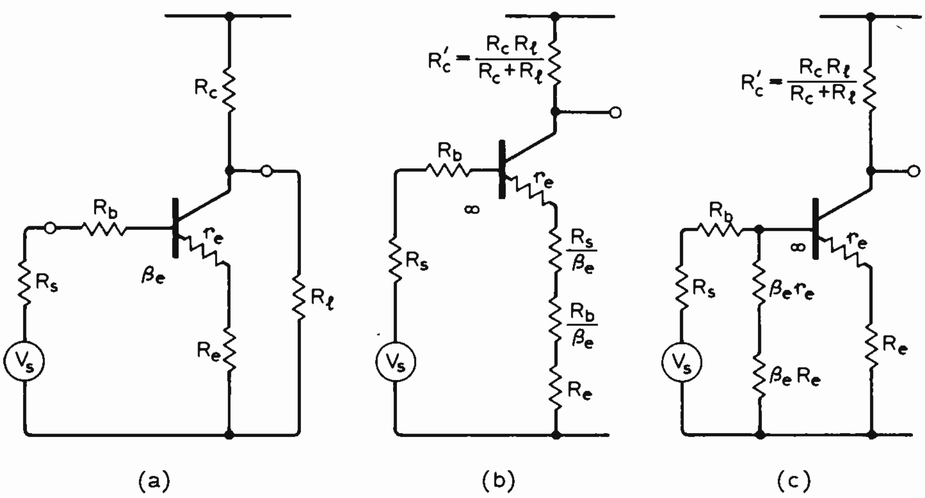

Fig. 13. In calculating the overall gain of the common-emitter circuit (a), resistances in the base circuit can be referred to the emitter circuit by dividing by β_e (d), or resistances in the emitter circuit can be referred to the base by multiplying by β_e(c).

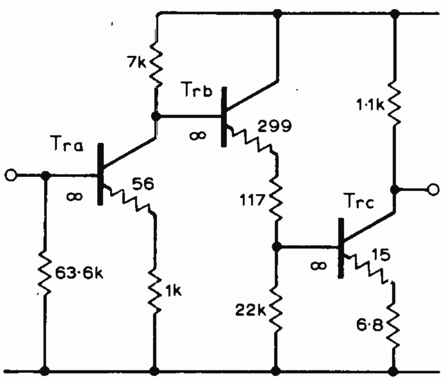

Fig. 14. Open-circuit gain of Fig. 12 circuit can be calculated more quickly using referred resistance technique of Fig. 13. Emitter resistance of Tr_a is transferred to base; Tr_b and Tr_c base resistances are transferred to their emitters; collector resistance of Tr_a is transferred first to Tr_b emitter by dividing by β_{eb} and then—with emitter resistance of Tr_b—to Tr_c emitter by dividing by β_{ec}.

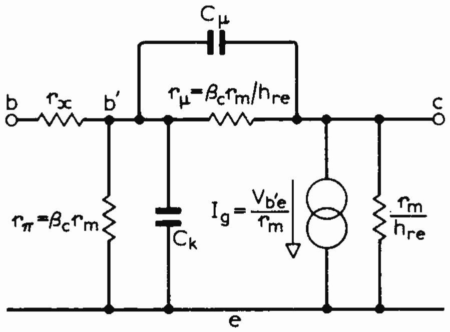

Fig 15. To find how the beta-barrier model compares to this hybrid-π circuit it is transformed to the circuit of Fig. 16.

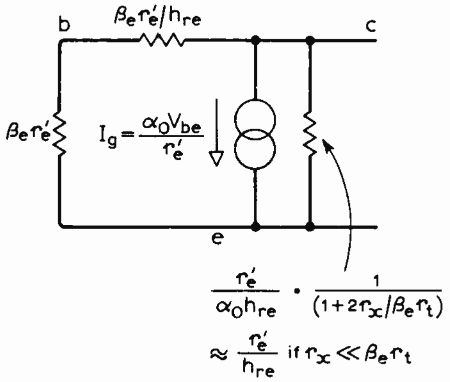

Fig. 16. Equivalent of hybrid-π circuit of Fig. 15 where r_e' is r_e plus a measurable correction term.

The calculation time is much lower with this method and once the principles of transferring the resistors has been understood the analysis is much easier.

Relation of beta-barrier model to the hybrid-π

The beta-barrier model is acknowledged to be an approximate one and it is interesting to examine the nature of the approximation. This can be done by comparison with the more exact models in use at present and it has already been done in the case of h parameters. Of the others only the hybrid-π circuit is worth considering because it allows fairly accurate representation of the transistor self-capacitances and so enables frequency response calculations to be made.[4] The beta-barrier model has been designed to be a simplified form of the hybrid-π circuit, into which it can easily be expanded.

Fig. 15 shows a standard form of the hybrid-π circuit[4, 5] where

$$r_m = r_t/\alpha_o \quad \text{and} \quad r_t = kT/qi_E.$$

An assumption in the values given is

$$h_{ie}h_{oe} = 2h_{re}h_{fe}.$$

which is true for step junctions and appears to be quite good for others.

The T circuit consisting of r_x, r_π and r_μ can be changed to a π circuit by the T to π transformation. However, this is not quite good enough because the node b', which disappears, controls the current generator so that other current generators appear controlled by nodes b and c. Avoiding details, the circuit transforms exactly to Fig. 16, where

$$\begin{aligned} r_e' &= \alpha_o(r_m + r_x(1+h_{re})/\beta_c) \\ &\simeq r_t + r_x/\beta_e \quad \text{as} \quad h_{re} \ll 1 \\ &= kT/qi_E + r_x/\beta_e \end{aligned}$$

We immediately recognise r_e' as r_e with a correction of r_x/β_e, i.e. the ohmic base circuit resistance referred to the emitter circuit.

Measurements indicate that this correction is not constant and it seems reasonable to suppose that it is made up of at least two terms: r_x/β_e plus a current-dependant term possibly due to Shockley's equation becoming invalid at high injected densities. In fact capacitance and frequency response measurements indicate that r_x is also unlikely to remain constant over the whole range of useful i_E. However the important thing is the practical correction factor and this can be measured.

Going back to Fig. 16 and selecting only r_{be} and the current generator, we can show that with r_e' replaced by r_e these are equivalent to the beta barrier model as they both have the same input resistance, deliver the same current for the same base-emitter voltage and have infinite output resistances—Fig. 17(a).

Thus an accurate low-frequency model is given by adding the feedback and output resistances of Fig. 16 to the beta-barrier model as in Fig. 17(b). This is now as accurate as the hybrid-π circuit for low-frequency work.

Of course it is possible to push Fig. 17(b) to the limit by adding an r_x in series with the base and replacing r_e by a value closer to r_t, allowing capacitances to be added to give the complete hybrid-π equivalent, but the problem is to decide how much of the correction factor really is r_x/β_e!

One can carry things too far. For those brought up with a standard set of components it is usually best to stick to them when the going gets tough. This implies returning to the conventional hybrid-π circuit when feedback and output resistance and capacitances become important. The value of the circuit in Fig. 17(b) lies in its suitability for assessing how important these secondary effects are. Since r_μ and r_o usually make only a small difference to the results, the best practical procedure is to use the simple beta-barrier theory to calculate all circuit voltages and currents, and then use these to find the currents that would flow in the extra components. It is then possible to estimate how much difference the secondary components make without doing an exact calculation; in many cases a simple first-order correction is all that is required to give a working accuracy.

Sometimes the correction turns out to be important and makes a large difference in the overall results. It is then necessary to make a a more exact calculation as in the case of the transistor pairs discussed in the next section.

Examples of circuit analysis

The final thing to do is to analyse a few circuits to demonstrate points of technique.

The super-alpha pairs frequently used are interesting. In the Darlington pair of Fig. 18(a) R_e' includes any load on the output terminals, for this is a bilateral circuit.

Transferring the coupling between Tr_1 and Tr_2 to the emitter of Tr_2 and transferring all the resistances to the base of Tr_1, enables both current gains to be put to infinity–Fig. 18(b). Then

$$A_V = \frac{R_e'}{r_{e2} + \dfrac{r_{e1}}{\beta_{e2}} + R_e'}$$

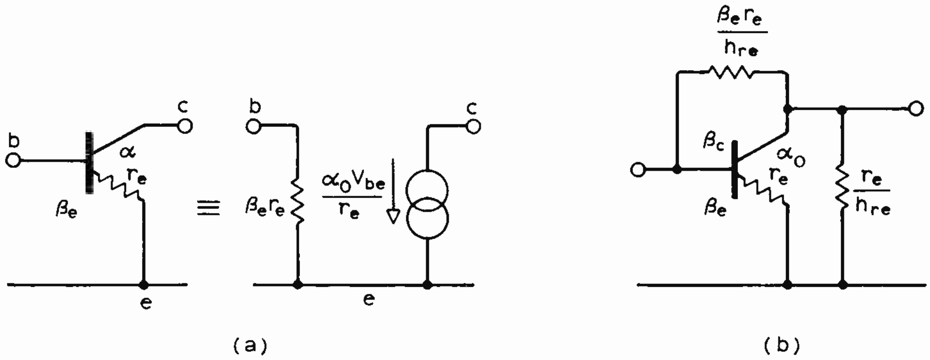

Fig. 17. Circuit of Fig. 16 is equivalent to the beta-barrier model by using only r_{be} and the current generator of Fig. 16 and replacing r_e' by r_e (a). A beta-barrier model (b) as accurate as the hybrid-π circuits for low frequencies is thus derived by adding feedback and output resistances of Fig. 16 to (a).

and

$$r_1 = \beta_{e1}(r_{e1}+\beta_{e2}(r_{e2}+R_e'))$$

Now r_{e1} and r_{e2} are not independent for the direct emitter currents are related because $I_{E1} = I_{B2}$, so that $I_{E1} = I_{E2}/\beta_{E2}$. The value of the beta-barrier model is again evident because d.c. and a.c. quantities can easily be mixed in the same equation if the correction for r_e can be ignored. (This is fair for r_{e1} because I_{E1} will usually be very low, but not so good for r_{e2}.) Then

$$r_{e1} = 0{\cdot}026/I_{E1} = 0{\cdot}026/(I_{E2}/\beta_{E2})$$
$$= \beta_{E2}r_{e2}, \text{ and}$$

$$A_V = \frac{R_e'}{r_{e2}+\dfrac{r_{e2}\beta_{E2}}{\beta_{e2}}+R_e'} \approx \frac{R_e'}{2r_{e2}+R_e'}$$

if $\beta_{E2} \approx \beta_{e2}$.

$$r_1 = \beta_{e1}(\beta_{E2}r_{e2}+\beta_{e2}r_{e2}+\beta_{e2}R_e')$$
$$= \beta_{e1}\beta_{e2}(2r_{e2}+R_e').$$

But these results are equivalent to those for a single transistor which has a current gain equal to the product of the individual gains and twice the usual emitter resistance – Fig. 18(c).

As a further exercise the effect of the correction terms can be included. The term for the single equivalent transistor is just that for Tr_2.

Another interesting case is the complimentary pair of Fig. 19. The referred resistance method is inappropriate here because it is the collector of Tr_1 which feeds Tr_2, and Tr_1 (as a circuit) has infinite output resistance. This is a case where the current gain method is better because $I_{c2} = \beta_{c2}I_{c1} = \alpha_{o1}\beta_{c2}I_{e1}$. Then

$$V_{in} = I_{e1}r_{e1}+(I_{e1}+\alpha_{o1}\beta_{c2}I_{e1})R_e'$$
$$= I_{e1}(r_{e1}+(1+\alpha_{o1}\beta_{c2})R_e').$$

Now $(1+\alpha_{o1}\beta_{c2}) \approx \alpha_{o1}(1+\beta_{c2}) = \alpha_{o1}\beta_{e2}$, so

$$V_{in} = I_{e1}(r_{e1}+\alpha_{o1}\beta_{e2}R_e')$$

Also $I_{E1} = I_{E2}/\alpha_{O1}\beta_{E2}$
so that $r_{e1} = \alpha_{O1}\beta_{E2}r_{e2}$.
If $\beta_{E2} \approx \beta_{e2}$ and $\alpha_{O1} \approx \alpha_{o1}$ then

$$V_{in} = I_{e1}(\alpha_{o1}\beta_{e2}r_{e2}+\alpha_{o1}\beta_{e2}R_e')$$
$$= I_{e1}\alpha_{o1}\beta_{e2}(r_{e2}+R_e')$$
$$V_{out} = (I_{e1}+\alpha_{o1}\beta_{c2}I_{e1})R_e' = \alpha_{o1}\beta_{e2}R_e'I_{e1}$$

and

$$A_V = \frac{V_{out}}{V_{in}} = \frac{R_e'}{r_{e2}+R_e'}$$

$$r_1 = \frac{V_{in}}{I_{b1}} = \frac{V_{in}}{I_{e1}/\beta_{e1}}$$
$$= \alpha_{o1}\beta_{e1}\beta_{e2}(r_{e2}+R_e')$$

This is equivalent to a single transistor of current gain $\alpha_{o1}\beta_{e1}\beta_{e2}$ and emitter resistance r_{e2}. This emitter resistance, which comes entirely from r_{e1}, will only need the r_{e1} correction factor which is negligible.

Comparison with more exact model

So much for the simple model; how does it compare with the more exact one? We redraw the Darlington circuit using the extended beta-barrier model of Fig. 17(b) as in Fig. 20(a). Because the positive d.c. supply rail is effectively at earth potential with respect to a.c., the top ends of all the new resistors are at earth potential and the diagram can be redrawn as in Fig. 20(b). In addition the emitter resistances of each stage have been transferred to the base circuits as r_{11} and r_{12} and the betas put to infinity.

First we find A_V. Suppose that Tr_2 works at 2 mA, then $r_{e2} = 15\,\Omega$ and, from the data for the BC108, $h_{re} = 1/5000$. If β_{C2} is 125, I_{E1} will be 16μA and h_{re1} is then about 1/100 and r_{e1} will be 1649Ω.

For a 10-V supply R_e' cannot be much more than 2500Ω. The collector-emitter resistor of Tr_2 is $r_{e2}/h_{re2} = 15\times5000 =$ 75,000Ω which, appearing in parallel with R_e', gives a total external emitter resistance of $R_e'' = 2420\Omega$. Then the input resistance of Tr_2 is $r_{12} = \beta_{e2}(r_{e2}+R_e'') = 126\,(15\times2420) = 304{,}000\,\Omega$. In parallel with r_{12} are two resistors: $\beta_{e2}r_{e2}/h_{re2} = 126\times15\times5000 = 9.37\,\text{M}\Omega$, and $r_{e1}/h_{re1} = 1649\times100 = 164{,}000\,\Omega$. The Tr_1 output resistance r_{e1}/h_{re1} is the most important, being about half r_{12}.

The total effective external emitter resistance for Tr_1 is then obtained by putting all the resistances in parallel giving a value of 106,000Ω so that $A_V = 106{,}000/107{,}649\times2420/2435 = 0{\cdot}979$. The value given by the simple analysis, allowing for the correction factor in r_2, is $2500/(13+15+2500) = 0{\cdot}989$. Of course the difference will not often be important.

The input resistance is much more interesting. The external emitter resistance of Tr_1 is 106,000Ω so $r_{11} = \beta_{e1}(1649+106{,}000)$. From the data β_{e1} is about 50 so $r_{11} = 5{\cdot}34\,\text{M}\Omega$. $\beta_{e1}r_{e1}/h_{re1} = 50\times1649\times100 = 8{\cdot}24\,\text{M}\Omega$, which in parallel with r_{11} gives an overall input resistance of 3·24 MΩ. The simple analysis gives $\beta_{e1}\beta_{e2}(2r_{e2}+R_e) = 50\times126(28+2500) = 15{\cdot}8\,\text{M}\Omega$, so the correct value is only a fifth of that given by the simple model. Most of the difference is accounted for by the output resistance of Tr_1 which is a function of h_{re1} and r_{e1}.

An improvement can be made by bootstrapping the collector of Tr_1 to the emitter of Tr_2. This can be done by connecting a capacitor between the two points and adding a feed resistor to the Tr_1 collector. The alternating voltage on the collector is then 0·979 times the base voltage and the voltage across the extra resistances of Tr_1 is only $1-0{\cdot}979 = 0{\cdot}021$ times its previous value, so that the currents are 50 times smaller.

A better solution is to choose for Tr_1 a transistor whose β and h_{re} values are good at the working current. The overall performance will then be closely predicted by the simple model.

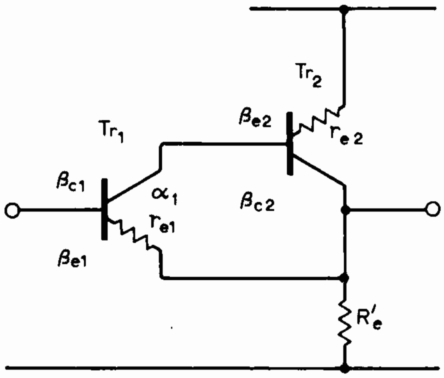

Fig. 19. Analysis of the complementary pair shows equivalence to a single transistor of current gain $\alpha_{o1}\beta_{e1}\beta_{e2}$ with emitter resistance r_{e2}.

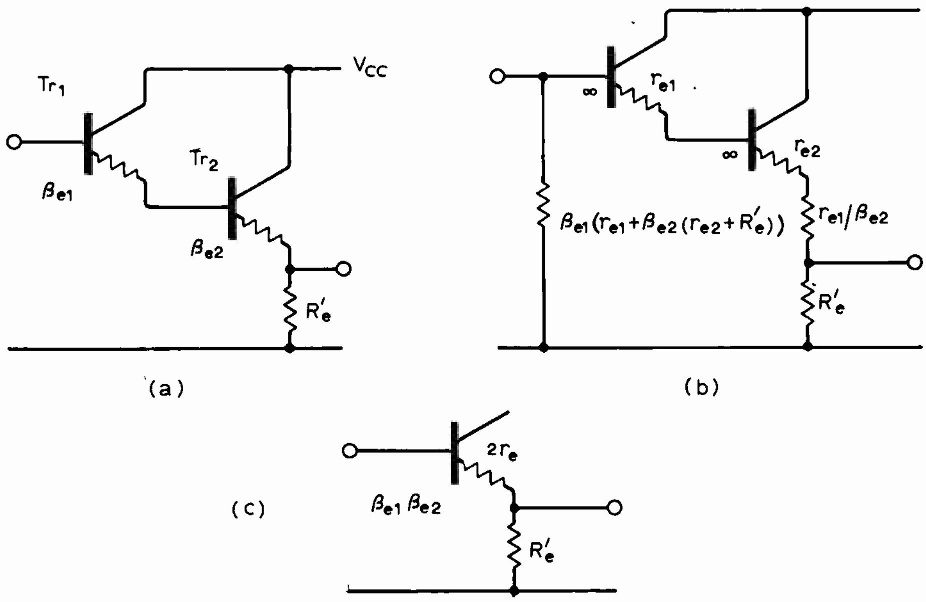

Fig. 18. Because both a.c. and d.c. quantities can be mixed in the same equation with the beta-barrier model it is easy to show that the Darlington pair (a) has a current gain equal to the product of individual gains and an emitter resistance of twice the usual value (c). Voltage gain is calculated by first transferring r_{e1} to Tr_2 emitter and then transferring all resistances to the base of Tr_1 (b) and using the relation $I_{E1} = I_{E2}/\beta_{E2}$.

Large signal and d.c. analysis

The model is adapted for large signal analysis by replacing the resistor r_e by a diode and using the $v_{be}-i_E$ characteristic. Analysis is now more difficult but it can be helped by making the hybrid-π approximation that

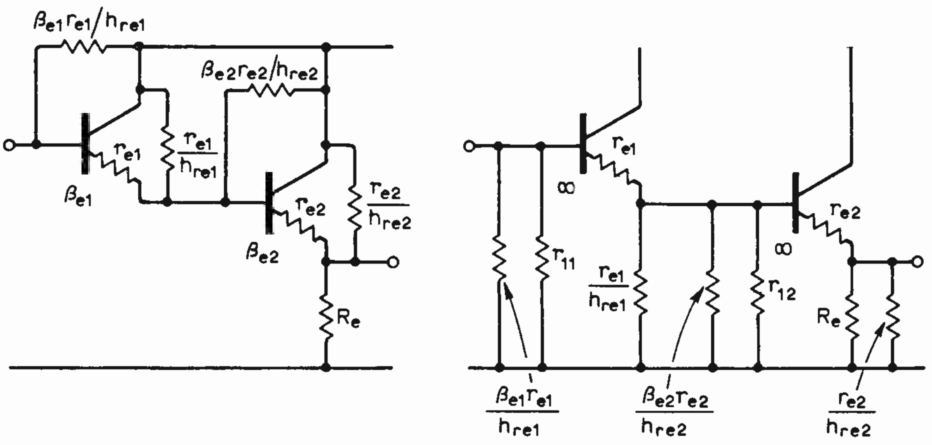

Fig. 20. To compare simple and more exact beta-barrier models for the Darlington pair, circuit is redrawn (a) using model of Fig. 17(b). Circuit (b) is equivalent to (a) with emitter resistances of each stage transferred to the base circuits as r_{11} and r_{12}. Two models give input resistances differing by a factor of five, but simple model gives more accurate result when Tr_1 collector and Tr_2 emitter are bootstrapped.

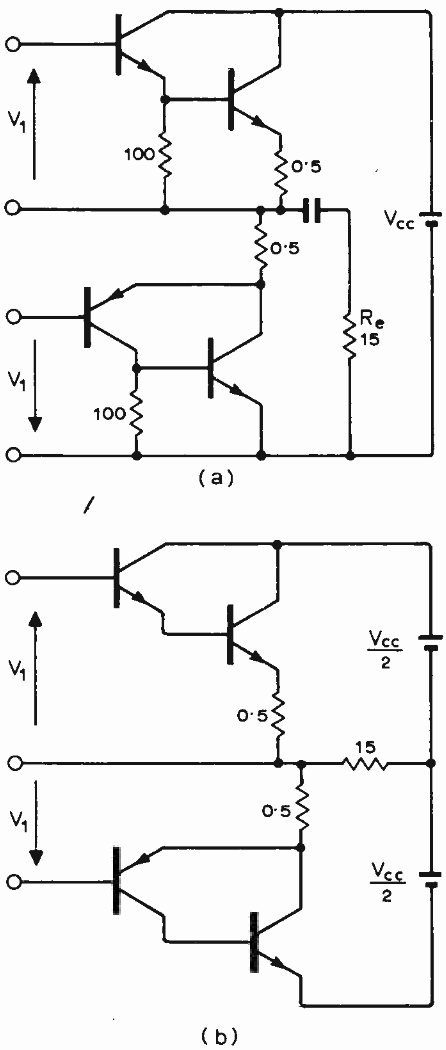

Fig. 21. For d.c. and large-signal analysis emitter resistors must be replaced by diodes. This Lin circuit (a) consisting of a Darlingtom pair and a complementary pair is equivalent to circuit (b) and is separated for analysis into Figs 22 and 23.

the correction factor is constant, i.e. that the deviation from the theoretical logarithmic-shaped diode curve is due to pure resistance of value r. Then

$$v_{BE} = \frac{kT}{q}\ln\frac{i_E}{I_S}+i_E r$$

As an example we will treat the Lin output stages that have received a lot of attention recently – Fig. 21(a). For simplicity the 100-Ω resistors, which modify the base-emitter characteristics at low currents, are ignored, the circuit then essentially consisting of a Darlington pair and a complementary pair operating independently but with a common ground rail. The common ground rail current serves as the output current of the stage and flows via an isolating capacitor to the load resistance. The position of the capacitor and the load can be interchanged without affecting the a.c. quantities so that if the ground rail is initially set to $V_{CC}/2$ then the capacitor will be charged to this value and it will be seen that the load is, in effect, tapped half way down the supply. In the final arrangement – Fig. 21(b) – the current out of each pair can be calculated separately.

The Darlington pair is shown in Fig. 22 with all the quantities indicated and where

$$v_{T1} = \frac{kT}{q}\ln\frac{i_{E1}}{I_{S1}}+i_{E1}r_1$$

$$v_{T2} = \frac{kT}{q}\ln\frac{i_{E2}}{I_{S2}}+i_{E2}r_2.$$

Then $v_1 = v_{T1}+v_{T2}+i_o R_1$

$$= \frac{kT}{q}\ln\frac{i_{E1}}{I_{S1}}+i_{E1}r_1+\frac{kT}{q}\ln\frac{i_{E2}}{i_{S2}}$$
$$+i_{E2}r_2+i_{E1}R_1.$$

Now $i_{E2} = i_{E1}\beta_{E2}$ so

$$v_1 = \frac{kT}{q}\ln\frac{{i_{E1}}^2\beta_{E2}}{I_{S1}I_{S2}}+\frac{i_{E2}}{\beta_{E2}}r_1+i_{E2}r_2+i_{E2}R_1$$

and as $i_O = i_{E2}$

$$\frac{v_1}{i_O} = \frac{kT}{qi_{E2}}\ln\frac{{i_{E1}}^2\beta_{E2}}{I_{S1}I_{S2}}+\frac{r_1}{\beta_{E2}}+r_2+R_1$$

This is the relation between the drive voltage v_1 and the output current i_O. For the complementary pair the circuit is as in Fig. 23 and

$$v_1 = v_{T1}+(i_{E1}+i_{C2})R_1$$

Now $i_{C2} = \beta_{C2}i_{C1} = \alpha_{O1}\beta_{C2}i_{E1}$

Then

$$v_1 = \frac{kT}{q}\ln\frac{i_{E1}}{I_{S1}}+i_{E1}r_1+i_{E1}(1+\alpha_{O1}\beta_{C2})R_1$$

but $(1+\alpha_{O1}\beta_{C2}) \approx \alpha_{O1}(1+\beta_{C2}) = \alpha_{O1}\beta_{E2}$

so that

$$v_1 = \frac{kT}{q}\ln\frac{i_{E1}}{I_{S1}}+i_{E1}r_1+i_{E1}\alpha_{o1}\beta_{E2}R_1$$

Next $i_o = i_{E1}+i_{C2} = i_{E1}(1+\alpha_{O1}\beta_{C2})$
$= i_{E1}\alpha_{o1}\beta_{E2} = i_{E2}$

Finally

$$\frac{v_1}{i_o} = \frac{kT}{qi_{E2}}\ln\frac{i_{E1}}{I_{S1}}+\frac{r_1}{\alpha_{O1}\beta_{E2}}+R_1 \quad (13)$$

The reason for the unbalance is now obvious. Taking equations (12) and (13) term by term we see that r_2 is missing in (13); that as $\alpha_{o1} \approx 1$ the terms in r_1 will be matched but the logarithmic terms are unbalanced, there being a term $(kT/q)\ln(i_{E1}\beta_{E2}/i_{S2})$ too much in equation (12).

There have been two recent proposals to improve the balance. The first was put forward by I. M. Shaw,[6] and the second by P. J. Baxandall (*W.W.* Sept. 1969). In both cases a diode is added to the complementary pair. Figs 24(a) and (b) show the two circuits and the analysis is as follows.

In Shaw's circuit the diode characteristic is

$$v_D = \frac{kT}{q}\ln\frac{i_o}{I_{SD}}+i_O r_d$$

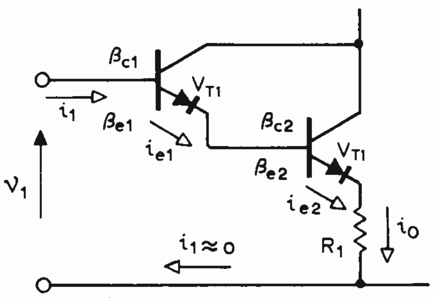

Fig. 22. Large-signal model of Darlington pair used to calculate expression for v_1/i_o. Comparing with expression for the complementary pair – derived from Fig. 23 – shows the two circuits are unbalanced.

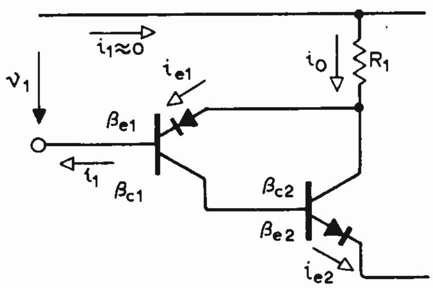

Fig. 23. Large-signal model of complementary pair.

Then

$$v_1 = v_{T1}+v_D+(i_{E1}+i_{C2})R_1$$

$$= \frac{kT}{q}\ln\frac{i_{E1}}{I_{S1}}+i_{E1}r_1+\frac{kT}{q}\ln\frac{i_{E1}+i_{C2}}{I_{SD}}+ (i_{E1}+i_{C2})r_1+(i_{E1}+i_{C2})R_1$$

$$= \frac{kT}{q}\ln\frac{i_{E1}(1+\alpha_{01}\beta_{C2})}{I_{S1}I_{SD}}+i_{E1}r_1+ i_{E1}(1+\alpha_{01}\beta_{C2})r_D+i_{E1}(1+\alpha_{01}\beta_{C2})R_1$$

$$= \frac{kT}{q}\ln\frac{i_{E1}^2\alpha_{01}\beta_{E2}}{I_{S1}I_{SD}}+i_{E1}r_1+ i_{E1}\alpha_{01}\beta_{E2}r_D+i_{E1}\alpha_{01}\beta_{E2}R_1$$

as $i_o = i_{E2}$

$$\frac{v_1}{i_o} = \frac{kT}{qi_{E2}}\ln\frac{i_{E1}^2\alpha_{01}\beta_{E2}}{I_{S1}I_{SD}}+\frac{r_1}{\alpha_{01}\beta_{E2}}+r_D+R_1$$

This is similar to the Darlington pair if $\alpha_{01} = 1$ and if

$$r_D-\frac{kT}{qi_{E2}}\ln I_{SD} = r_2-\frac{kT}{qi_{E2}}\ln I_{S2}$$

so that $r_D = r_2+\frac{kT}{qi_{E2}}\ln\frac{I_{SD}}{I_{S2}}$

Because r_D and r_1 are independent of i_{E2} then I_{SD} must equal I_{S1} and r_D must equal r_2.

P. J. Baxandall puts the diode in the emitter of Tr_1 in parallel with a 100-Ω resistor which we will ignore in this simplified analysis. Using the same expression as before for the diode

$$v_1 = v_{T1}+v_D+i_OR_1$$

$$= \frac{kT}{q}\ln\frac{i_{E1}}{I_{S1}}+i_{E1}r_1+\frac{kT}{q}\ln\frac{i_{E1}}{I_{SD}}+ i_{E1}r_D+(i_{E1}+i_{C2})R_1$$

but $i_{C2} = \beta_{C2}i_{C1} = \alpha_{01}\beta_{C2}i_{E1}$

so $v_1 = \frac{kT}{q}\ln\frac{i_{E1}^2}{I_{S1}I_{SD}}+i_{E1}r_1+i_{E1}r_D+ i_{E1}\alpha_{01}\beta_{E2}R_1$

also $i_O = i_{E1}\alpha_{01}\beta_{E2} = i_{E2}$

so that

$$v_1 = \frac{kT}{qi_{E2}}\ln\frac{i_{E1}^2}{I_{S1}I_{SD}}+\frac{r_1}{\alpha_{01}\beta_{E2}}+\frac{r_D}{\alpha_{01}\beta_{E2}}+R_1.$$

This is similar to the Darlington pair if $\alpha_{01} = 1$ and if

$$\frac{r_D}{\beta_{E2}}-\frac{kT}{qi_{E2}}\ln I_{SD} = r_2-\frac{kT}{qi_{E2}}\ln\frac{I_{S2}}{\beta_{E2}}$$

so that $r_D = \beta_{E2}r_2+\frac{kT\beta_{E2}}{qi_{E2}}\ln\frac{\beta_{E2}I_{SD}}{I_{S2}}.$

Again r_D and r_2 are independent of i_{E2} so for equality of characteristic

$$I_{SD} = I_{S2}/\beta_{E2} \text{ and } r_D = \beta_{E2}r_2$$

It is not difficult to work out the input impedances for these circuits when it will be found that the same conditions apply.

The next step in the analysis would be to introduce the output and feedback resistors and the 100-Ω resistors normally inserted in the Tr_1 emitters.

In conclusion it should be emphasized that the main purpose of the beta-barrier model is to provide a quick method of making a reasonably accurate analysis of

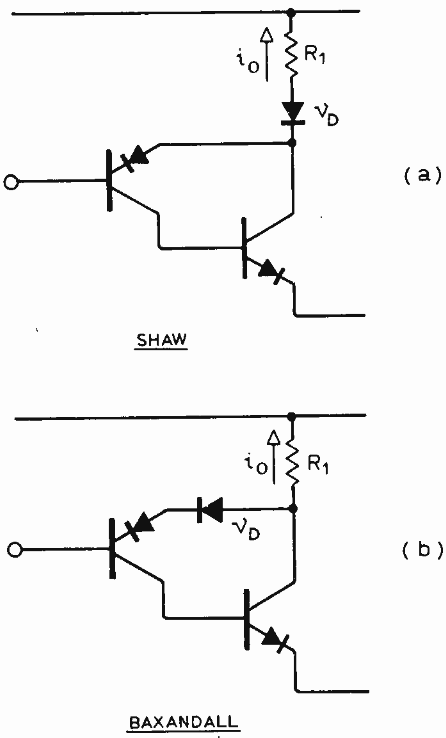

Fig. 24. Modification of complementary pair due to I. M. Shaw (a) and to P. J. Baxandall (b). Text shows how balance is improved.

transistors amplifiers by allowing the circuit diagram to be used as the equivalent circuit diagram. The load on the memory is not heavy; the most important things to recall are ideas rather than formulae. Many designs need only a minimum value for h_{fe} and this can always be obtained from manufacturers' short summary booklets or similar publications. Finally when trouble comes the simple model can be extended by stages to the hybrid-π circuit and a better analysis made.

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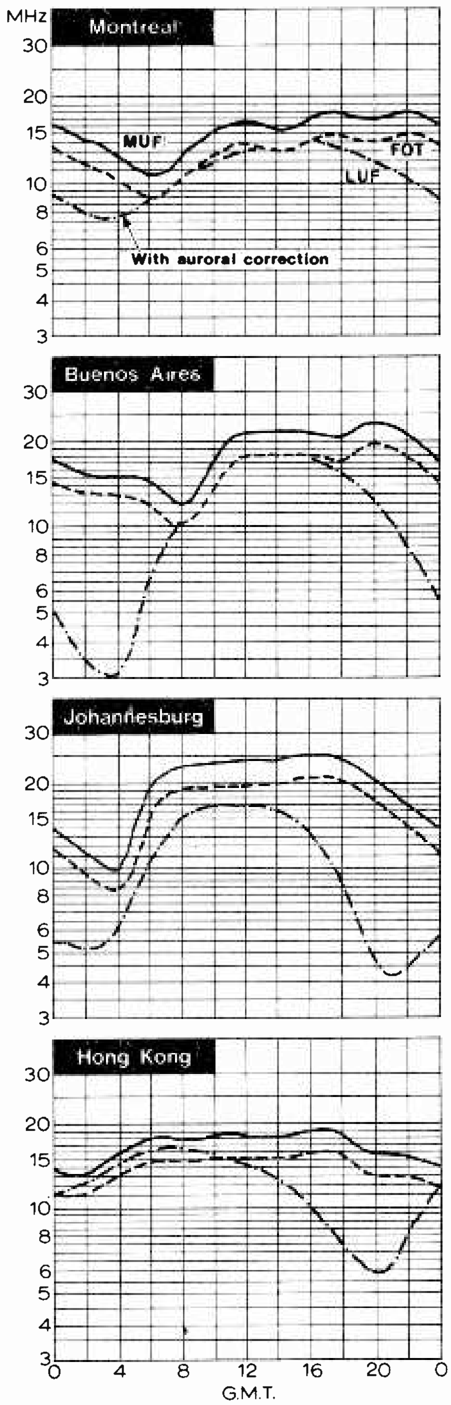
H.F. Predictions —July

The charts are based on an ionospheric index of 77. This is midway between maximum and minimum conditions giving LUF's close to MUF's for long periods, conditions similar to those of 1966/67. Over the next few months U.K. daytime working will improve but during the hours before dawn conditions will become worse.



Audio Sweep Generator

Using f.e.ts in a Wien bridge circuit

by F. H. Trist, B.Sc.

This circuit uses f.e.ts as voltage-dependent resistances in a Wienbridge oscillator. Frequency sweep is achieved by applying a ramp voltage to the f.e.ts from an op-amp Miller integrator, switched at a pre-determined rate by a comparator in a feedback loop, giving a 10:1 change. An improved design – not tested – using operational amplifiers throughout provides better sweep linearity, adjustable output level and simplified calibration.

In this oscillator design a ramp generator feeds a voltage to the gates of two f.e.ts used as voltage-dependent resistances in a Wien bridge circuit, thus effecting a frequency sweep.

Automatic gain control of the Wien bridge type of oscillator is critical and must maintain a loop gain of exactly unity for stable and undistorted oscillation. This does not imply that the signal produced will be constant in amplitude, as some variation is essential to compensate for changes in circuit characteristics, in particular thermal effects and tuning network attenuation. This last is most critical, as these changes occur during every sweep due to what I call 'dynamic mismatch' between the two f.e.ts. The large-signal resistance characteristic of two typical p-channel devices–Fig. 1–shows the ratio of their resistance changes with gate-to-source potential and so the attenuation through an *RC* network also changes with frequency. These changes must be offset by a.g.c. and the greater the degree of dynamic mismatch, the greater will be the variation in the signal level over each sweep. It is important therefore to match these devices as closely as possible–to 5% for a constant level within 1dB. Devices of equal drain-to-source resistance at zero bias invariably possess this degree of dynamic match over their useful range.

The higher the value of this resistance, R_0, the greater the frequency range obtainable with any pair of tuning capacitors. A ratio of 10:1 was chosen and about half of a large batch of f.e.ts had resistances

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Specification of prototype

Sweep linearity: better than 15% on all ranges. (A marker generator could be used to pin-point frequencies required to greater accuracy.)

Frequency ranges: 10-100Hz, 100Hz-1kHz, 1-10kHz, 10-100kHz. (Can be set to within 3% using a digital frequency meter, or more accurately using 25-turn potentiometers.)

Sweep times: 40s for greatest accuracy; 4s for faster sweeps using long-persistence c.r.ts; 0.1s on upper three ranges only.

Amplitude: fixed at 155mV (within ±0.5dB on lowest range, ±0.2dB on next, and ±0.1dB on higher ranges). Variable output can be provided by a 10kΩ potentiometer and emitter follower between Tr_3 emitter and output socket.

Harmonic distortion: less than 1%.

Power supply: +15V and −15V ±5% needed, regulated to 0.5% from 20 to 80mA.

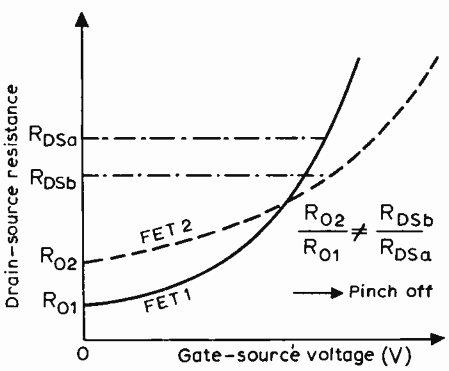


Fig. 1. Automatic gain control offsets 'dynamic mismatch' which occurs when f.e.ts are used in a Wien network. This 'mismatch' is caused by the ratio of the drain-source resistances varying with gate-source voltage as shown.

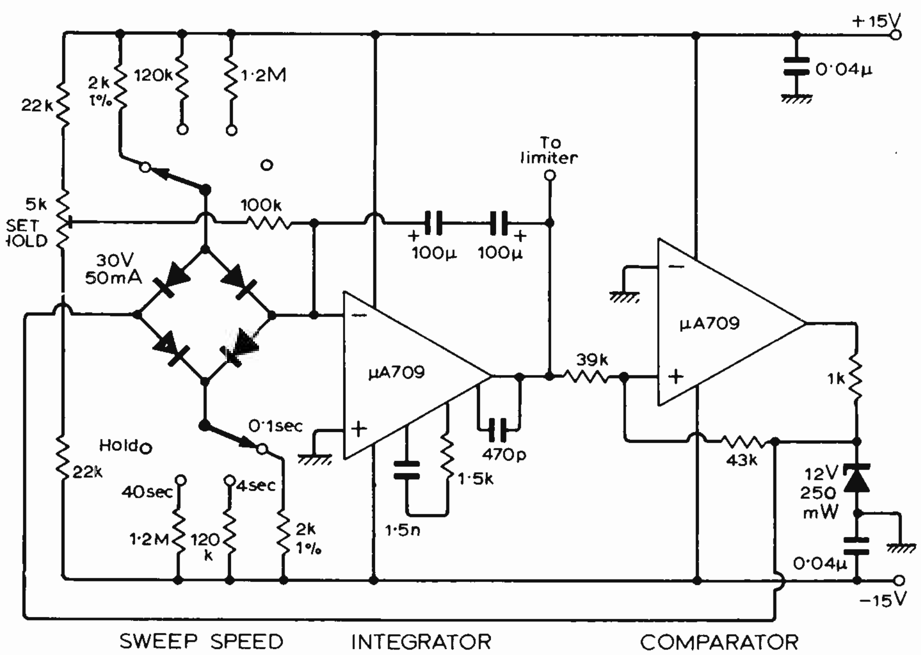


Fig. 2. Ramp generator uses Miller integrator switched at selected rates by a comparator in the feedback loop. (Resistors in all circuits should be ½-watt, ±5% tolerance unless shown otherwise. Compensation capacitors should be polystyrene dielectric.)

high enough to provide this ratio. The devices used are type 2N3820, though the n-channel equivalent is cheaper and can be used by modifying the circuit so that the gates have a negative control voltage. The minimum value of R_0—as measured on the 'ohms' range of an Avo multimeter – is 320Ω, though this is not essential for the a.g.c. device. Devices with R_0 below this figure may not be suitable for tuning.

The ramp generator consists of a Miller integrator, switched at a selected rate by a comparator in a feedback loop[1]—Fig. 2.

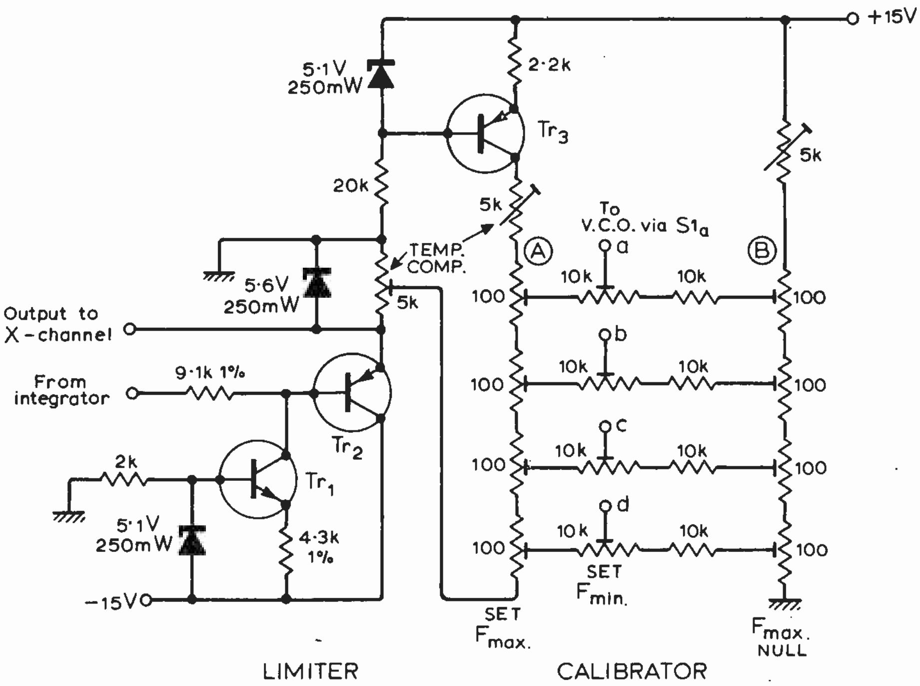


Fig. 3. Limiter and range calibrator includes three pre-set potentiometers for each range to set maximum and minimum frequencies. Null potentiometers allow minimum frequencies to be adjusted without affecting maximum frequency. (Potentiometers can be skeleton pre-set or, for greater precision, multi-turn pre-set types.)

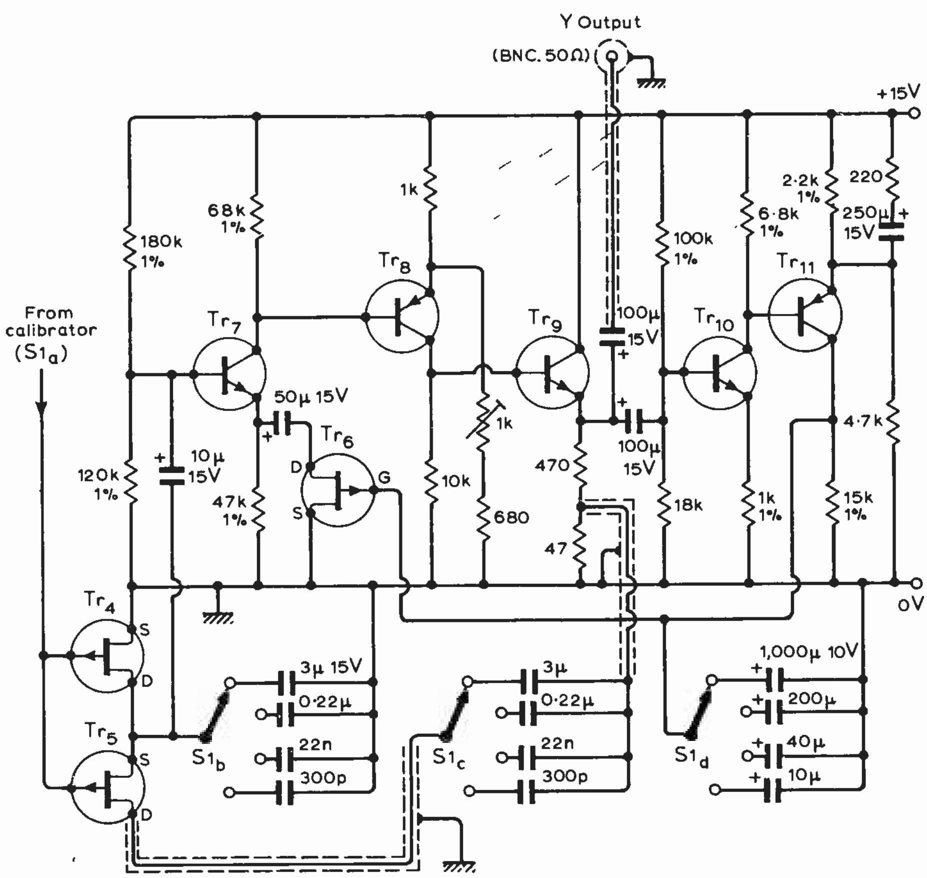


Fig. 4. Voltage-controlled oscillator with f.e.ts as resistors in Wien network uses another f.e.t. for a.g.c. Allow circuit to settle for one minute before starting sweep. (Non-polarized capacitors in the range switching should have polyester or polystyrene dielectrics.)

Amplitude is defined by the zener diode, providing a threshold reference level to the comparator. The comparator output switches the diode bridge, giving a step input of ± 15 V to the integrator. In the 'hold' position the pre-set potentiometer can be set to offset any drift in the integrator, thus presenting a constant amplitude to the oscillator.

The generator incorporates a limiter which provides a pause between each sweep. This is particularly useful when using the slowest sweep speed as adjustments can be made to the network under test during this time without stopping the generator or spoiling a photographic record. The slowest speed is primarily intended to enable useful photographs to be taken on time-exposure. By providing a 'rest' between sweeps, the demands made on a.g.c. response time are eased.

Because the long sweep times are not available on oscilloscopes, a voltage sweep output is provided after the limiter (Fig. 3) for direct coupling to the *x*-channel of the oscilloscope.

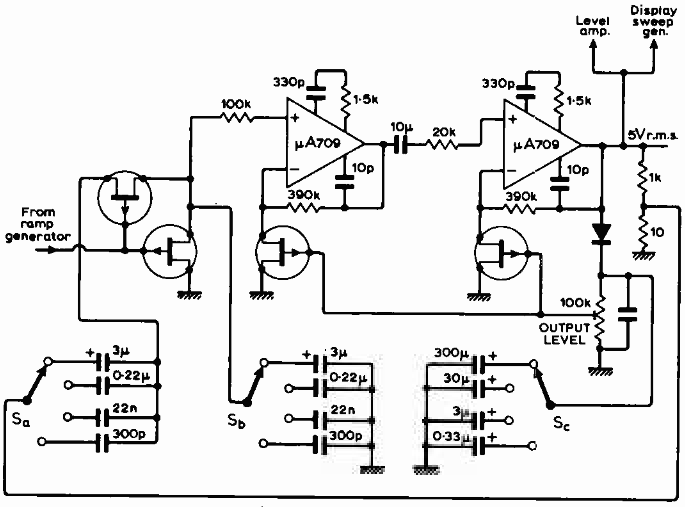
A range calibrator—Fig. 3—is included to provide adjustment for tolerance spreads in the f.e.ts and capacitors used in the tuning bridge. There are three potentiometers for each range. Adjust the maximum frequency for each range on the f_{max} potentiometers with the f_{min} pots at maximum amplitude. When these four have been set, adjust the 5-kΩ variable resistor in the null potential divider to give the same potential at point B as at A when the ramp generator is at its mimimum-amplitude pause. (Use the slowest sweep or the 'hold' setting.) The null potentiometers are then adjusted to give equal slider potentials to those on the corresponding maximum frequency potentiometers. This procedure gives a null balance so that the f_{min} potentiometer can be adjusted during the maximum ramp pause without affecting the maximum frequency settings. These last set the minimum frequency for each range.

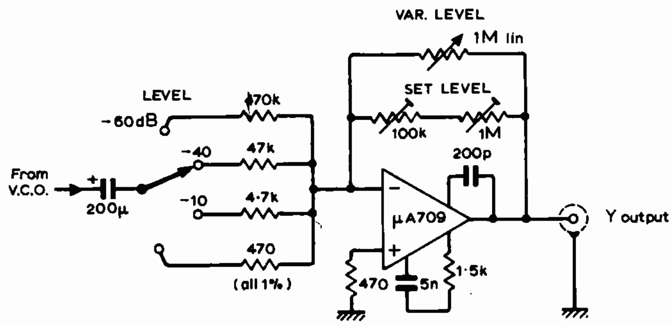
The potentiometer in the emitter of Tr_2 adjusts the overall sweep amplitude on all ranges and the resistor in the collector of Tr_3 allows maximum frequency shifts on all ranges. Used together, they allow compensation of temperature effects on the f.e.ts.

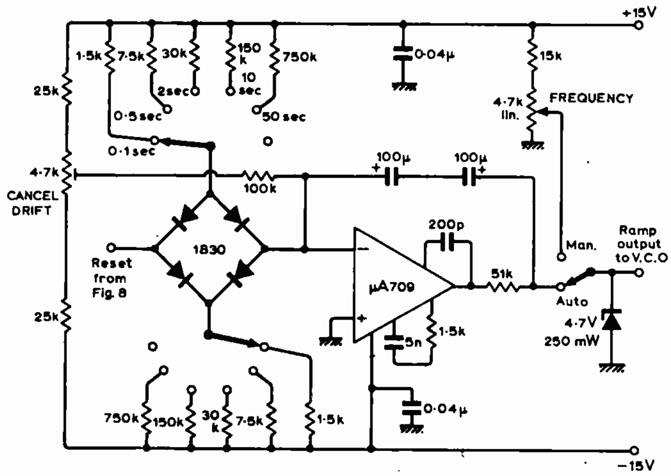
Before attempting to set up the calibrator, make sure each range is allocated the correct calibrator output. To ensure this, measure the d.c. level required to give maximum frequency on each range. Allocate the range with the highest level to calibrator output *a* and so on. On initially setting up, use the temperature compensation pots to ensure that output *d* never goes negative at any point in the cycle and that output *a* minimum frequency can be obtained with the bottom f_{min} potentiometer at maximum output setting.

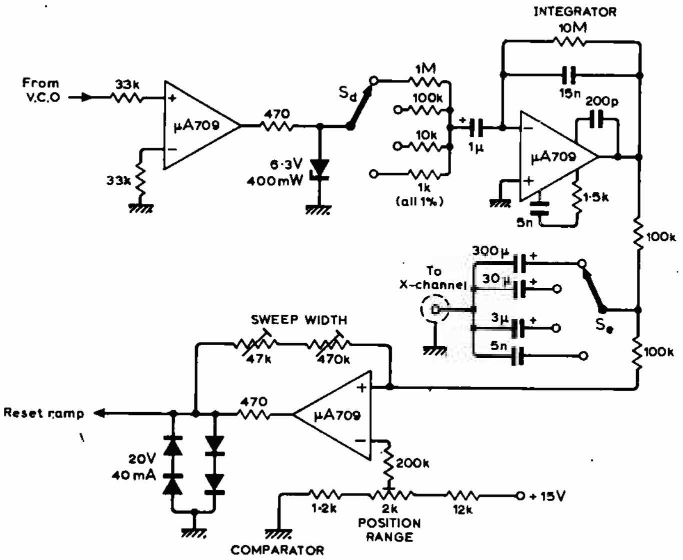
In the voltage-tuned oscillator – Fig. 4 – the switch selects the range calibrator output ($S1_a$, not shown) as well as the tuning and a.g.c. smoothing capacitors for each range. Using the same capacitor

Suggested Improved Version.

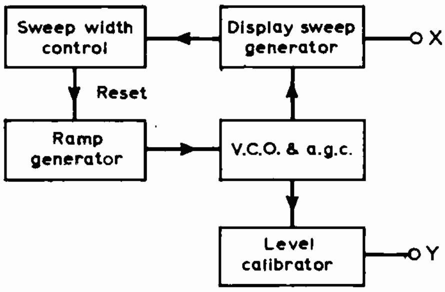








In this suggested improved version a ramp generator (above) feeds a two-stage v.c.o. (top left) giving better sweep linearity. An integrating frequency-to-voltage converter (bottom left) provides the display time-base—also having better linearity. The comparator detects the sweep range limit and reverses the direction of frequency sweep via the reset connection to the v.c.o. Close tolerance components in the integrator allow all four ranges to be set to within ±2% with one setting. Set the calibrated output level amplifier (top right) to give say 5V r.m.s. output on the lowest switch position. The three upper positions will then be accurate to ±1%. Op-amp supply lines (+15V and −15V) should be decoupled with 0.04-μF capacitors.



Although the unit described has proved very useful, its performance can be improved to allow accurate measurement of network response. Disadvantages are the calibration procedure (to compensate for f.e.t. spreads), the display sweep generator is not very linear with frequency, and the output level is not fully adjustable.

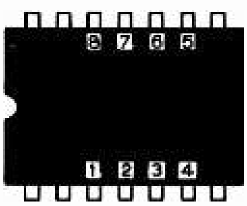
Much setting-up procedure and non-linearity of the first design is eliminated in this proposal (see block diagram). In addition, manual frequency and amplitude control is incorporated. Operational amplifiers have been used throughout to simplify design.

for a.g.c. smoothing on all ranges presents the possibility of squegging should there be the smallest trace of mains pickup in the circuit. The values selected prevent this.

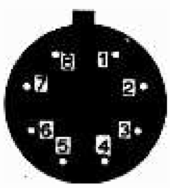
Transistors Tr_7 and Tr_8 provide a non-inverting amplifier, the stage gain of Tr_7 being controlled by the resistance across the drain-source of Tr_6 and hence by the gate-source voltage. Signal input to the tuning network is too small to cause serious frequency modulation at signal frequencies because of the potential divider in Tr_9 emitter. At the same time it gives useful output amplitude (155mV r.m.s. on the prototype) and an adequate signal-to-noise ratio.

Further amplification – about 50 times – and half-wave rectification of the oscillator signal is provided by Tr_{10} and Tr_{11}. The d.c. level at the collector of Tr_{11} is fed back to the Tr_6 gate providing gain

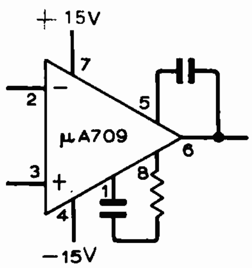
A709 Connections



14-pin dual in line pack



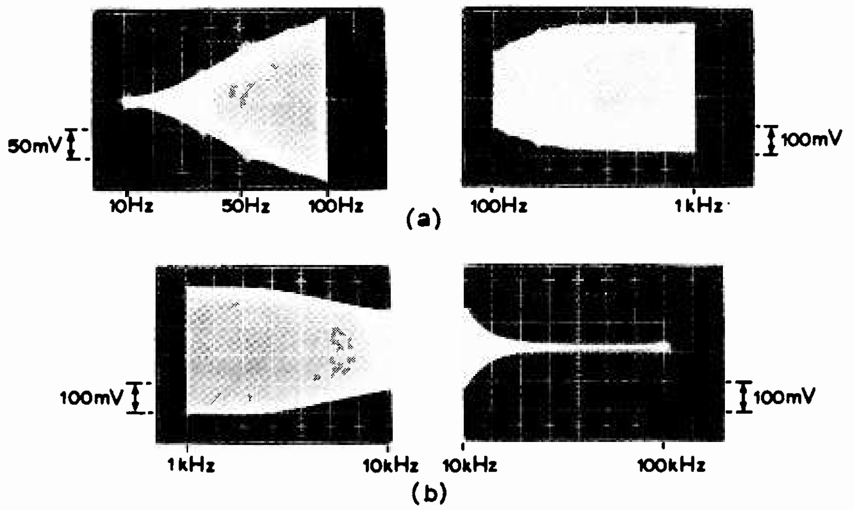
TO-5



Transistors

Bipolar types should have $h_{fe} > 100$ at 1mA. Low-noise transistors are preferred for the oscillator section.

Tr_1, Tr_7, Tr_9 & Tr_{10}	ME4103, BC107, BC109, BC167, BC169, BC184L or 2N3707
Tr_4, Tr_5 & Tr_6	2N3820—see text
Tr_2, Tr_3, Tr_8 & Tr_{11}	ME0413, 2N4058, 2N4062, 2N4126 or 2N4289



Application of sweep generator. Lower traces show envelope response of 2nd-order low-pass filter with 10kHz 'break' frequency Generator set to 4s sweep time. Upper traces show envelope response of 2nd-order high-pass filter with 100Hz 'break' frequency. Generator is uncalibrated and set to 40 sweep time. Spikes at 50Hz are due to hum on the signal.

control for the oscillator. The time-constant formed by the collector load on Tr_{11} is large enough to remove virtually all signal frequencies from the d.c. level.

The f.e.t. is biased very near to pinch-off – the most dynamic region (Fig. 1). The high loop gain around this f.e.t. ensures this condition is maintained without pinching off. The loop gain necessary to obtain these conditions was calculated from an expression derived by Middlebrook[2] which relates the resistance function of the junction f.e.t. to V_{gs}, V_{ds} and V_p

$$R_{ds}=R_0/(1-V_{gs}/V_p-V_{ds}/V_p)$$

The ratio V_{gs}/V_p is 0.98 nominally with V_{ds} assumed zero. Simple circuit analysis dictated a nominal stable loop gain for the oscillator amplifier of 33. This demands R_{ds} to be nominally 20kΩ. By substituting extreme values of R_0 for Tr_6, (200 and 400Ω), the above ratio was obtained to ± 0.01, with a loop gain between oscillator output and f.e.t. gate of 50. The oscillator signal level variation was also calculated for a 3% mismatch between Tr_4 and Tr_5, and found to be very small. In practice, this degree of control is not obtainable due to errors in the a.g.c. voltage produced by the time-lag in the smoothing network. Superior performance could be obtained if the smoothing network is replaced by a linear sample-and-hold circuit of wide range. Such circuits are elaborate and not justified in this low-cost system.

The variable resistor at Tr_8 emitter sets d.c. level in the oscillator and minimizes signal level fluctuations during sweep. It should be set before the range calibrator, because it affects input impedance of Tr_7 which is across Tr_4 and thus marginally varies frequency.

Construction

The prototype was built on three 0.15-in matrix Lektrokit pin boards mounted in a Lektrokit case. If tracked Veroboard is used 15-pF capacitors may be needed across the bases of Tr_7, Tr_8 and Tr_{10} (Fig. 4). Layout of operational amplifiers is critical, particularly in the comparator where there are no compensation networks. Decouple their supplies as close to the supply pins as possible and keep connections minimum in length. Keep input leads away from output leads.

References

1. G. B. Clayton, 'A triangular-square wave generator' *Wireless World,* vol.75 1969, pp.586-7.
2. R. D. Middlebrook, 'A simple derivation of field-effect transistor characteristics' *Proc. I.E.E.E.* vol.51 1963, pp.1146-7.

N.B. U.S. patent 3,432774, filed March 1971 by O. A. Fick, covers the use of f.e.ts in Wien-bridge voltage-tuned oscillators.

Announcements

The **fourth International Broadcasting convention,** now held in London biennially, has been arranged for 4th to 8th September 1972. The convention and association exhibition will again be held at Grosvenor House, Park Lane. Jointly sponsored by five institutions plus the Electronic Engineering Association, the secretariat is provided by the I.E.E., Savoy Place, London WC2R OBL.

Two one-day seminars are to be held on the 21st and 22nd of September by the IPC Business Press quarterly **Computer Aided Design** to study the application of c.a.d. techniques to engineering.

Dolby Laboratories Inc. and the Signetics Corporation jointly disclosed that they are collaborating to develop a monolithic **integrated-circuit version of the Dolby**-B compatible noise reduction system. The i.c. version is expected to be available to Dolby licensees early in 1972.

A compact **radar altimeter** developed by Honeywell Inc. in the U.S.A. for aircraft and missile programmes has been selected by the U.K. for use on The Hawker Siddeley Harrier vertical take-off and landing combat aircraft and the British aircraft Corporation Jaguar fighter for the R.A.F. The altimeter is also to be installed on the Westland Lynx general-purpose helicopter.

A range of Vidicon television camera tubes manufactured by Heimann GmBh, of Weisbaden, is to be marketed by Top Rank Television under the brand name of top rank Heimann.

An agreement to grant sales and manufacturing rights of the Thomson-CSF ground i.l.s. systems type LS371 has been signed between Thomson-CSF of France and the Decca Navigator Company Ltd.

Field Tech Ltd, of Heathrow Airport, London, now have the world-wide marketing rights (except Scandinavia) for the airborne applications of the **aerial matching unit** type 780 produced by Satt Electronic AB, of Stockholm, Sweden.

Rofin Ltd, (technical developments) Laser division, 3 Windhill, Bishop's Stortford, Herts, are introducing to the British market a large range of novel optics, **optical components** and instruments made by the Oriel Optics Corporation in the U.S.A.

Echometrix Ltd, announce that they have been appointed exclusive U.K. agents for Schurig Electronics, of West Germany, who manufacture a wide range of **digital instrumentation.**

Scientific Electro Systems (Essex) Ltd, have been appointed sole U.K. agents for the French **microwave manufacturing company,** M.D.P. Electronics who manufacture some 600 microwave items.

Senistron Semiconductors of America have appointed the D.T.V. Group Ltd, sole U.K. distributors for their complete range of **semiconductor devices.**

Lyons Instrument Ltd of Hoddesdon, Herts, and **Nu-Devices Inc.** of Norwalk, Connecticut, U.S.A., have concluded an agreement whereby Lyons become exclusive U.K. representatives for the Nu-Devices range of electronic instrumentation.

The Post office have awarded a contract to Dynamco, worth more than £100,000, for one hundred and twelve Dynamco 7060 precision **TV waveform and picture monitor** test sets now designated P.O. NO 13B (see R.E.C.M.F. Exhibition report).

Greater London Council Ambulance Service is one of the first to concur with the recommendation put forward by the Department of Health and Social Security to use **f.m. communications.** An order has been placed with Stono Ltd to equip 300 ambulances with mobile radiotelephones.

GEC-AEI Telecommunication Ltd, of Coventry, have obtained orders worth £0.25M from Empresa Nacional de Tele-communicaciones S.A. (ENTEL), the national telephone operating company in Chile, for expanding the 1800 km **microwave radio** system already supplied by GEC.

The Plessey Electronics Group has received an order valued in excess of £600,000 from the Ministry of Aviation Supply for lightweight PTR446 **i.f.f.-transponder equipments.** These are to be installed in helicopters of all three British services.

Varta AG, one of the largest **battery manufacturers** in Europe, with a new marketing subsidiary company in the U.K. (Varta Batteries Ltd) have announced several new batteries for transistor radio and other applications to their range.

R. S. Delgliesh Ltd, Newcastle upon Tyne, have placed an order with **Marconi Marine** for full communications and navigational aid installations for their three new bulk carriers under construction at Cammell Laird & Co., (Shipbuilders and Engineers) Ltd, Birkenhead.

The Danish Posts and Telegraphs Department have ordered six **v.h.f. television transmitters** of a new type worth £200,000 from Marconi to replace equipment installed in 1966.

News of the Month

High-density holographic memory

The Central Research Laboratory of Hitachi Ltd has developed a holographic memory capable of storing 20,000 bits of digital information, equivalent to 2,500 characters, in a space of only 0.5mm in diameter. The memory storage density is 100,000 bits per/mm^2. With this type of memory device, which uses laser beams to record holographic information in a specially treated transparent gelatine film, noise causes trouble as the concentration of the information-bearing laser increases in a particular area. This, in the past, has limited the storage density to around 10,000 bits/mm^2. The problem was solved by developing a special optical plate that can evenly diffuse the information-bearing laser beams. The optical plate is made of multi-layered thin films of cerium oxide evaporated on a glass substrate through several kinds of random patterned screens. Laser beams disperse as they pass through this plate which is called a 'random phase shifter'.

Because reading of the stored information is done easily by directing a laser on the holographic memory, the reading time is only 1 μs.

Possible applications of the memory device include large-capacity, high-speed computers. For instance, a total of 10,000 holographic memories, which can be laid out on a 5 × 5cm plate, have a total storage capacity of 200 million bits, with a read-out time of a few microseconds.

Hybrid to be checked in space

Hybrid microcircuits have been with us for some time but not long enough for much to be known about their reliability—much the same could be said for monolithic integrated circuits. Many military users are still very cautious when it comes to incorporating monoliths in equipment. Take the new military radio equipment 'Clansman' for instance; every i.c. in this is subjected to rigorous electrical and environmental tests; but in addition every chip is visually examined using a high-power microscope to check for manufacturing defects which do not show up on the other tests and may lead to shortened life.

Hybrids, with their components printed on a ceramic substrate. when viewed under a high-power microscope resemble a ploughed field complete with trenches. In an effort to discover how a hybrid microcircuit will withstand an encounter with the severities of space one is to be incorporated in the British satellite Black Arrow X3 which is due for launch late in the summer this year.

The main contractor for the £2.5M satellite is Marconi Space and Defence Systems who are responsible to the Royal Aircraft Establishment for the project. The satellite is now assembled and is undergoing a series of pre-launch checks.

The hybrid microcircuit contains an analogue-to-digital converter and an analogue multiplexer which duplicate items in the satellite's main data coder. Outputs from the main coder, and the hybrid counterpart, will be compared so that the performance and stability of the hybrid can be assessed.

Shown here is RCA's semiconductor factory in Herstal, Liege, Belgium. The $10 million plant is located on a 20-acre site and includes 100,000 square feet of floor space. It will manufacture semiconductor power devices, general purpose silicon power transistors, silicon controlled rectifiers and triacs. It is interesting to note that construction of the factory started in November 1969, production started in October 1970 and the millionth unit was produced in March 1971.

Noise reduction in tape cassettes

A noise suppression system for cassette recorders and players which doesn't rely on specially prepared recordings has been developed by Philips in Eindhoven. Using a 'dynamic noise limiter' circuit effective in the playing mode only it will be included in Philips cassette players to be introduced later this year.

The idea is similar to that used in the Sanyo tape recorder (p. 585/6 December 1970 issue). Frequencies above about 4kHz are attenuated during low-level passages where tape noise would be most noticeable. This is achieved slightly differently in the two systems. In the Sanyo circuit the collector load of a transistor shunts the signal path, the transistor being fed by a d.c. signal derived from the a.c. signal after passing through a high-pass filter. In the Philips circuit progressive attenuation is achieved by cancellation of the signal by a signal from an auxiliary channel. This channel includes the high-pass filter and a level-sensitive attenuator, and the technique may give smoother operation.

It is clear that some signal is lost in these systems but it is argued that when musical instruments are played softly, their harmonic content is much reduced so that with this system some loss at high frequencies can be tolerated. While this may be true with many instruments there are others which retain a substantial amount of h.f. information when played softly—cymbals for instance and possibly stringed instruments—so it will be interesting to hear this in operation. We note that the makers include an on/off switch for these circuits. Philips claim a signal-to-noise ratio improvement of 10dB at 6kHz and 20dB at 10kHz unweighted. They also claim an improvement in transient response because of the circuit introducing a phase retard at high frequencies, compensating for the lead due to the equilization circuits.

Circuit analysis bureaux

If you think that computer-aided design is a highly expensive process only suitable for large companies Time Sharing Ltd would be pleased to prove you wrong. They have available two programmes for circuit analysis that do not involve one in a great deal of expense. You need a computer terminal at your premises—a Teletype 33 costs £33 per month to hire which includes maintenance—and you will have to arrange for the Post Office to fit a suitable modem. Other charges depend on how much you use the service, the type of work you are doing and how much material you want to store away in the computer's memory for future reference. For example a fairly comprehensive analysis of a single transistor amplifier might take about 20 minutes and cost less than £5.

The first programme is called Telinac (Telcomp linear a.c. circuit analysis). To use it one sketches the circuit and assigns each connection point a node number. The computer is given the circuit by typing the component type (*R, C,* etc.), giving its value and the node numbers to which it is connected. Transistors can be specified in terms of h_{FE}, μ, f_T, C_{OB}, etc or by *y*-parameters. Other components that can be added are transformers, inductors (coupled or uncoupled), operational amplifiers and transmission lines. The programme will calculate the gain and phase shift of the circuit at different frequencies, the voltage at any node and will printout the circuit admittance matrix and the *y*-parameters of the network or a graph of gain against frequency. All these facilities are options and the user can manipulate the computer to his own ends within certain limits.

The second programme is called FNAP (Fortran linear a.c. analysis). It complements the first programme and will handle larger circuits (up to 30 nodes and 100 branches at 100 frequencies). Operation is similar to Telinac, it is faster, and will perform a Monte Carlo analysis for simulation of production runs with user's choice of spread distributions.

Free adhesive know-how

Designers and constructors in many industries have increasing need for knowledge of the various types of adhesive, and for advice on the properties, advantages and disadvantages of adhesives in particular roles. With long experience in the physical chemistry of surfaces, Sira Institute has for years offered adhesives consultancy both to its members and to a growing number of non-member clients. From now on Siraid-Commercial (who have been giving free instrumentation advice for some time) will answer where-to-buy-what-adhesive enquiries free (there are more than 600 brands from which to choose!). If a problem demands special expertise or research the enquirer will be referred to Sira Institute's consultants, whose fees will be agreed with the client in advance. If you are in industry and would like to take advantage of this service ring 01-467 2636, or write to Siraid-Commercial, Sira Institute, South Hill, Chislehurst, Kent, BR7 5EH.

Britain at Telecom '71

Sixteen British companies will share the 750 square metre stand making up the U.K. joint venture at Telecom '71 in Geneva sponsored by the Electronic Engineering Association in conjunction with the Department of Trade and Industry. The event runs from June 17th to 27th coincident with the World Administrative Radio Conference for Space Telecommunications on which we hope to report in a future issue.

The companies taking space on the U.K. stand are: British Oxygen; Cable and Wireless; EMI Electronics; Ferranti; Granger Associates; Hewlett Packard; International Aeradio; Marconi Co.; Marconi Instruments; Microwave Associates; Plessey; Post Office Telecommunications; Science Research Council; Solartron; Sperry Rand; and the Gardos Corporation.

Microcircuit symposium

A successful second symposium on 'Microcircuits and their Applications' was held recently at the Polytechnic of North London and organized by the Department of Electronic and Communications Engineering. Two hundred and sixty delegates heard a total of twenty-one papers covering a wide range of recent developments in the field of monolithic and hybrid integrated circuits.

The symposium began with papers on the technology of integrated circuits. One paper covered the isoplanar process which, as far as complex bipolar i.cs are concerned, should produce a considerable reduction in the area taken up by the isolation regions. The paper also covered the m.o.s. silicon gate process.

The principles embodied in a paper on the fundamentals and applications of m.o.s. logic were illustrated in one which followed on desk calculators. It was shown how a desk calculator could be constructed from only four basic standard i.cs; this is being developed further and will result in a single i.c. desk calculator which will be available in the near future.

A paper on thin-film active filters described how hybrid techniques were being employed successfully in their construction. This was followed by the final paper on the application of i.cs in the automotive industry which stressed the importance of overcoming pollution and of improving safety and performance.

Babbage memorial meeting

The British Computer Society and the Royal Statistical Society are to jointly sponsor a meeting to commemorate the centenary of the death of Charles Babbage—considered to be the pioneer of the computer. The meeting will take place on 18th October, in the main lecture theatre of the I.E.E., Savoy Place, Victoria Embankment, London W.C.2.

Charles Babbage was born at Totnes in Devon during 1791. There is very little doubt that his Analytical Engine formed the theoretical basis of today's electronic digital processor. Babbage also played a leading part in the establishment of statistics in this country.

O.S.I.?

We now have another set of initials to learn which—for some reason best known to themselves—Plessey have coined. They use the initials o.s.i. (optimum scale integration) to describe two new integrated circuits which together form the complete colour processing circuitry for a television receiver (chroma amp., gated burst amp. with 45° switch, reference amp., PAL switch, colour killer, stabilization circuitry, colour demodulator and matrices). The circuits are the result of cooperation between Plessey and Rank Bush Murphy and are in production at Plessey's Swindon plant.

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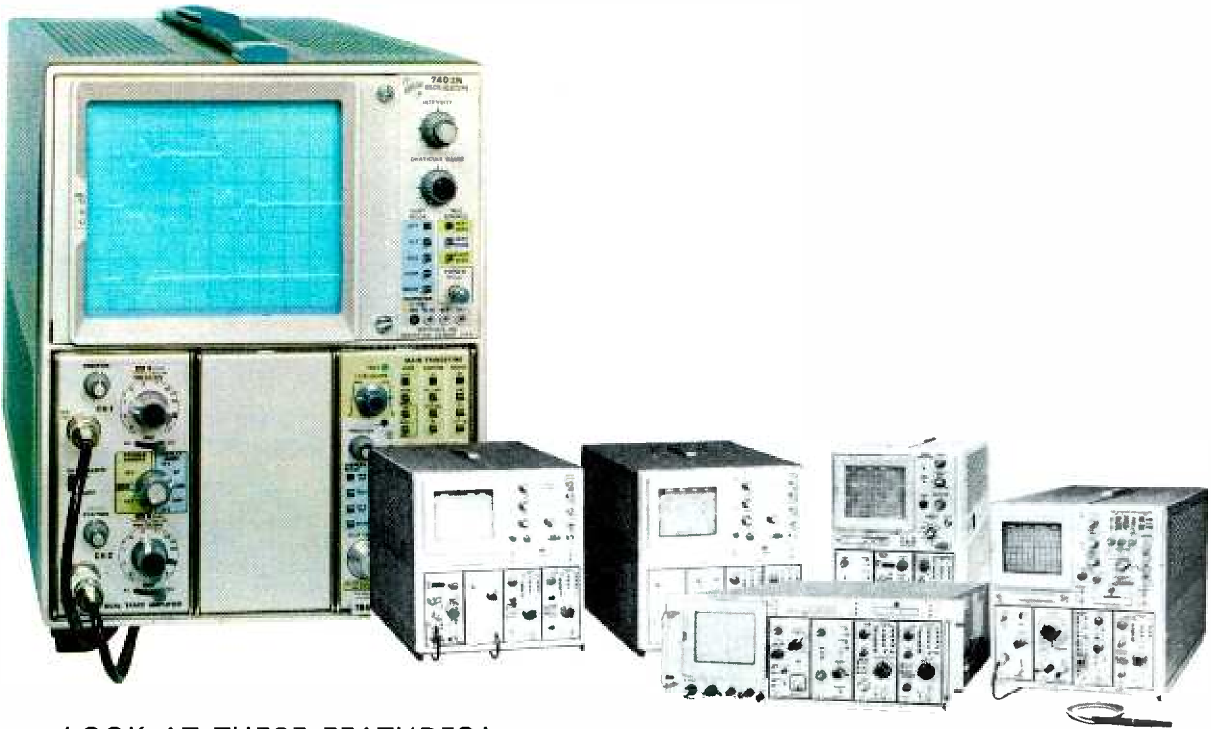

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TEKTRONIX

Circuit Ideas

Low cross-over distortion class B amplifier

A difficulty with class B amplifiers is that although it is possible to set the quiescent current at the time of manufacture to a pre-determined value which gives low distortion this current is liable to change greatly with ageing, temperature, and changes in power supply voltage.

The circuit shown reduces these effects by using a comparator (A_2) to detect when the current through R_1 (shown as 3.9kΩ) drops below the value of $I_{min} = (18-12)/R_1$ amps, and then integrating its output by means of A_3 and its associated R and C. The slowly changing voltage produced is applied to the resistor chain of 820Ω, 820Ω and 470Ω, its effect being to increase the voltage across the 470Ω resistor so that the quiescent current through the output transistor never falls below the value of I_{min}. The junction of the two 820Ω resistors is bootstrapped by the 250µF capacitor so that both sides of the complementary 'White emitter follower' output pair are driven with nearly the same signal voltage. During the part of the cycle when Tr_1, Tr_2 are conducting, D_1 conducts providing a low impedance path to the +12V rail without which only a very small current could be provided via the 18V rail and the 3.9kΩ resistor.

Overall feedback is provided to the input of A_1 by means of the 10kΩ and 100kΩ resistors. An interesting feature of the circuit is that because of the on-off nature of the error detector the minimum current rises and falls again to its minimum value at about 5Hz. However, because this occurs within the loop at a frequency at which the open loop gain of A_1 is greater than 15,000, it is quite unmeasurable at the output.

A secondary +18V supply is required. This is obtained from the main + and − 12 volt supplies. A_4 is part of a square-wave generator the output of which is d.c. restored by D_2, rectified by D_3 and zener stabilized by D_4 to produce 18V. This voltage is applied to A_2 enabling it to operate with about 12V at its input terminal. It is also used to establish the minimum current through R_1.

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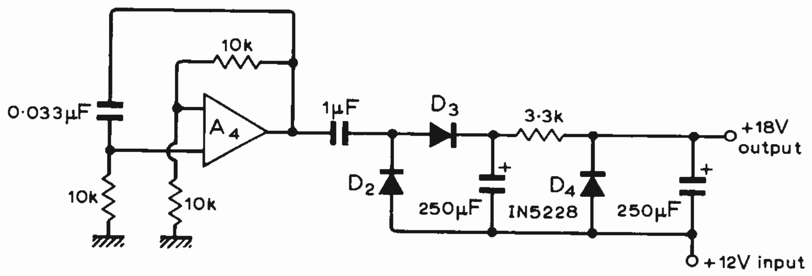
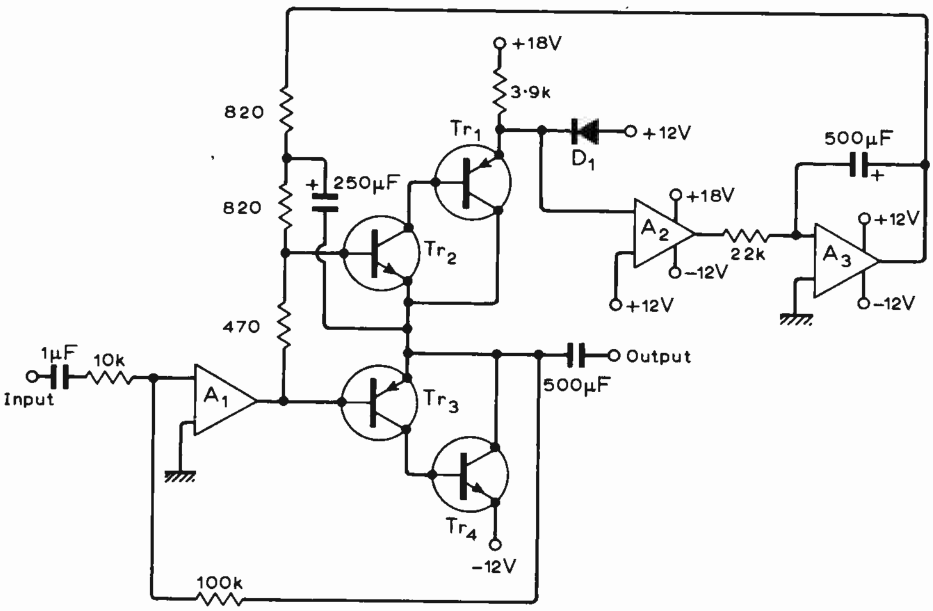
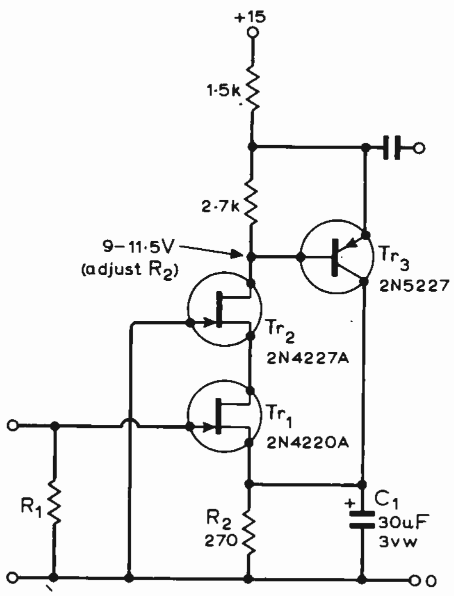




Low-noise f.e.t. amplifier

The circuit presented is that of a low-noise amplifier suitable for use with signals from high source impedances.

For low input capacitance a cascode configuration of f.e.ts is employed. The use of a second f.e.t. in the upper position, instead of a bipolar transistor, results in a lower noise figure* for the amplifier. Maximum voltage gain (about 85) is obtained by bootstrapping the cascode load resistor with Tr_3, which also provides, through its collector circuit, negative d.c. feedback to establish the operating point of the circuit.



Performance:
Voltage gain, a.c. 85 with C_1
5 without C_1
Input capacitance 6pF with C_1, dependent on Tr_1 used
Input resistance up to 1000MΩ dependent on gate leakage of Tr_1
Total distortion at 1kHz, with C_1 in circuit, 1.1% (V_{out}=3V p-p)

The distortion figures remained the same for V_{dss} of Tr_2 varying between 1.6 and 3.4V. This voltage is dependent on the I_{dss} of Tr_2, which must be greater than the I_{dss} of Tr_1 for correct biasing conditions.

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University of Canterbury,
New Zealand.

* S. Cantarano, and G. V. Pallottino, 'A low noise f.e.t. amplifier for a spaceborne magnetometer'. *Electronic Engineering*, Sept. 1970 page 57.

Elements of Linear Microcircuits

9. Voltage regulators

by T. D. Towers, M.B.E.*

The d.c. voltage regulator is a very common circuit in electronics as practically all equipment requires a power supply which in many cases must be stabilized. This means that a power supply's voltage must not vary with changes in mains voltage, load current or ambient temperature. Complete voltage regulator circuits are easily made in both monolithic and hybrid microcircuits.

Op-amps for voltage regulation

Although a variety of ready-made voltage regulator microcircuits are available, general purpose op-amps are now so common that many designers 'roll their own' regulators using a standard μA709, μA741, LM101 or a similar device. Fig. 1 is a typical example which will supply 12V at 100mA. The μA741 serves as a d.c. error signal amplifier. Its output current supplies the base of the series pass transistor Tr_1. The non-inverting input is held at the constant 6.2V by the zener diode. The inverting input receives an error signal proportional to the stabilized output voltage (about half) from the potential divider R_3, R_4, R_5. Fine adjustment for exactly 12V is by R_4.

Simple regulator microcircuits

Monolithic voltage regulators fall into two classes: simple medium-performance multi-option building blocks and complex high-performance complete regulators.

As a typical example of a simple regulator, Fig. 2(a) shows the circuit of the Westinghouse WM330. The compound-connected Darlington pair, Tr_1, Tr_2 has a current gain of over 10,000 and functions as the series control element. Tr_3 is the feedback amplifying transistor, while the zener diode, provides a 6.2V reference. The temperature coefficients of the V_{BE} of Tr_3 and of the zener voltage diode are equal and opposite, resulting in good temperature stability. The whole circuit is contained in a 3.5 × 3mm silicon chip mounted in an 8-pin TO-3 package, and is capable of handling an output current up to 1A when bolted to a heat sink. Fig. 2(b) shows the simplest way of using the WM330.

Where high output current handling is not needed, you can use one of the simple regulator microcircuits available in small-signal transistor packages. Typical of these is the G.E. (U.S.A.) D13V utility voltage regulator. See Fig. 2(c) for the circuit. This is basically a shunt regulator in which terminal three is held at a voltage above terminal one equal to the sum of V_{BE_1}, V_D, V_{BE_2}. On its own, it can be connected as a shunt regulator as in Fig. 2(d), where:

$$V_{out} = V_3 \times (R_1 + R_2)/R_2$$

The regulator adjusts the current drawn through R_3 to hold V_{out} constant. As a shunt regulator the D13V can handle up to 40mA shunt current and give a regulated output voltage up to 40V, provided the maximum permissible device dissipation of 400mW is not exceeded. For higher currents or lower standing drain from the input power supply, it can also be connected as a series regulator as in Fig. 2 (e). In this arrangement, it can control a base current of up to 40mA in the series-pass transistor Tr_3, which gives possibilities of using a power transistor for outputs up to 1A.

High-performance voltage regulators

Manufacturers have developed a wide range of more complex microcircuits using the advantages of the monolithic technology to the full and covering output voltages from 1 to 100V. Mostly these are in multi-lead TO-5, dual-in-line or flat-pack form, and usually capable of dissipating not more than about 500mW. However, higher power versions in multi-lead TO-8 and TO-3 or heat-sinked dual-in-line are becoming available.

As yet there is little standardization, although 'second sourcing' makes it possible to obtain some types from more than one manufacturer. Two regulator microcircuits have become almost industry standards in this way: the Fairchild μA 723 and the National Semiconductor LM100.

Into a silicon chip (1.3 × 1.5 × 0.18mm) the μA723 crams a power series-pass transistor, reference amplifier, error amplifier and current limiting circuitry using planar epitaxial processes.

Fig. 3 shows the internal circuitry of the 723. In this, Tr_{15}, Tr_{16} is a compound Darlington series pass element. The circuits around D_2 comprise the fixed voltage reference source. The long-tail pair Tr_{10}, Tr_{13} is a feedback amplifier with Tr_{12} as its constant current load resistor. The components Tr_1, Tr_2, R_1, R_2 and D_1 form the base biasing network for all the constant current transistors Tr_3, Tr_7 and Tr_{12}. Together Tr_3, Tr_4, Tr_5, Tr_6 provide a constant current feed for the zener D_2, with negative feedback ensuring a low output resistance for the voltage reference source. Tr_7, Tr_8, Tr_9 provide a suitable drive for the long-tail pair constant current transistor Tr_{11}.

Thus far, the 723 can be seen to be merely a refined version of the basic regulator type of Fig. 2(a). Extra features of the 723 are Tr_{14} with isolated leads offering optional uses as a feedback current limiter or as a pre-regulator. Also, both inputs to the feedback amplifier are isolated to allow additional flexibility, and the collector of the series pass transistor Tr_{16} is separated from the internal circuitry.

For full details of the performance of the μA723 you must consult the detailed data and applications sheets, but some indication of its capabilities can be seen from the following figures. It can be used with input voltages from 9.5 to 40V and output voltages from 2.0 to 37V. It can provide output currents up to 150mA, so long as the power dissipation rating of

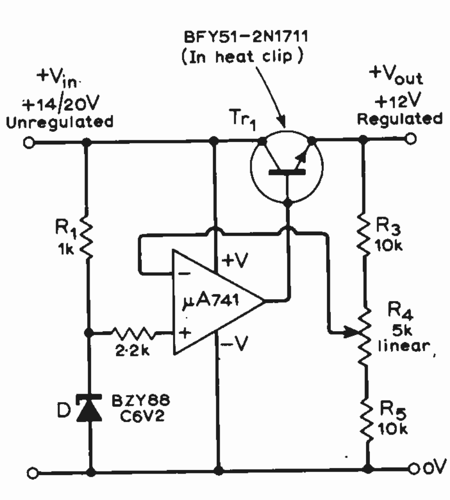

Fig. 1. Using a standard monolithic op-amp (μA741) to make up a 12V, 100mA stabilized d.c. supply.

* Newmarket Transistors Ltd.

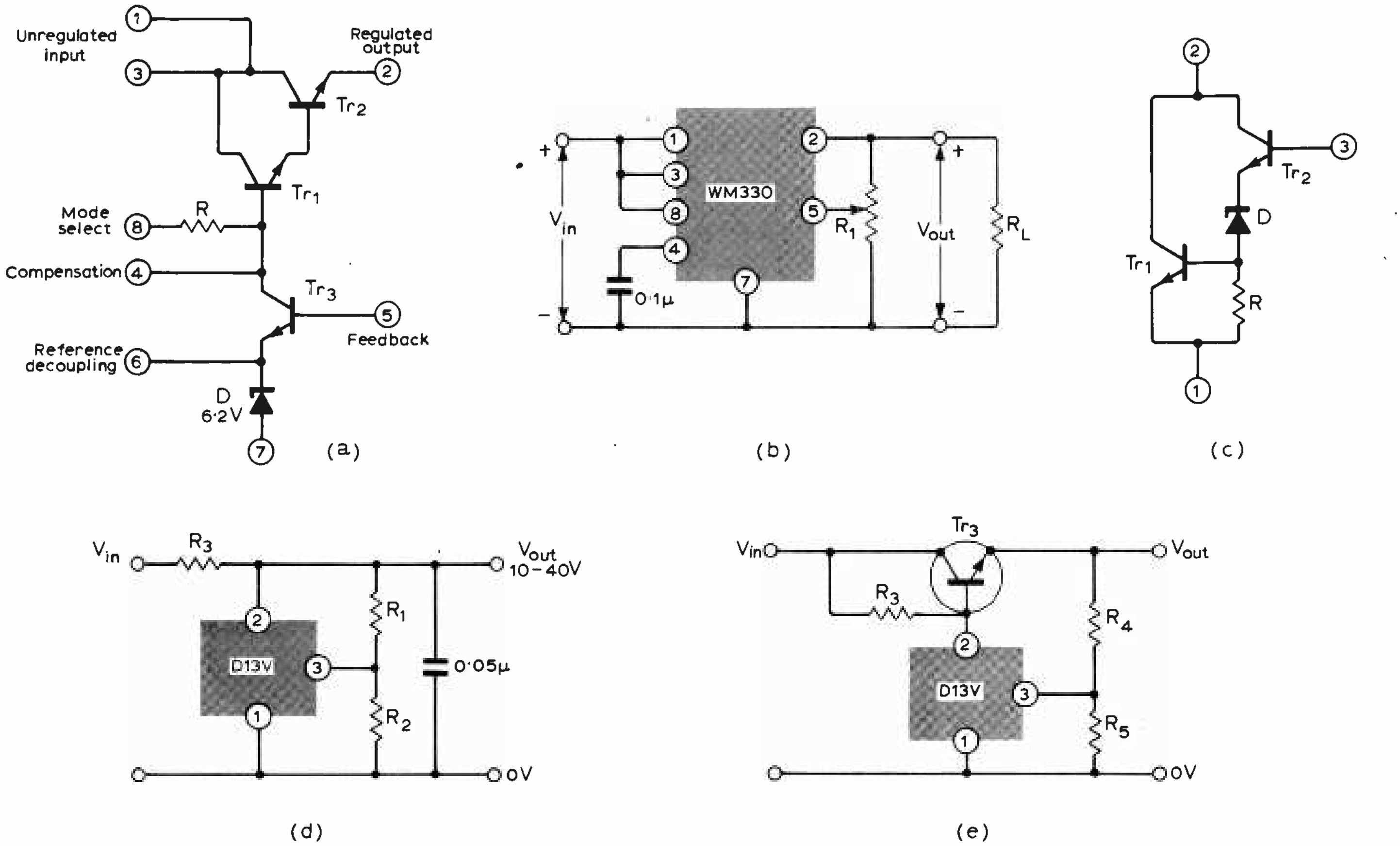

Fig. 2. Simple voltage regulator microcircuits. (a) Westinghouse WM330; (b) connection of WM330 in practical circuit; (c) G.E. (U.S.A.) D13V utility voltage regulator; (d) the D13V as a shunt regulator; (e) the D13V as a series regulator.

800mW is not exceeded. For a nominal 12V input, and 5V regulated output at a nominal load current of 5mA, V_{out} varies less than 5mV for a change of V_{in} from 12 to 15V, and less than 25mV for a V_{in} change from 12 to 40V. With V_{in} fixed at 12V for 5V output, a load current variation from 1 to 50mA will give less than 10mV variation in V_{out}. Ripple rejection is typically 80dB, i.e. 1V ripple on the input gives only 0.1mV ripple at the output. Output voltage varies with temperature less than 0.015% per C, i.e. on a 5V output less than 750 μV for 1°C change. The standby current drain of the 723 is less than 4mA, and with an external 10Ω short-circuit current limiting resistor in the output line, the output current will self limit at about 65mA.

The μA723 is supplied by many manufacturers. In the U.K. apart from Fairchild's own version, the device appears under other

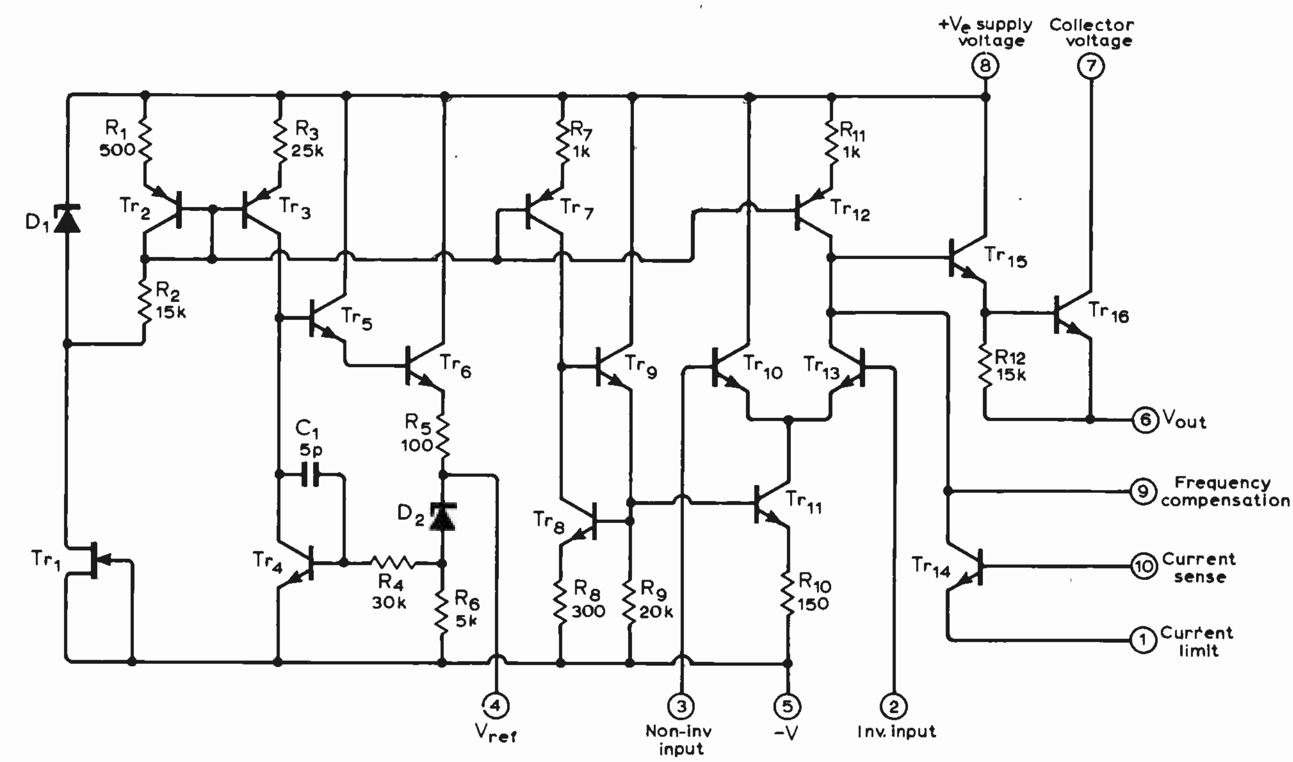

Fig. 3. Internal circuitry of industry-standard Fairchild Semiconductors μA723 voltage regulator microcircuit.

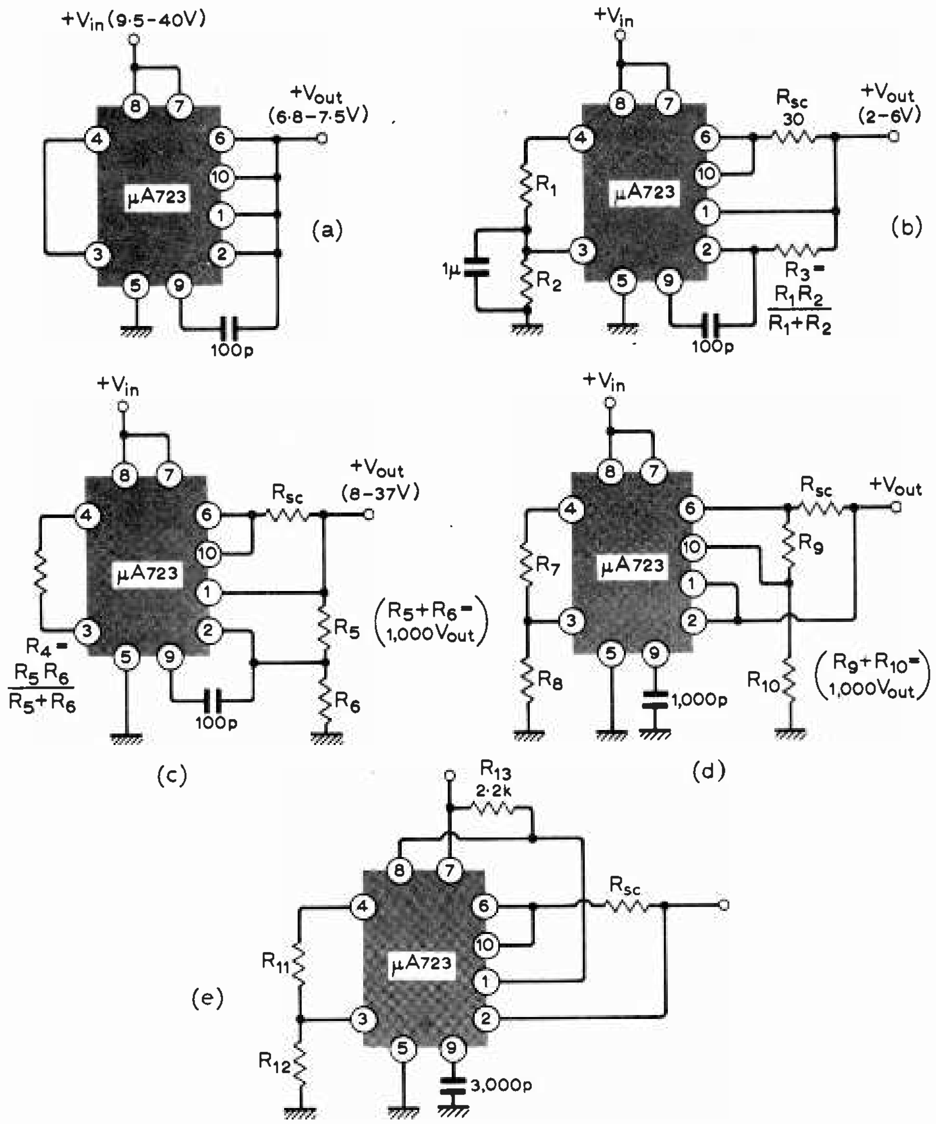

Fig. 4. Versatility of commercial voltage regulator microcircuits illustrated in typical circuit connection options for standard μA723. (a) Nominal 7.15V output with only one external capacitor; (b) low voltage (+2 to +6V) output; (c) high voltage (+8 to +37V) output; (d) foldback current limiting arrangement; (e) pre-regulated low voltage output.

manufacturers' numbers such as Mullard's TBA281, S.G.S's L123 and I.T.T's MIC723.

Applications of the μA723

To illustrate the versatility of the 723, Fig. 4 gives a number of circuit arrangements using only the 723 and passive components. Monolithic i.cs such as the 723 can provide in themselves only limited voltage (up to about 40V) or current (up to about 150mA). However, external transistors can be used to extend their capabilities in this respect. For example adding an outboard 2N3055 power transistor to the basic 723 as in Fig. 5(a) raises its output current capability to over 1A,

To achieve a regulated output voltage above the limit of the 37V implicit in the 723 specification, the substrate of the microcircuit can be elevated above ground potential by tying its negative supply terminal to a regulated voltage high enough above ground to bring the output to the required voltage. Fig. 5(b) shows how a 100V, 50mA output is obtained in this way.

Terminals three and two, the two inputs to the feedback amplifier bases, are virtually at the same potential. Thus the voltages across R_5 and R_3 are equal. Now R_3 and R_4 are equal and in series across the internal 7.15 reference voltage of the 723, so that the voltage drop across R_5 (equal to that across R_3) is 3.57V. Thus the voltage drop across R_6 is $(R_6/R_5) \times 3.57V = 102 \times 3.57/3.57 = 102V$. This sets the output line 100V above ground.

The LM100

The other workhorse voltage regulator, the LM100, uses the circuit of Fig. 6. This device contains, on a single silicon chip, the voltage reference, the feedback operational amplifier and the controlled series pass transistor to make up a voltage regulator. The voltage reference part of the circuit starts with a zener diode D_1 that is supplied by a current source (one of the collectors of the multi-collector transistor Tr_2) from the unregulated input. The output of D_1, which has a positive temperature coefficient of 2.4 mV/°C, is buffered by an emitter follower, Tr_4, which increases the temperature coefficient to +4.7mV/°C. This is further increased to +7mV/°C by the diode-connected transistor, Tr_6. A resistor divider, R_1, R_2 reduces this voltage to exactly compensate for the negative temperature coefficient of Tr_7, producing a fully temperature-compensated output of 1.8V at the base of Tr_8.

The transistor pair Tr_8, Tr_9 form the input stage of the operational amplifier. The gain of this stage is made high by the use of a current source (one of the collectors of Tr_2) as a collector load for Tr_9. The output of this stage drives a compound emitter follower Tr_{11}, Tr_{12}, to supply a regulated output voltage at terminal one. An additional transistor, Tr_{10} is used to permit limitation of the output current of Tr_{12}. This current limit is determined by an external resistor connected between terminals one and eight, with a value between 10 Ω for 30mA current limit to 30 Ω for 10mA. As for the rest of the circuit, Tr_1, Tr_3, Tr_5 are part of a bias stabilization circuit for Tr_2 to set its collector currents at the desired values. Resistors R_9, R_4 and zener diode D_2 serve the sole function of starting the regulator. Finally D_3 is a clamp diode which keeps Tr_9 from saturating on feedback overload.

The LM100 can be obtained in an 8-lead TO-5, dual-in-line or flat-pack form. The terminal numbers in Fig. 6 refer to the TO-5 version. The basic LM100 is specified for a −55 to +125°C temperature range. The same device also appears as the LM200 for −25 to +85°C, and LM300 for 0 to +70°C. The LM100 is available from a number of manufacturers, usually under a related number as LA100 (Nucleonic Products), or SG100 (Silicon General). Also, we find alternative types, such as the RCA CA3055, with different internal circuitry but which are completely interchangeable with LM100 having the same pin connections and performance.

Performance-wise the LM100 is not dissimilar to the μA723. Its input voltage range is 8.5 to 40, and output 2.0 to 30V. Its load regulation is better than 0.5% for a current output from 1 to 10mA. Its line regulation is less than 0.2%/V, and its standby current on no load less than 3mA.

Applications of the LM100

Circuit applications of the LM100 follow very much the pattern of the 723 as indicated in Figs. 4 and 5 above, and will not be detailed here. However, an illustration of how the LM100 can be used in conjunction with general purpose op-amps to produce a practical regulated double-rail bench supply for working with op-amps is given in Fig. 7.

Fig. 7(a) is the mains step-down, rectifying and smoothing unit to give positive and negative 24V unregulated d.c. rails, A and B, with a ground rail G.

Fig. 7(b) shows the section to produce stabilized positive and negative 20V rails, C and D. The LM100 is connected to give the positive rail C directly. An op-amp, A_1, with its non-inverting input connected to the ground rail through a 10kΩ resistor has its input virtual earth at ground potential. The 20kΩ input resistor from the +20V rail to the inverting input and the

20kΩ resistor from the inverting input to the output establish the output at −20V, to provide the negative regulated rail, D.

The third section of the system shown in Fig. 7(c) is designed to provide a further two stabilized positive and negative rails, switchable through the range ±20, 15, 10 and 5V. The regulated +20V applied at the input to the ladder network of resistors, sets up selectable reference voltages of 2.5, 5.0, 7.5 and 10.0V which can be applied to the non-inverting input of the op-amp, A_2. The 20kΩ resistors from the inverting input to ground and to the output set up the output voltage of A_2 at (20+20)/20=2 times the input voltage on the non-inverting input. This gives a positive output rail E whose voltage can be set at 5, 10, 15 or 20V. The op-amp A_3 is used to produce an inverted output equal and opposite in sign to E. Thus F gives an output of −2.5, 5, 10, 20V corresponding to the voltages on E.

Although the op-amps shown in the design are LM101, they could equally well be any standard device such as the μA709 or μA741.

Special-purpose voltage regulators

So far we have discussed only general-purpose voltage regulators which can be adapted to many different voltage requirements. There is growing up, however, a range of devices specially fabricated for a single use.

An example of these is the Philips TAA550, an integrated monolithic two-terminal voltage stabilizer in a two-lead TO-18 can which is specially designed to provide the supply voltage for variable capacitance diodes in television tuners independent of supply voltage and temperature variations. With a nominal stabilized voltage of 33V, all these require are a series resistance to the unregulated power supply and a shunt capacitor. They take typically 5mA of current.

Another useful example of special-purpose regulators is the LM309, which is a complete 5V regulator on a single silicon chip. Designed for local regulation on digital logic cards, the 309 neatly eliminates distribution problems caused by single central-point regulation in the system. No external components or adjustments are required. In a TO-5 package, it handles currents up to 200mA, and in a TO-3 over 1A.

Hybrid voltage regulators

We nowadays have a rather impressive range of monolithic voltage regulators readily commercially available, and yet hybrid microcircuit manufacturers continue to introduce new regulators. Why is this? Well, you can build higher power hybrid regulators than you can monolithic. But the main advantage of hybrid assembly is that hybrid techniques permit you to 'trim on test' during manufacture, and adjust the output voltage much more exactly than can be achieved in monolithics. Also any high-frequency compensating capacitors can be included in the package to give you a truly self-contained

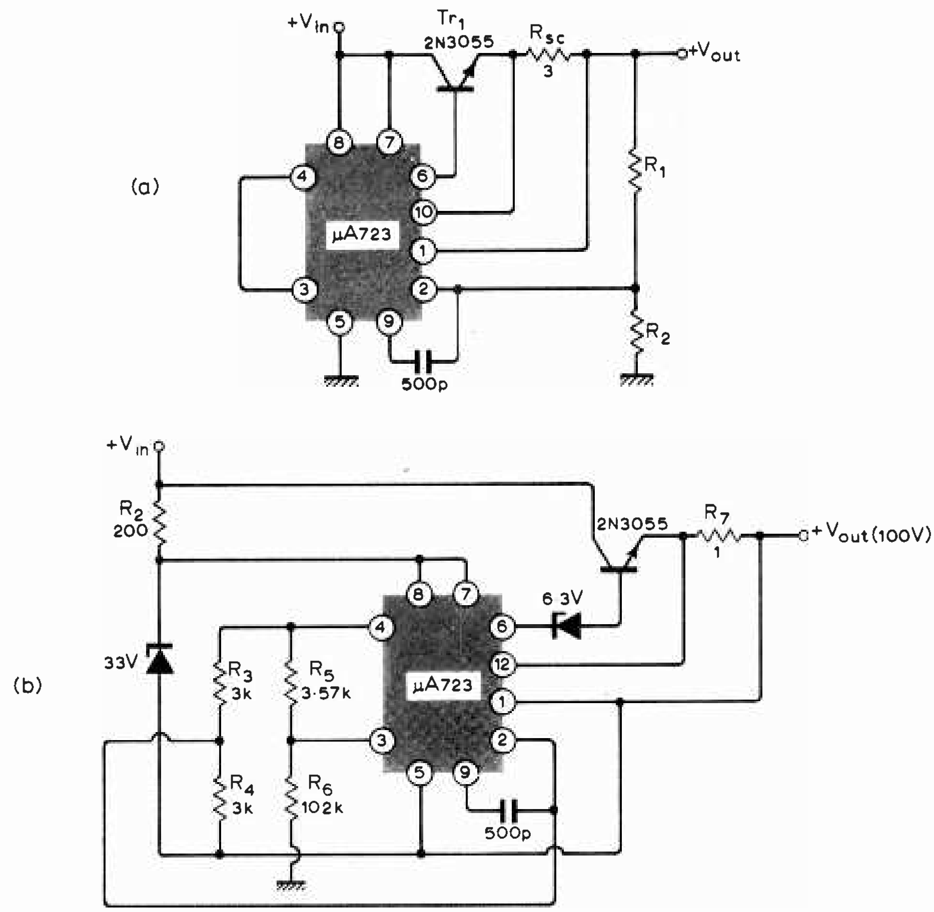

Fig. 5. Typical uses of external transistors to extend output capabilities of standard voltage regulator microcircuit (μA723). (a) high-current series-pass external transistor; (b) 'floating' high voltage (100V, 50A) output.

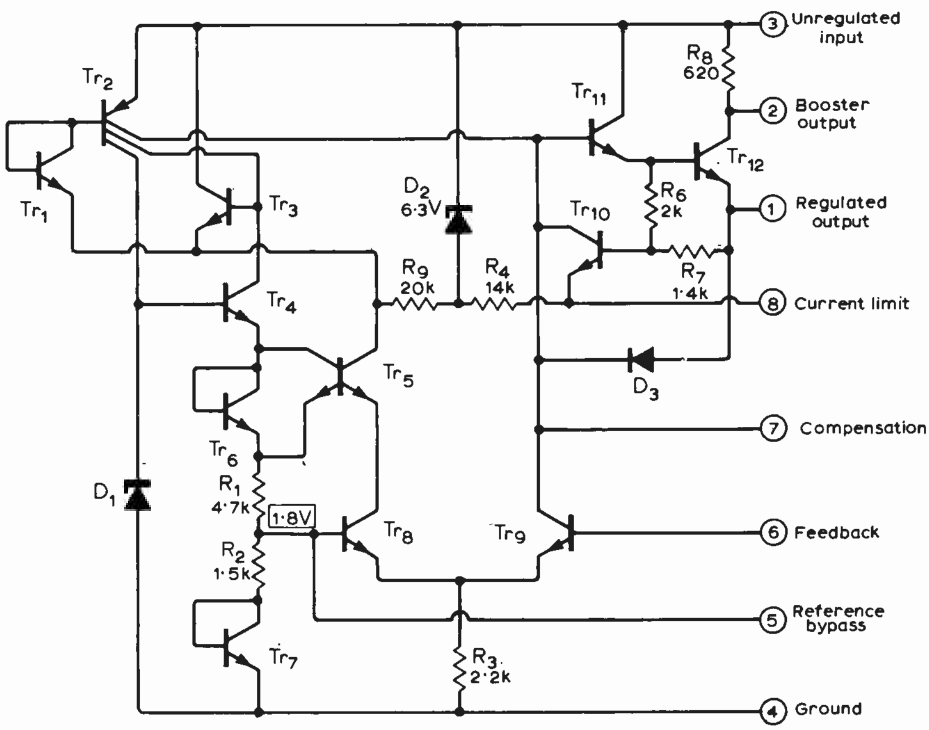

Fig. 6. Internal circuitry of industry-standard National Semiconductors LM100 voltage regulator microcircuit.

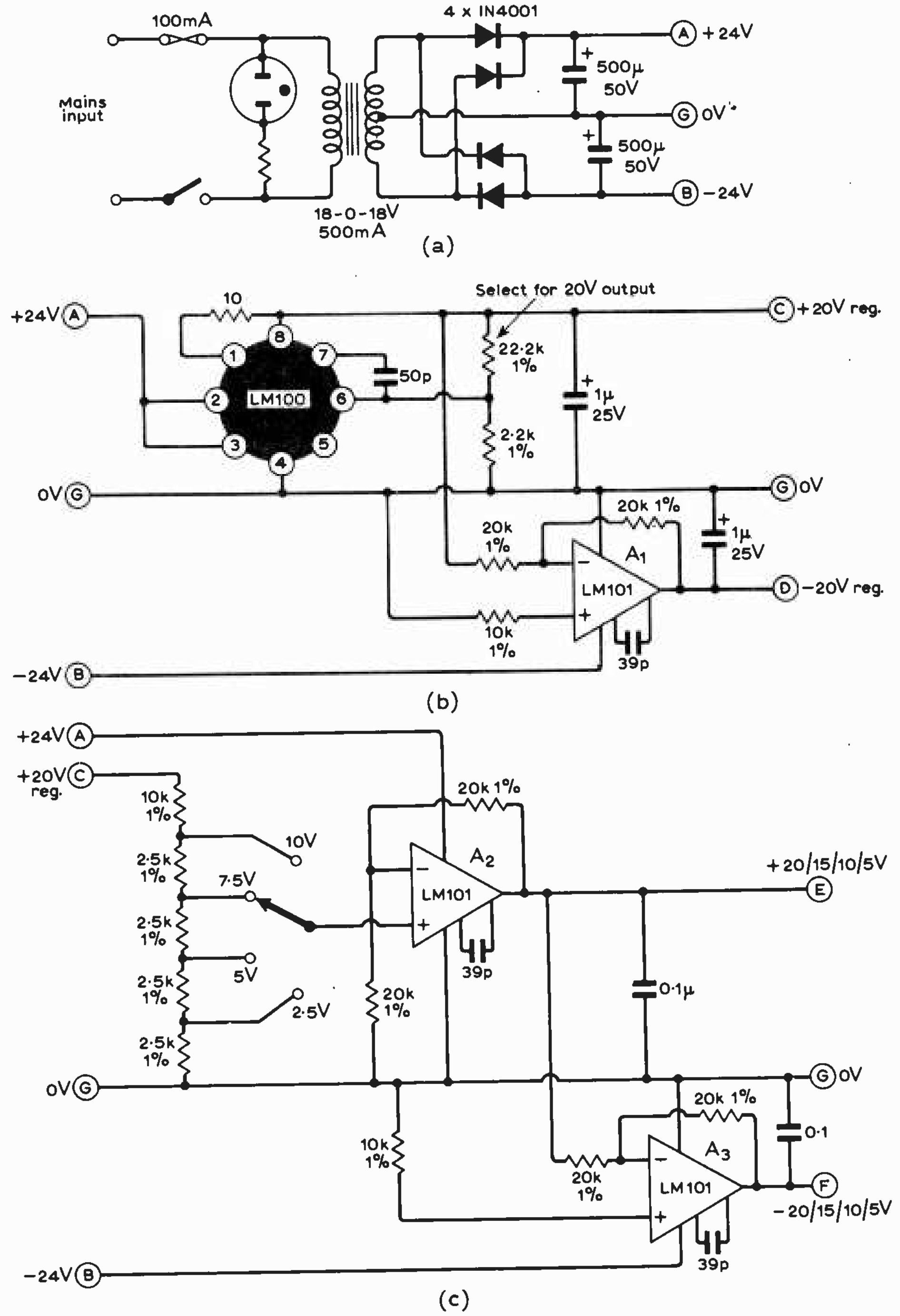

Fig. 7. Application of LM100 in regulated double (±) rail bench power supply for use with linear microcircuits: (a) rectifying-smoothing giving ±24V unregulated; (b) fixed ±20V regulated section; (c) switchable ±5, 10, 15, 20V section.

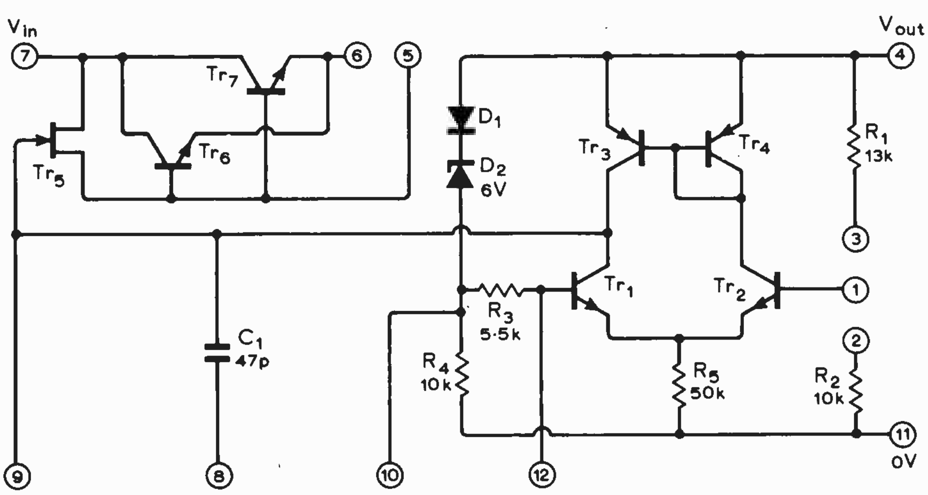

Fig. 8. Circuit of hybrid voltage regulator, General Instruments NC562.

circuit requiring no additional external components.

Fig. 8 is the circuit of the General Instruments NC562 hybrid regulator. Typical of hybrid voltage regulators, this circuit is thermally and electrically more efficient than an equivalent monolithic version because of the use of parallel pass transistors Tr_6, Tr_7 with low saturation resistance. The control amplifier uses high-gain n-p-n and p-n-p transistors, Tr_1-Tr_2 and Tr_3-Tr_4, to ensure high open-loop gain and minimum standby current. A junction f.e.t., Tr_5, forms a constant current source to drive Tr_6 and Tr_7 bases under feedback control by transistor Tr_1. The zener reference element D_2 is compensated by D_1 to provide excellent temperature characteristics for the regulator, and the unit is encapsulated in a high-dissipation 12-lead TO-8 package.

If terminals one, two and three are connected together, and terminal eight is connected to twelve, and six to four, and if a supply of more than 13V is connected to terminal seven then the output from terminal four is a precise stabilized 12V at up to 800mA with 0.1Ω output resistance.

By connecting a variable potentiometer across one-two-three, the output can be adjusted between 10 and 20V. A current limiting circuit can be connected at terminals four, five and six and a decoupling capacitor for the reference element at terminal ten.

State of the art

Except for the general adoption of the μA723 and the LM100, there is no effective standardization of voltage regulator microcircuits. Hitherto most of the regulator microcircuits available have been single-rail only, but a fairly recent development has been the appearance of double-rail types such as the Motorola Semiconductor's ±15V MC1567.

Finally, a likely development is that hybrid manufacturers will take basic chips like the LM100 and incorporate them with all the necessary extra components to produce self-contained three-terminal packages, that only have to be inserted between the unregulated supply and the regulated output lines with a common earth line.

The remaining three instalments in this series of articles on microcircuits will cover:

10—A.M. receivers
11—F.M. receivers
12—Television receivers

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WW—069 FOR FURTHER DETAILS

New Products seen at the London Components Show

In addition to details of a selection of the new products introduced on the 360 stands at the Electronic Components Show (Olympia May, 18-21) we have included a few items seen at the shows put on by some companies at nearby hotels. Further information on any product can be obtained by professional readers by inserting on the reader reply card the appropriate reference number.

Television waveform monitor

Dynamco displayed a precision television video waveform monitor (type 7060) which is particularly useful for checking the quality of video signals after they have been relayed by landline–in fact the Post Office is to use the instrument for just this purpose. Any degradation of the quality of the signal, due perhaps to a landline defect, can be quickly seen and measured. Of course the instrument is also valuable for monitoring the picture quality of outside broadcasting units and for c.c.tv applications.

The 7060 consists of a standard oscilloscope with a good deal of extra electronics added. The display is presented on a 127mm (5in) retangular c.r.t. Basically there are the following four modes of operation:

1. Normal: In this mode the instrument functions as a conventional oscilloscope with a frequency response from d.c. to 5MHz within 0.1dB, to 10MHz within 0.2dB and to 20MHz within 3dB. The input attenuator varies the deflection sensitivity from 50mV/division to 0.4V/division in 6dB steps. Two input sockets present impedances of 1MΩ and 45pF or 75Ω. One of the plug-in timebase units provides sweeps from 0.1μ s/division to 2s/division in 22 (1-2-5) calibrated steps with all the usual triggering facilities and a ×10 magnifier.

2. Raster ×1: With the function switch in this position and a video signal complete with synchronizing pulses—either composite or separate—applied to the input a 90×67mm television picture will appear on the screen. An internal sync. separator provides trigger pulses which may be switch selected on the standard timebase unit which provides the horizontal sweep. The sweep rate is set by the normal timebase speed controls so any line standard can be accommodated. A strobe pulse can be adjusted to brighten any line or any part of any line, or any section of up to six lines on the raster. The portion of the raster covered by the bright-up strobe pulse can then be expanded to fill the screen so that it can be examined in detail.

3. Raster ×2: Vertical deflection is multiplied by two; timebase can be triggered at any point on the raster so that larger sections of the raster can be examined in detail.

4. Waveform: The video waveform for the section of the raster covered by the bright-up pulse described above is displayed on the screen. A special graticule and vernier fitted to the display enables precise measurements (0.02dB) of picture quality to be made in the mode.

Other features include a black-level clamp which may be switched in or out or the removal of an internal link removes the interlace component of the video signal for ease of line selection. Many other options are available. Dynamco Ltd, East Main Industrial Estate, Broxburn, West Lothian, Scotland.

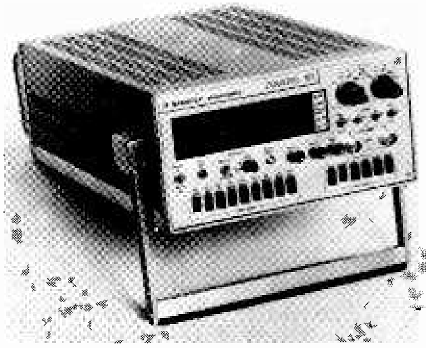
WW374 for further details

60MHz counter/timer

Bradley Electronics had a compact 60MHz counter/timer (model187) among the new products they introduced at an exhibition at Kensington Close Hotel which ran at the same time as the R.E.C.M.F. exhibition at Olympia. The instrument will measure frequency, period (single and average), true time interval, ratio, and has totalize and scaling functions.

The d.c. to 60MHz channel A has a sensitivity of 10mV at 30MHz rising to 40mV at 60MHz. Channel B will operate from d.c. to 10MHz and in this case the sensitivity is 10mV. Both channels have an input impedance of 1MΩ and 20pF with the input attenuator in any but the ×1 position where the capacitive component rises to 50pF. The input attenuators are identical with four positions marked ±250mV to ±250V (× 1 to × 1000).

The internal timebase is derived from a 1MHz crystal oscillator with a typical stability, after a 72 hour warm up period, of 5 parts in 10^9/day or 3 parts in 10^8/week. Each of the nine timebase ranges are individually selected by a separate switch. Time base speeds available go from 1μ s to 100s in decade steps.

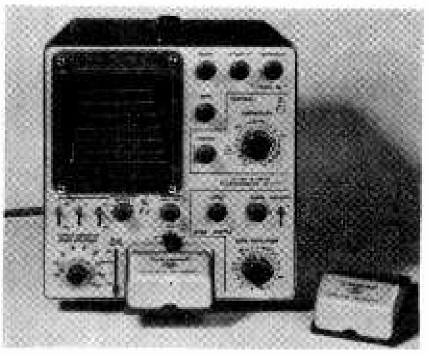


The accuracy of the instrument in its various modes is as normal for this type of equipment, i.e. ±1 count, ± timebase error or ± trigger error. The latter parameter, trigger error, is calculated from 0.008 divided by signal slope in volts per second, the answer being in seconds, The various functions of the instrument are selected on individual switches and not on a rotary selector switch. G. E. Bradley Ltd, Electral House, Neasden Lane, London N.W.10.

WW377 for further details

Oscilloscopes and curve tracer

Three new dual-trace oscilloscopes from Telequipment have bandwidths of 25MHz at 10mV/div or 15MHz at 1mV/div (D66) and 15MHz at 10mV/div or 10MHz at 1mV/div (D65). Model D68 has high-gain differential amplifiers giving a sensitivity of 10μ V/div (common-mode rejection 100dB) and 2-MHz bandwidth. Prices are £195 (D65), £225 (D66), and £320 (D68). Curve tracer CT71 (illustrated) displays



transistor and diode characteristics at currents of up to 2A, reverse currents down to 5nA and reverse voltages up to 1kV. Two different characteristics can be displayed on the 10 × 10cm screen. Price £195. Telequipment, 313 Chase Road, London, N14 6JJ.
WW351 for further details (scopes)
WW352 for further details (tracer)

Versatile signal generator

Model TF2008 is a signal generator introduced by Marconi Instruments which covers the range from mid-audio to u.h.f. with a choice of amplitude or frequency modulation. In addition it is a sweep generator capable of sweeping from 10kHz to 4.5MHz up to 360 to 510MHz, while still retaining its a.m./f.m. capability—useful for many dynamic measurements.

Carrier frequency: 10kHz to 510MHz in 11 bands. Range switch changes the scale so that only the frequencies available on that band are visible on the tuning scale leading to easy, unambiguous frequency setting. Accuracy ±0.5% above 22.5MHz. Stability is typically 5p.p.m. above 22.5MHz. An uncalibrated fine-tuning control is provided which has a very limited range–fine tuning can also be carried out electrically via a front panel terminal (±4V).

Calibrator: An internal crystal oscillator provides 13 check-points per band which are indicated on the tuning scale. The calibrator oscillator can be used to provide markers when operating in the sweep mode.

Incremental frequency: Precise incremental frequency changes can be made using the internal Δf control without upsetting the standardization of the main tuning scale. The control is calibrated in kHz and operates in conjunction with a range switch with settings at 3, 10, 30 and 100kHz for carrier frequencies below 45MHz, with an additional setting (300kHz) for higher carrier frequencies.

Narrow sweep: A voltage of ±5V applied to the external narrow sweep terminal will produce a carrier shift of ±100kHz at carrier frequencies below 45MHz and ±300kHz at higher carrier frequencies. The shift voltage is applied to the same varicap diode as is used for the incremental frequency control.

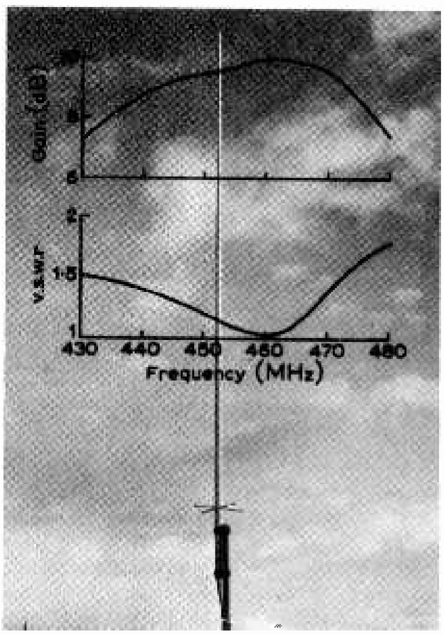
Wide sweep: An internal triangular wave oscillator operating at 18Hz controls the frequency of a voltage controlled oscillator which covers the same frequency ranges as the main carrier oscillator. Sweep width and centre frequency controls are provided. The carrier oscillator provides a marker at the frequency indicated on the main tuning scale.

Modulation: An internal oscillator, variable between 300Hz and 3kHz, provides the source of internal modulation. Amplitude modulation can be to a depth of 80% and frequency modulation up to a deviation of 100kHz below 45MHz, and 300kHz above this, is obtainable. The modulation frequency characteristic is within 0.6dB from 30Hz to 53kHz with negligible phase shift making the instrument suitable for stereo application.

R.F. output: The output level of the instrument is variable from 0.2μV to 200mV from a 50Ω source. Adjustment is by a coarse control covering 110dB in 10dB steps and a fine variable control covering 10dB. The automatic carrier level control obviates the need for a set carrier control–but a meter is provided to check the correct functioning of the automatic system. The modulation oscillator also has a similar meter and automatic level control system. The r.f. output waveform has less than 5% total harmonic distortion. The instrument will accept the output of an external modulation oscillator or an external sweep oscillator for narrow or wide sweep. Marconi Instruments Ltd, St Albans, Herts.
WW373 for further details

Colinear array

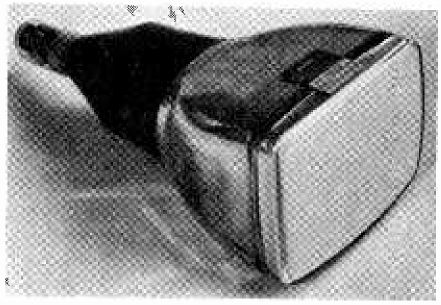
The new u.h.f. colinear array by J-Beam giving 10dB gain is complemented with a 6-dB gain u.h.f. aerial (£37), a 6-dB gain v.h.f. aerial (£62) and a 3-dB v.h.f. aerial (£33). These aerials combine glass-fibre construction with new-style printed phasing elements instead of coaxial lines. As an example of their characteristcs, the 10-dB u.h.f. aerial has a 2½% bandwidth



giving a frequency range of 450-470 MHz with a maximum v.s.w.r. of 1.5. Impedance is 50ohms and half-power beam-width 8°. J. Beam Engineering Ltd, Rotherthorp Crescent, Northampton.
WW370 for further details

28-cm c.r.t.

Cathode-ray tube type LD740 is electrostatically deflected with 20 × 16cm picture size and made by M-O Valve Co. (GEC). Designed for general use it is capable of operation up to 25MHz and



has deflection coefficients of 6 and 8V/cm. Grid voltage for cut-off is −90V and line width is 0.6mm (measured by shrinking raster at 10 μA beam current). M-O Valve Co Ltd, Brook Green Works, London W.6.
WW358 for further details

H.F. radiotelephones

Model 401 s.s.b. transmitter-receiver for the band 1.6 to 4.2MHz made by Hatfield Instruments is intended for maritime use. Giving 400 watts peak envelope power it adopts the common technique of using a valve output stage. It has 23 transmission channels and 35 receiving channels, including the 2.182-MHz distress channel. A 200-W version will be introduced shortly. Hatfield Instruments Ltd, Burrington Way, Plymouth, Devon, PL5 3LZ.
WW350 for further details

Light sensing array

Probably the largest integrated circuit chip in the world contains a light sensing array and is manufactured by Integrated Photomatrix Ltd., The Grove Trading Estate, Dorchester, Dorset. The chip which measures 25.9 × 1.52mm houses 256 photo-diodes formed in a long row and a 256 bit shift register.

The device would normally be operated in the recharge sampling mode as follows. A '1' is allowed to circulate through the shift register at a known rate under the influence of an externally generated clock pulse. The photo diodes in the array are charged sequentially by this '1'. The rate of discharge of each diode is proportional to the amount of light falling upon it and each diode will be recharged on every

256th clock pulse as the '1' propagates through the register. The amount of charge required by each diode–proportional to the amount of light falling on the diode—is monitored on a line common to all diodes and is converted to an output voltage. The output waveform will have 256 sections, each section having a value corresponding to the amount of light falling on one particular diode.

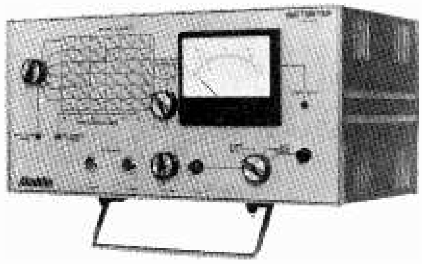
The device is available in six sizes, i.e. 50, 64, 100, 128, 200 and 256 diodes long, but no doubt special lengths could be manufactured. In fact I.P.L. make the chips much longer than required and then select serviceable sections. The manufacturing yield on these devices must be fairly small because of their large size. This is reflected in the price–the 256 diode version costs £500.

Applications include pattern recognition, data transmission, position sensing, machine tool control, etc.

WW375 for further details

Power meter for semiconductor devices

For measuring power in semiconductor devices, magnetic devices and electronic circuits generally, Aladdin Instruments—a recently formed division of Aladdin Industries—announce model 6311A electronic wattmeter. The instrument compares magnitude and phase of voltage and current in a circuit or device without imposing a heavy load as in dynamometer wattmeters. The new instrument has a

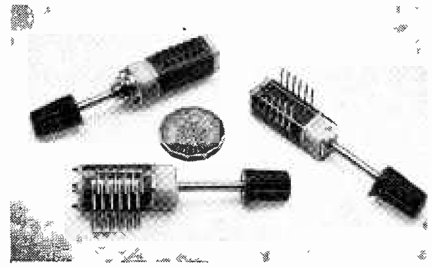


sensitivity of 10,000 ohms per volt with an input capacitance of 10pF. Thermal converters are used to produce a d.c. output from the input signals—thus it is independent of input waveform and reads true r.m.s. power. It covers inputs from 300mV to 300V and 10mA to 10A with power indication from 3mW to 3kW. It handles waveforms up to 500kHz and risetimes of 200ns. Aladdin Industries Ltd, Greenford, Middlesex.

WW357 for further details

Miniature rotary switch

Guest International are marketing a miniature rotary switch with screw transmission and rectilinear displacement of slide contacts. The switch, type KR10C, is intended for p.c. board mounting. Type KR10B, for wire connections, has a fixing socket. The nominal working voltage is 150V and the current carrying capacity



150mA. Insulation between adjustment contacts is 10^6MΩ. Versions are available with one, two, or three wafers. Guest International Ltd., Nicholas House, Brigstock Road, Thornton Heath, Surrey CR4 7JA.

WW390 for further details

Digital counter

A custom-built multi-stage m.o.s. counting module in the AMF Venner model 7737 digital counter replaces seven boards that would have been necessary had a conventional i.c. design been used. This general-purpose instrument, which measures 289 × 216 × 89mm and weighs 4kg, provides push-button selection for frequency and multi-period measurement, simple and two-line timing, and counting.

The 7737 has a 7-digit display with an integrated automatically-positioned decimal point. Its principal measurement specifications include frequencies up to 50MHz (±1 count); multi-periods, in 0.1μs units, up to 1 MHz; timing units between 0.1μs and 10s (±0.1μs) in decade steps; and counting up to a maximum frequency of 50MHz. Provision is also made for serial or parallel 1248-code data outputs, and the display can be normal or stored, the display time being adjustable from 0.1 to 5s, or infinite.

The new digital counter has an input impedance of 1MΩ, with an input sensitivity of 10mV r.m.s., and incorporates a 10-MHz crystal-controlled oscillator as an internal reference. Price in the U.K. is £245. AMF International Ltd., Kingston By-Pass, New Malden, Surrey.

WW393 for further details

D.C. motors

An interesting range of high-quality, very reasonably priced, d.c. motors was exhibited by Portescap (U.K.) Ltd. The motors, because of their low starting voltage (typically 100mV) and low inertia (rest to 63% full speed in milliseconds) are ideal for use in small servo systems. They may also be used as tacho generators as their output voltage is within 1% of linearity with rotation speed—a data sheet is available for using the motors in this way. Self lubricating phosphor bronze bearings are used, the multi-segment commutators are of silver alloy and gold alloy is employed for the brushes. The rotors contain no iron and consist of self supporting windings encapsulated in a thin coat of resin.

The smallest motor in the range is the Escap-15. This is 15mm in diameter and 20 to 33mm long, depending on the model. Motors are available in this range from 2 to 12V with output powers of 0.24 to 0.7W; efficiency is 80% and starting torques range from 5.23 to 17.5 gcm. A range of 19 gear boxes is available giving output shaft speeds from 25,000 r.p.m. to 3 r.p.m.

The largest motor, Escap-26P, can be powered by up to 24V and has a maximum power output of 3.5W and a maximum starting torque of 180gcm. Nine-segment commutators are employed on these models and a time constant of 20ms is obtained.

Each of the range of motors is sub-divided into numerous variants. Prices start at about £3 per motor. Some models have built in v.d.rs to eliminate surges. Portescap (U.K.) Ltd, 204 Elgar Rd, Reading, RG2 0DD.

WW378 for further details

Solid-state lamp and holder

A lamp having a solid-state light emitter is available from Oxley Developments Company. The holder incorporates the 'Barb' Cone-lock principle for rapid assembly to panel or chassis without risk

of damage. Switch-on is surge free. Characteristics:

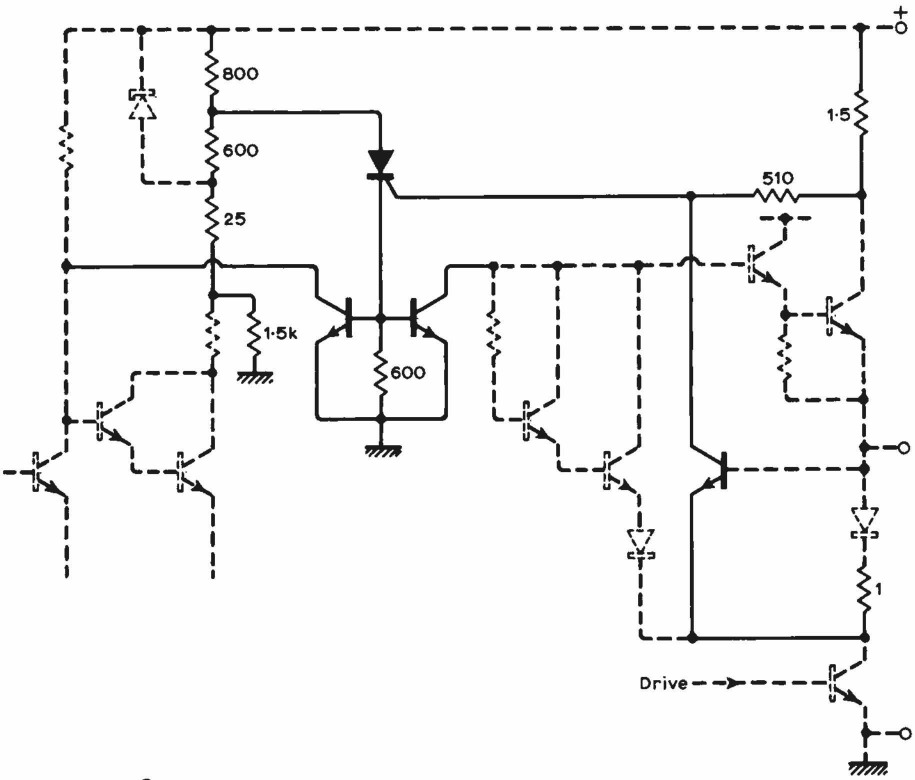
emitter	red
operating current	20mA (max 40mA)
nominal operating voltage	1.7V
brightness	50ft-l (170 cd/m²)
emission peak wavelength	650 nm
maximum operating temperature	70°C
emission rise and fall time	1.0ns
maximum reverse current	0.3μA (V_t 3V)

Oxley Developments Co Ltd, Priory Park, Ulverston, North Lancashire.

WW388 for further details

I.C. audio amplifier

Integrated audio amplifier type SL403D is a short-circuit proof version of SL403A. It delivers three watts of power continuously into an eight-ohm load directly from a piezo-electric pickup. Distortion is 0.3 to 0.5% from 100Hz to 5kHz (as for the earlier version). Short-circuit protection is achieved by including sensing resistors in series with the output transistors (see diagram). If the voltage rises above a



pre-set value the s.c.r.—integrated onto the chip—conducts turning on two additional transistors and turning off the output devices. To switch off the s.c.r. the supply must be interrupted. Type S1402D (two watts) is also available. Plessey Microelectronics, Cheney Manor, Swindon, Wilts.
WW363 for further details

Mercury-wetted relays

A range of mercury-wetted relays with no contact bounce is claimed by Associated Automation to be the only type with a single-pole switch. Contacts are rated at 1A or 250V with a maximum of 50VA. Operating life is quoted as 1000 million operations and contact resistance is 40 milliohms. They use a single-pole wetted switch suitable for telephone use because of its small size. Operate and release ampere-turns are 55 and 20 respectively. Associated Automation Ltd, 70 Dudden Hill Lane, London N.W.10.
WW360 for further details

Sandwich stepper

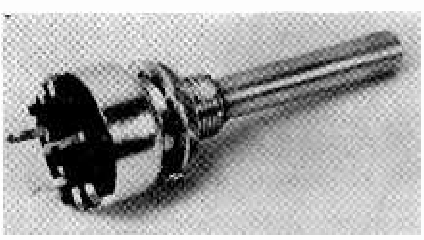
N.S.F. Switches and Controls introduced a neat little stepping switch of unusual design. The switch is rectangular in shape, quite small (75×56×12mm), and 12.7mm thick. The actuating solenoid and drive assembly is sandwiched between two printed circuit boards which carry the printed contacts and wiring. The stepper has twelve positions and incorporates a 'home on zero' arrangement. Life of the device depends on the load switched by the contacts and lies between 2 and 5 million operations. The contacts are capable of carrying a current of 2A and will break a current of 120mA at 120V a.c. or 500mA at 28V d.c. Maximum stepping speed is 60/sec—not continuous. N.S.F. Ltd, Keighley, Yorks BR21 5EF.
WW381 for further details

Contact resistance meter

In the model RM371 milliohmeter made by British Physical Laboratories the test specimen is connected to a constant 10mA source at 10 or 30mV and 1kHz and the voltage drop across it measured. Range is 20μΩ (first marking) to 300Ω with an accuracy of ±2% of full scale reading. It includes a go/no go indicator for production use. As well as measuring contact resistance of relays, switches and connectors, it is useful for p.c. boards, heating elements, fuses and thermo-electric elements. Price is £150. B.P.L. Instruments Ltd, Radlett, Herts.
WW361 for further details

Instrument potentiometer

A 1.5-watt linear wire-wound potentiometer for instrument applications is now made by Welwyn Electric. Based on an earlier potentiometer designed for television convergence controls it is now available as a P29 type in a resistance range from 5Ω to 5kΩ with 10% tolerance, or 2% to special order. It is



suitable for use up to 500V. Price is 15p in bulk quantities. Welwyn Electric Ltd, Bedlington, Northumberland.
WW353 for further details

Video transistors

Three n-p-n video transistors from Mullard have low feedback capacitance and high voltage rating. Maximum V_{CBO} is 185V for BF336, 250V for BF337 and 300V for BF338. Maximum V_{CEO} is 120V for BF336, 180V for BF337 and 180V for BF338. Other characteristics shared by the three devices are as follows:

maximum I_{CM} (peak value)	100mA
(for period $t \leqslant 27\mu s$)	150mA
(for period $t \leqslant 0.5\mu s$)	200mA
maximum P_{tot} ($T_{mb} \leqslant 145°C$)	2.75W
maximum junction temperature	200°C
minimum h_{FE} ($I_C = 30mA$, $V_{CE} = 10V$, $T_j = 25°C$)	20
minimum f_T ($I_C = 30mA$, $V_{CE} = 20V$)	80MHz
typical $-C_{RE}$ ($I_C = 10mA$, $V_{CE} = 20V$)	3.0pF

Mullard Ltd., Mullard House, Torrington Place, London W.C.1.
WW391 for further details

Transistor tester

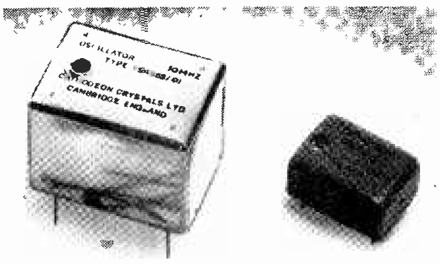
The characteristics of bipolar transistors, diodes and zener diodes can be measured using this low-cost transistor tester (TM12) from Levell Electronics Ltd, Park Rd, High Barnet, Herts. An abridged specification appears below; the price is £65.

I_{CBO}, I_{EBO}	5 ranges between 10nA and 100μA f.s.d. at any of 12 voltages between 2 and 150. Short circuit current limit 1mA.
BV_{CBO}	10 or 100V f.s.d. at currents of 10 or 100μA, or 1mA., o.c. voltage limit=150.
I_B	Decade ranges from 10nA to 10mA f.s.d. at fixed I_E between 1μA and 100mA. V_{CE}=2V.
h_{FE}	10 to 2000, f.s.d., three scales.
V_{BE}	1V f.s.d.
$V_{CE(sat)}$	1V f.s.d. at I_C between 1 and 100mA with I_C/I_B selected at 10, 20, or 30.
I_{DR}	As I_{EBO}
V_Z	As BV_{CBO}
V_{DF}	1V f.s.d. at currents of between 1μA and 100mA.

WW 380 for further details

Crystal oscillators

Two compact oscillators, FS5903 and FS5953, made by Cathodeon Crystals allow for voltage control of oscillation frequency. Frequency can be altered by a variable potentiometer or modulated at audio frequencies. Each unit can be directly interfaced with t.t.l. logic gates in the 74 (or similar) series, and can be directly connected into a phase locked



loop. The oscillators are based on the FS5901 and FS5951, the latter having compensation for temperature effects and allowing for frequency stability of ±0.1 p.p.m. between 0° and 60°C. Linearity for both packages is better than ±5% on the control range 0.5V to 5.0V, and the output is a 0-2.8V minimum square wave. Cathodeon Crystals Ltd., Linton, Cambridge.
WW387 for further details

Digital voltmeter logic module

A single m.o.s. integrated circuit manufactured by Integrated Photomatrix Ltd., Grove Trading Estate, Dorchester, Dorset, provides all the logic necessary for a digital voltmeter with a four digit plus 1 display. To build a complete voltmeter it is necessary to add only an integrator, clock multiplexing switches, comparator and single display decoder. Use of the new i.c. results in a saving of some 20 standard t.t.l. packages. The device, MC9C2, will give up to five readings a second, is capable of phase locked loop operation, and has facilities for autoranging and set-point comparison.
WW379 for further details

Communication receivers

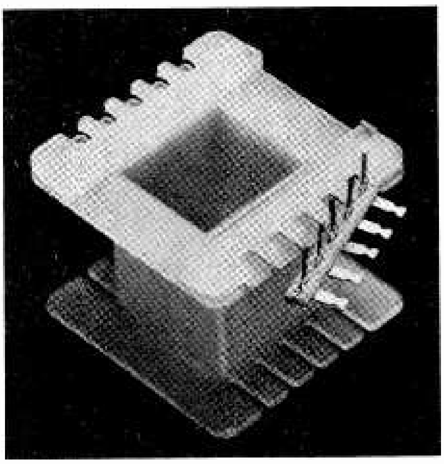
Eddystone had their impressive range of communication receivers on display at a small private exhibition. Among the various receivers was the model 1830 general purpose h.f/m.f. receiver. *Wireless World* used a pre-production prototype of this model for its 60th birthday amateur radio station, GB3WW, which operated during April. The 1830 is a double conversion superhet covering 120kHz to 30MHz in nine bands—incremental tuning is available above 1.5MHz Reception modes are c.w., m.c.w., d.s.b. and s.s.b.; a four-position selectivity filter is provided. Sensitivity is 3μV for 15dB signal-to-noise ratio. Ten switched crystal-controlled channels are included, in addition to the continuous tuning, in the standard version.

The EB37 is a broadcast receiver developed from, and intended to replace, the EB35. Unlike the EB35 it does not have a v.h.f. band. Coverage is long-wave, medium-wave and 1.5 to 22MHz in three bands. Sensitivity is 5μV for 15dB signal-to-noise ratio up to 3.5MHz and 15μV at higher frequencies.

Eddystone also had on display a v.h.f. interference tracing and measuring receiver, developed for the Post Office. The measuring range provided is 110dB and measurements may be made to an accuracy of ±2dB over the frequency range 31-250MHz (three bands). For a 6dB indication above noise an input of 2μV is required—field strength < 20μV/m. Reception modes are c.w., a.m. and f.m. It will be more than 12 months before the noise measuring set No. 31A is generally available. Eddystone Radio Ltd, Alvechurch Rd, Birmingham B31 3PP.
WW376 for further details

Solder tags for inductors

To avoid the problem of the cheaper kinds of plastic melting when soldering to attached tags, Aladdin Components have produced a new tag arrangement for transformer bobbins. The tags are set in a thermosetting plastics material which is



clipped into place on the thermoplastic nylon bobbin. This avoids the high cost of a thermosetting plastics material for the whole bobbin. Aladdin Industries Ltd, Greenford, Middlesex.
WW356 for further details

Time-standard quartz crystals

ITT have developed two crystals, available in glass envelopes or elongated TO-5 and TO-8 metal cans, with frequencies of 16,384 and 8,192Hz. When used with standard 7-bit i.c. binary dividers these provide 1Hz reference accurate to 2 minutes per year. Standard Telephones and Cables Ltd., Edinburgh Way, Harlow, Essex.
WW389 for further details

Reliable electrolytics

Made in France by Seco Novea, new high-value electrolytic capacitors have a life of 100,000 hours under 'normal' conditions. Known as the Prosec 85 series they are available in voltage ratings from 6.3 to 80V and capacitance values from 820μF to 0.15F. They are specially suitable for smoothing with 100-Hz ripple current rating of 16A for 12.000μF at 80V and 5.5A for 10,000μF at 6.3V. (These 20°C figures derate by just over a factor of two at 85°C.) Leakage current (in μA) is less than $10\sqrt{CV}$ (C in μF). Available in the U.K. from Advance Filmcap Ltd, Rhosyedre, Wrexham, Denbighshire.
WW359 for further details

Planar transistors

Three silicon planar n-p-n chips by Ferranti are the basis of a new range of transistors. The devices have a V_{CEO} rating of 80V and a minimum h_{FE} of 60 at 1A. They are available in packages allowing a dissipation of 11 watts (TO-5), 15 watts (TO-66) and 20 watts (TO-3).

	I_C	h_{FE}	V_{CEsat}	f_T(MHz)
ZTU1	3A	60@1A	<0.5V	60
ZTU2	5A	60@3A	<0.5V	60
ZTU3	10A	40@6A	<0.5V	30

Other types which may be produced from these chips are BDY60, 2N4000 (ZTU1), BFX34 (ZTU2) and 2N3420 (ZTU3). A new p-n-p- equivalent of the ZTX341 100-volt tube driver is the ZTX541. New Micro-E transistors are BF403 (similar to BC107), BF404 (similar to BC179), BF405 (similar to 2N2220) and BF406 (similar to BCY70). New types ZTX384A-C are high gain low-noise transistors with spreads of 240-500, 240-900 and 450-900. Ferranti Ltd, Gem Mill, Chadderton, Oldham, Lancs.
WW 364 for further details (ZTU1-3)
WW 365 for further details (tube driver)
WW 366 for further details (BF403-6)
WW 367 for further details (ZTX384)

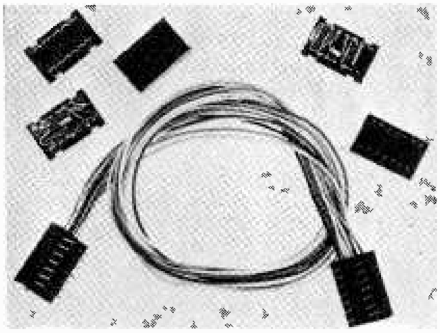
Automatic digital bridge

Direct reading of capacitance, inductance, conductance, resistance, loss factor and Q is provided in the automatic digital bridge, model B900, announced at the show by Wayne Kerr. This four-quadrant bridge

has twin displays reading up to 19999. Either or both displays can be used as a four-range d.v.m. In addition a reciprocal capacitance facility provides a linear distance/readout relationship for checking capacitive transducers. Wayne Kerr Co., Roebuck Rd, Chessington, Surrey.
WW395 for further details

Dual in-line components

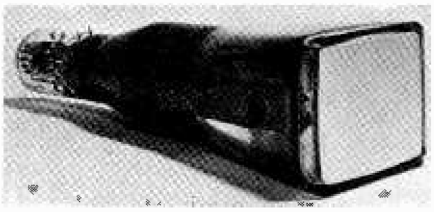
Dual in-line switch by Erg provides a variety of switching arrangements from 1-pole 8-way to 4-pole 2-way. Called DILswitch 16, it is rated at 28V, 250mA and has a minimum life of 20,000 contact



wipes. Price is about £1. DILpack 14 (illustrated) is a package for assembling components costing £20 for 100. Erg Industrial Corporation Ltd, Luton Road, Dunstable, LU5 4LJ, Beds.
WW362 for further details

100-MHz c.r.t.

Brimar cathode-ray tube type V4152B made by Thorn is intended for oscilloscope use at frequencies up to 100MHz, and especially for computer servicing. Side y-plate connectors give a low capacitance to all other electrodes of 3.5pF and this,



together with small spot size, make the tube suitable for 100MHz use. High y-sensitivity (deflection coefficient 2.8 to 3.6V/cm at 12kV) allows the tube to operate with 43V pk-pk for 1.5 times screen height. Control grid cut-off voltage is −40V to −70V. Thorn Radio Valves and Tubes Ltd, 7 Soho Square, London, W1V 6DN.
WW355 for further details

Variable networks

By sequentially contacting over 1000 individual thick-film capacitors the Sprague Varinet variable networks provide capacitances variable over a range of 1:1000. The latest Varinet units also incorporate variable resistors as well as static *RC* networks. Standard units, which measure 1 × 1 × 0.5in, incorporate one or two variable capacitors (10-10,000pF) as well as variable *RC* combinations with constant impedance at 1kHz, or a constant *RC* product of 160μs. Sprague Electric (U.K.) Ltd, 159 High St., Yiewsley, W. Drayton, Middx.
WW394 for further details

High-density power supplies

High-current models in the BRM range of power supplies by Advance Electronics have a power output density of one watt per cubic inch. The range comprises units providing up to 60 V at 1 or 3 A and up to 40 V at 1, 5, 10, 30 and 50 A. The 30 and 50-A models are 19-in rack mounting size and the rest half-rack size. They are provided either with thumb-wheel switches for output selection or potentiometers with meter indicators. High packing density is achieved by a special transformer design, which eliminates the necessity of a choke, together with a thyristor regulator. Advance Electronics Ltd, Raynham Road, Bishop's Stortford, Herts.
WW354 for further details

● Pye TMC has developed a range of both plastic cased and plastic sleeved foil capacitors having low self-inductance, low series resistance and low dissipation. The capacitance range is 1000 pF to 0.5μF at 160V. Pye TMC Ltd., Capacitor Division, Oldmedow Road, Hardwick Trading Estate, King's Lynn, Norfolk.
WW392 for further details

● Plessey showed the Planar 850 **random access core memory,** claimed to be the lowest-cost system ever produced by Plessey. Designed to provide capacities up to 32,786 words of 18 bits, it comprises modules each of 4096 words, 8 bits. Plessey Components Group, Wood Burcote Way, Towcester, Northants.
WW369 for further details

● **Miniature relays** made in Germany are available from Londex. Model 5200 and 5510/50 are suitable for p.c. board mounting and are designed for use with transistor circuits. Type 5200 has silver/nickel contacts rated at 2A and 250V (75VA max.) and will operate at 50Hz. Type 5510 has silver contacts rated at 5A (and 350V (450VA max). Coil power for both types consumes 800mW. Londex Ltd, P.O. Box 79, 207 Anerley Rd, London, SE20 8EW.
WW371, for further details

● Copper tubes are used for water cooling on the BK448 **ignitron** for welding control, made by EEV. This prevents corrosion in older ignitrons resulting from water impurities acting on stainless steel tubes. The ignitron works from a 250 to 600-V supply and can provide up to 600kVA with two tubes in parallel. English Electric Valve Co., Chelmsford, Essex.
WW372 for further details

● Included in the range of 20 new products shown by Belling & Lee are miniature fuseholders and delay fuses, an illuminated push-button circuit breaker, latching coaxial plugs and sockets, and 9- and 50-way miniature connectors. Belling & Lee Ltd, Great Cambridge Road, Enfield, Middlesex.

● The lead length has been increased and a pip has been raised on the lead out of the resistor range 174 from Erie Electronics. The idea of course is to ensure that the resistor does not fall off the circuit board before soldering on production lines. Three versions of the device are available all rated around 0.25W at 70°C. The resistors are available from 10Ω to 12MΩ in ±5, 10 and 20% tolerances. Erie Electronics Ltd, South Denes, Great Yarmouth, Norfolk.
WW382 for further details

● New **microwave power transistor** made by GEC-AEI Semiconductors, Witham, gives ½-watt output at 4GHz with 6dB gain. (Their older DC5501 gives 1 watt at 2GHz.) It is hoped to extend power output to 5 watts.
WW368 for further details

● One of the six new products introduced by Fluke International Corporation was the model 8200A digital voltmeter. The four-digit display enables measurements to 1kV with a resolution of 1μ V and an accuracy of ±0.01% of input ±0.01% of range.
WW383 for further details

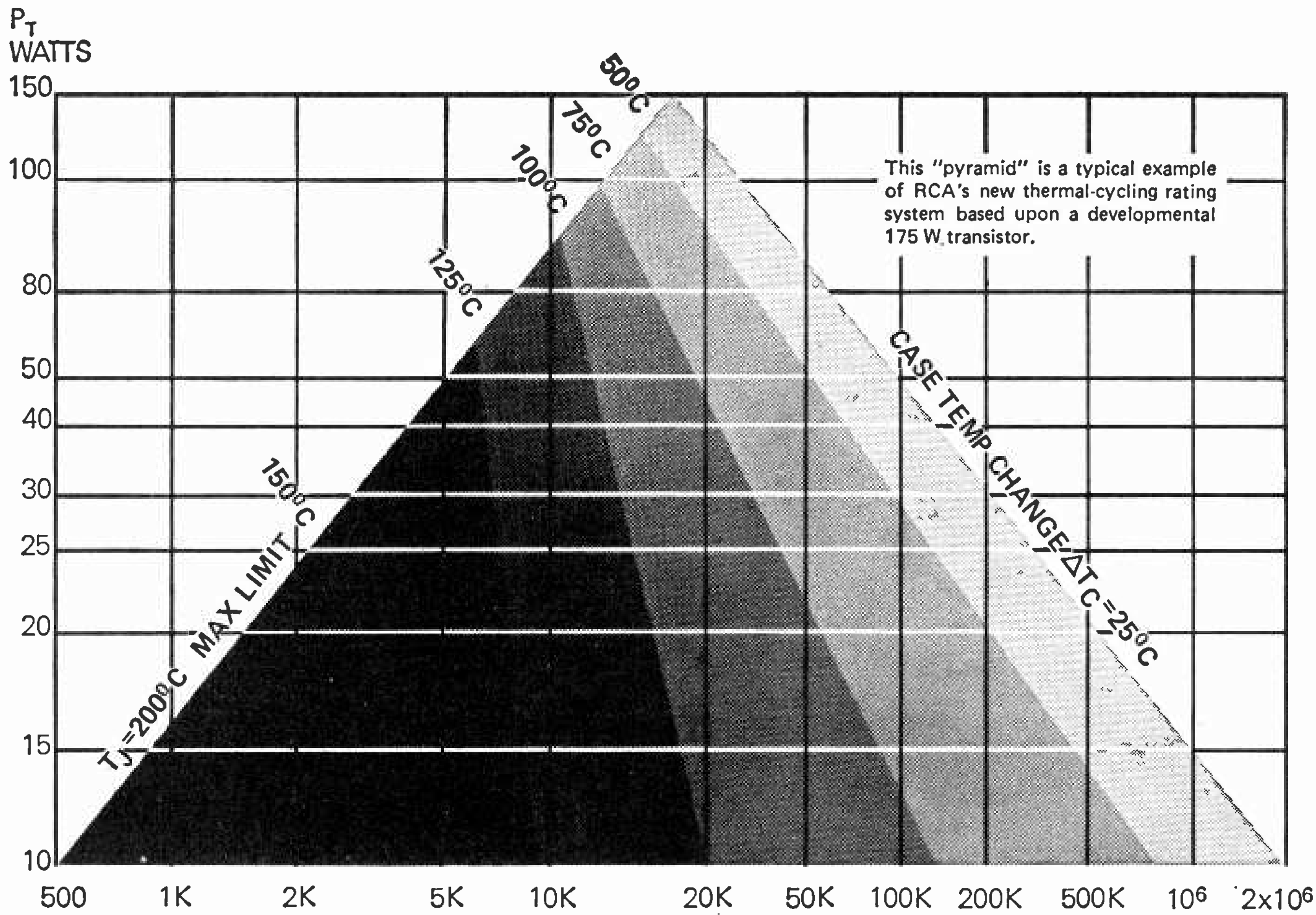
● Only £245 will buy you the latest 50MHz counter/timer (TF2416) from Marconi Instruments (St Albans, Herts). The TF2416 has a six-digit display plus polarity indication, a 10MHz internal frequency reference with a stability ±1 × 10^{-6}, gating times from 0.1⁻μs to 10s in decade ranges and three inputs, etc. Several options are available.
WW384 for further details

● A range of kits, called Josty Kits, could be seen on the stand of Stylus Supplies (Mountings) Ltd. These kits, which are manufactured in Denmark, should appear on the British market sometime in the future when a suitable distribution chain has been set-up. The range includes most of the electronic novelties normally built by the home constructor including automatic car parking lights, a projector control unit, windscreen wiper control unit, 'psychedelic light controller', photo timer, as well as audio, r.f. and f.m. equipment and transistor ignition systems. Stylus Supplies (Mountings) Ltd, P.O. Box 41, Tavistock St, Bletchley, Bucks.

● Hewlett Packard (224 Bath Rd, Slough, Bucks SL1 4DS) have announced a new low-cost 3-digit display multimeter. Ranges are 1mV to 500V a.c. (20Hz to 10 MHz), 100mV to 1kV d.c., 1μA to 100mA and 1 Ω to 10mΩ. All figures given above are f.s.d.; over-range of 100% f.s.d. is possible on all ranges except 1kV; polarity indication is automatic and overload protection is available on all ranges. Model 3469A, price about £300 including duty.
WW385 for further details

● A 'Sucobox' is a screened container for such things as r.f. attenuators, matching units, probes etc. Sucoboxes are available in several sizes with a variety of coaxial sockets; they are manufactured by Suhner Electronics Ltd, 172/176 Kings Cross Rd, London WCIX 9DH.
WW386 for further details

RCA Announces the Industry's First Power Transistor Thermal-Cycling Ratings.



The Rating "Pyramid"–built with the help of RCA's Controlled Solder Process.

RCA, the industry leader in over-all silicon resources, introduces a totally new concept in thermal-cycling ratings to help you establish and extend equipment life.

Using these new thermal-cycling ratings, you can tell at a glance the life expectancy of any given RCA power transistor in terms of number of cycles, power dissipation, and case temperature change. A rating chart is being developed for each family of RCA power transistors, and will be included in data sheets as they are completed. RCA's Controlled Solder Process (CSP) has made possible these ratings – the only such ratings in the industry.

Controlled Solder Process is an RCA development. With it, RCA can control the effects of thermal stress between the pellet and mounting base, and thereby extend the number of times a transistor can be cycled thermally. CSP increases the device thermal-cycling capability from five to 20 times. The RCA "pyramid" is the only rating chart yet devised to help you avoid thermal-fatigue failure in the field.

This announcement of thermal-cycling ratings on power transistors is made in the same spirit as RCA's pioneering disclosure in 1964 on Second Breakdown capability. The philosophy, simply, is to continue to provide power transistor users with the best possible tools to achieve the optimum interface between the capabilities of RCA devices and the needs of their applications.

For more information on RCA's new thermal-cycling ratings, consult your local RCA Representative or your RCA Distributor or write to : RCA Ltd., Solid State Division, Sunbury on Thames, Middx. Tel : Sunbury 85511. Telex : 24246. Grams : RCA London or on the Continent to: RCA, 2-4 rue du Lièvre, 1227 Geneva, Switzerland.

RCA Solid State

WW—071 FOR FURTHER DETAILS

Sonic Scanning for Tubeless TV

A formula for the future

by J. J. Belasco

For many years television production has been frustrated by the sheer physical size of television cameras. Film cameras are much smaller and more mobile and consequently television suffers from a surfeit of old fashioned, stylized film techniques and clichés. Because of the availability of small film cameras little work appears to have been done to reduce the size of television cameras and this has affected outside broadcasting above all. This writer who is currently concerned with television o.bs, looked forward to lightweight o.b. cameras with the arrival of the vidicon/Plumbicon, but hopes were dashed when it was found necessary to use three tubes for colour and despite the B.B.C. publishing a monograph on a two-tube camera based on an idea by the writer (B.B.C. Monograph No.50, September 1963), anything less than three tubes has not been used for professional television. A knowledgeable section of the industry even insist on four tubes and television o.bese is the order of the day (see article in the *Royal Television Society Journal,* Vol.11, No.10, Summer 1967). Until a one-tube camera arrives television will not compete in mobility with a 16mm cine camera, although it is already far superior in picture quality. Even when the single-tube camera arrives, the tiny pick-up area of the Plumbicon is nullified by the length of the tube necessitated by the gun assembly and scanning/focus coils. At the receiving end the viewer has to suffer a similar assembly which makes his display nearly as deep as it is wide (although it makes little difference if the display is monochrome or colour). Thus the viewer is limited in screen size. The whole problem seems to revolve around the scanning system—and the requirement of the scanning system of an inertialess reading/writing device. Current technology uses an electron beam to read or write. Light beams have been used (Baird), but light beams require mechanical devices to scan them and these are big and cumbersome. Scanning by mechanical means has been used as recently as the Apollo 12 missions for frame sequential colour and although this produced a very lightweight camera (which the writer thinks has great possibilities for television) it can only be a frame sequential device.

There is, however, one other inertialess device which might be useful for scanning—an electric field. If an electric field could be persuaded to perform the classic scanning motion over a photosensitive surface it might be possible to extract the appropriate brightness information from it. To this end the writer proposes the following suggestions (Provisional Patent 28737). Refer to Fig.1, which represents one television scanning line only. This line is made of a bar of glass or steel or some such solid but elastic material. At one end of this line bar is an electromechanical transducer which is fed

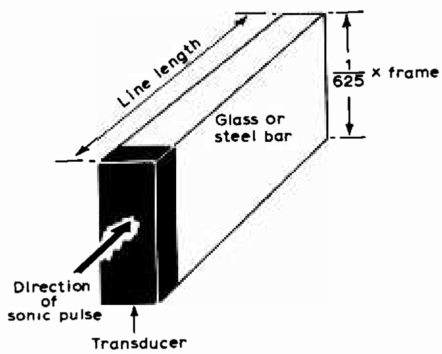


Fig. 1

with a voltage pulse. This transducer thus excites the line bar and sends a pulse of sound—a sonic pulse—travelling down it. This sound pulse, of longitudinal elastic deformation, travels along the bar at the speed of sound (in a solid medium). If the bar is made the correct length the sonic pulse will travel down it in the time of one television line. Sound waves are, of course, normally longitudinal waves, i.e. the wave motion is in the direction of propagation (unlike light or electromagnetic waves whose wave motion is at right angles to the direction of propagation). However a little used physical law, Poisson's, states that in solid bodies any elastic deformation in a longitudinal direction is accompanied by a proportional deformation in a transverse direction. One way of utilizing this travelling mechanical wave for scanning is to place a slab of piezoelectric crystal in intimate contact with the bar. Thus the mechanical pulse moving along the bar produces a travelling

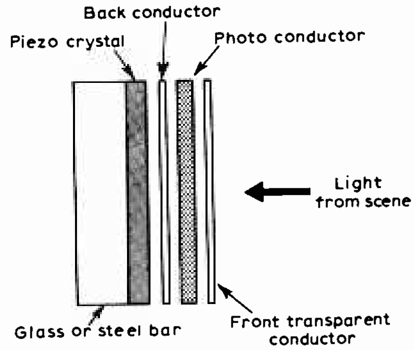


Fig. 2

voltage pulse in the piezoelectric crystal. This is the basic principle of sonic scanning—a sonic pulse travelling in an elastic medium generates a travelling electric field in a crystal lattice.

To utilize this travelling voltage pulse (Fig.2) a 'sandwich' constructed of a back conductor, a photoconductor and a front transparent conductor is laid on top of the crystal. Light from the televised scene travels through the front conductor. A voltage bias is applied to the front and back conductor and has a polarity such that a current cannot pass through the photoconductor until the arrival of the travelling voltage pulse. The current that flows through from the front signal plate to the back signal plate is thus proportional to the light falling on the photo-sensitive surface at any given point on the scanning line, but is only delivered to the output terminals on the arrival of the 'electrosonic' gating pulse. Thus one line scan is achieved.

Frame scanning is achieved by passing the voltage pulse at the end of the line bar to another transducer at the beginning of the next line bar, which sonically excites

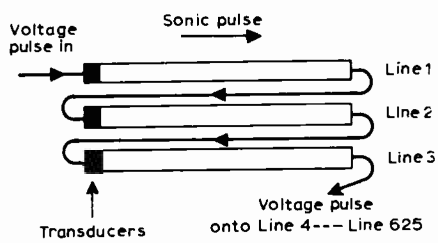


Fig. 3

this second line bar, and so on. Thus the cycle is: line sonic pulse moving along a line bar (accompanied by travelling voltage pulse), voltage pulse transferred in line blanking to next line bar transducer, and so on. Once the sonic pulse is fed into line bar No.1 it will run on down at scanning speed to line 625.

As an alternative, frame scan could be produced by attaching a vertical bar and piezoelectric crystal to the back of the assembly of line bars (Fig.4) and sending a sonic pulse down this vertical bar. Appropriate connections are made from the vertical crystal to the back conductors of each line bar sandwich and the biasing

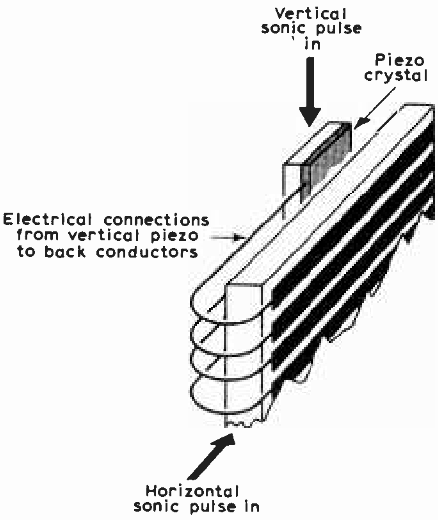


Fig. 4

is arranged so that the light sensitive layer does not become conducting until the arrival of both a line and frame 'electrosonic' gating pulse. The vertical bar would need to have a sound transmission speed (or appropriate length) to equal frame scan time. (Or, alternatively, an electrical frame delay line could be used.) An advantage of this latter frame scanning technique is that all the line bars and piezo crystals could be made into one solid slab of picture area, on top of which are laid discrete line 'sandwiches'. The line sonic pulse could then be injected laterally through the whole slab (instead of line by line) since each 'sandwich' requires the arrival of a line and frame pulse to make it conduct.

The modification for transmission of colour pictures (Fig.5) is a simple one. Each line 'sandwich' would consist of a single back conductor on which are laid three parallel layers of photoconductor and a front transparent coloured conductor. The travelling 'electrosonic' pulse thus runs along all three colours simultaneously producing simultaneous R, G, B outputs. No registration problems are created and no scan controls are required. However, the speed of sound in steel or quartz is about 3,200 metres per second, giving rise to a line length of 16cm for a 625-line system. The optics for a taking area this size may be inconvenient at the present state of the art, but geometric electron image magnifications

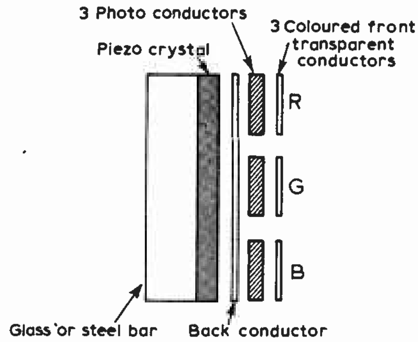


Fig. 5

may provide the answer to the problems of taking area. Nevertheless the possibility of strapping a flat plate of approx. 6in side over the back end of a zoom, albeit of complicated optics, ought to excite the television industry.

The display side could also benefit by this system. It should be possible with sufficient development to propagate a sonic pulse through a crystal lattice in such a way that light cannot normally pass through the crystal due to crossed planes of polarization but upon the arrival of the sonic pulse, the plane of polarization is aligned, permitting light to pass. Thus a solid slab of piezoelectric crystal (or equivalent) may behave as a photographic transparency, allowing a light to be projected through the crystal slab onto a projection screen. The lightness of the image is thus not determined by phosphor brightness, but by the brightness of the projection lamp. (Prov. Patent 49465.)

Looking into our crystal ball, perhaps we shall see a future generation of television viewers also looking into a crystal ball activated by sonic scanning producing television in the round!

Books Received

Solid-State Devices and Applications by Rhys Lewis. The author, a lecturer in electronics at Llandaff Technical College, Cardiff, has written this book specifically for technicians. In it he has assembled the theory of operation, manufacture and main applications of all the major solid-state devices now available. The first part summarizes fundamentals of semiconductor theory and describes diodes, bipolar and unipolar transistors, and integrated circuits. Part two discusses applications of these devices in relation to amplification, oscillation, non-linear circuit operation, logic and power control. The first chapter of the final part describes equivalent circuits for semiconductors, showing how these are derived from four-terminal network theory. This is followed by two chapters on logic, including treatment of Boolean algebra, Veitch diagrams and de Morgan's theorems. Pp 258 including index. Price £3. Butterworth & Co. (Publishers) Ltd., 88 Kingsway, London WC2B 2AB.

Pickups and Loudspeakers by John Earl. Designed as a companion to Mr. Earl's ***How to Choose and Use Tuners and Amplifiers*** this book completes his survey of the audio reproducing chain. After an introductory chapter, outlining the manufacturer of gramophone records and discussing some fundamental technical aspects of pickup systems and loudspeakers, the book deals very practically with pickups and speakers. The discussion afforded under the headings 'using' and 'choosing' is very valuable and there seems to be no significant aspect left out. The two last chapters deal with turntable units and headphones. Pp.203 including index. Price £3. Fountain Press Ltd, 46-47 Chancery Lane, London WC2A 1JU.

Conferences and Exhibitions

Further details are obtainable from the addresses in parentheses

LONDON
July 12-17 Imperial College
Industrial Measurement and Control by Radiation Techniques
(I.E.E., Savoy Place, London WC2R OBL)

BIRMINGHAM
July 5-9 Bingley Hall
Materials and Fastenings Exhibition
(Business Conferences & Exhibitions, Mercury House, Waterloo Road, London S.E.1)

BRISTOL
July 9-12 The University
Marine Electronics
(S.E.R.T., 8-10 Charing Cross Rd., London W.C.2)

CARDIFF
July 5-9 Sofia Gardens
Advanced Industrial Measurement & Control
(Exhibitions Wales & West, Holly House, Rhiwderin, Nr. Newport, Mon. NF1 9YF)

EXETER
July 3-5 The University
Band Structure in Solids
(Inst. Phys. 47 Belgrave Sq., London S.W.1)

NOTTINGHAM
July 6-8 The University
Electronic Control of Mechanical Handling
(I.E.R.E., 9 Bedford Sq., London WC1B 3RG)

OVERSEAS
July 13-15 Philadelphia
Electromagnetic Compatibility
(R. Showers, Moore Sch. of E.E., Univ. of Penna., Philadelphia, Penna 19104)
July 26-Aug 6 Louvain
Summer School—Impact of Optimization Theory on Technological Design
(Dr. M. J. Rijckaert, Inst. voor Chemie-ingenieurstechniek, Katholieke Universiteit Leuven, de Croylaan 2, 3030 Heverlee, Belgium)

Personalities

H. Stanesby, C.G.I.A., F.I.E.E., director of radio technology at the Ministry of Posts and Telecommunications since the formation of the ministry, retires on August 2nd. Immediately prior to this appointment he was deputy director of research at the Post Office having been staff engineer in the radio planning and provision branch of the Engineering Department from 1952 to 1960. Mr. Stanesby, who is 65, joined the Post Office Radio Laboratories at Dollis Hill as a youth-in-training in 1924 and in 1951 was made responsible for the direction of the laboratories. He played an important part, especially in the design of the quartz crystal filters, in developing coaxial systems for multi-channel telephony.

C. W. Sowton, O.B.E., B.Sc.(Eng.), F.I.E.E., at present deputy director of radio technology at M.P.T., will succeed Mr. Stanesby as head of the department. He is also appointed chairman of the technical sub-committee set up by the Television Advisory Committee which was reconstituted by the Minister last January. Mr. Sowton was staff engineer in the overseas radio planning and provision branch of the Post Office from 1961 until his appointment in the M.P.T. in 1969. For about 10 years prior to 1961 he was concerned with the technical aspects of the sound and television broadcasting services in this country, especially on questions of frequency allocation. He was also for some years secretary of the T.A.C. technical sub-committee. The other members of the T.A.C. technical sub-committee, of which Mr. Sowton is chairman, are: **Professor J. Brown** and **Dr. J. A. Saxton** (independent members); **M. A. E. Butler, R. J. Clayton** and **K. I. Jones** (radio industry); **R. P. Gabriel** (Relay Services Assoc.); **J. Stuart Sansom** (Independent TV Companies Assoc.); **J. Redmond** (B.B.C.); **F. Howard Steele** (I.T.A.); **J. K. S. Jowett** and **D. Wray** (Post Office); **E. S. Mallett** (Dept. of Trade and Industry); and **T. Kilvington** (Min. Post & Tel.). The reconstituted technical sub-committee has been asked by the T.A.C. for advice on the technical problems involved, the time scale for implementation and the costs of development in terrestrial and satellite broadcasting, the distribution of broadcasting by wire and the introduction of apparatus to be used with television sets for recording and playing back programmes.

E. L. E. Kluth, Ph.D., M.Sc., has been appointed assistant to the managing director, **P. C. G. Danby,** of Brookdeal Electronics Ltd, of Bracknell, Berks. Born in Danzig, Dr. Kluth, who is 32, came to England in 1964 to take his Ph.D. at Reading University, having spent the previous twelve years in Canada where he graduated and gained his masterate at the University of Manitoba. In 1968 he went to the U.S.A. and spent 18 months on a post-doctoral fellowship at the State University of New York, Buffalo, concentrating on low temperature specific heat measurements. Since 1969 he has been with Moore Business Forms Inc. of Niagara Falls, New York, as a research physicist in charge of the physics department.

The gold medal of the Royal Television Society "for outstanding contributions to television", has been awarded to **T. H. Bridgewater,** O.B.E., F.I.E.E., who retired from the B.B.C. three years ago. Mr. Bridgewater, who is 63, joined the Corporation in 1932 as an assistant maintenance engineer in the small nucleus of staff who installed and operated the experimental 30-line television studio, after working for four years on television development with Baird. He was appointed a senior maintenance engineer at Alexandra Palace when the B.B.C's 405-line service started in 1936. After war service with the R.A.F., in which he was engaged on radar and navigational aids and attained the rank of Squadron Leader, he returned to the B.B.C. in 1946. He became superintendent engineer, television outside broadcasts in 1952 and chief engineer, television in 1962, a post he held until his retirement.

A. C. Richards has been appointed deputy managing director of International Aeradio Ltd which he joined in 1947. As head of the Services Division he will be responsible for the organization which plans, installs, operates and maintains technical services for aviation and telecommunications in nearly 60 countries. He will also have overall responsibility for the subsidiary companies overseas. Following commissioned service in the Royal Air Force during the war, Mr. Richards joined the company as an air traffic control officer. He served at a number of stations overseas including acting as adviser on air traffic control to the Director General of Civil Aviation in Italy.

Norman Parker-Smith (right), technical manager of Marconi's Broadcasting Division, receiving, on behalf of the design team responsible for the Marconi mark VIII colour camera, a Pye trophy, plus £1050, from Peter Threlfall (managing director of Pye) at the Royal Television Society's annual ball, on May 14th. The camera was chosen as "the most significant contribution during the year to the development of colour television". The team also received the Society's Geoffrey Parr Award.

David G. Dalgoutte is this year's recipient of the John Logie Baird Travelling Scholarship awarded jointly by Radio Rentals and the Royal Television Society. David Dalgoutte left the High School of Glasgow in 1966 for Glasgow University where he took a B.Sc. with first class honours last year. He also won the Isaac Newton Medal in Natural Philosophy and is now doing post-graduate research in optical guided waves. He plans to visit the U.S.A. to extend his studies.

The Marconi International Marine Co. has announced the appointment of **John Older** as its representative in North America. He succeeds **David Bowker** who is returning to the United Kingdom to take up another appointment. Mr. Older joined the company's sea-going radio officer staff in 1956 and in 1964 was appointed to the staff at the Hull depot as a marine technical assistant. He has served at various company depots both at home and overseas, his last appointment being company representative in Nigeria.

Keith H. Billings, M.I.E.R.E., has joined Coutant Electronics as head of their ceramic thick film and encapsulation activities. Mr. Billings was formerly technical manager of the standard and encapsulated power supply development group at Roband Electronics for 4½ years. Before that he was with the Ministry of Technology as technical controller of the electronics test equipment design and development group.

V. O. Stokes, who joined the Marconi Company in 1926 and has throughout most of his career worked on transmitter research and development, has retired. Last year his book 'Radio Transmitters' was published. Mr. Stokes has been editor of the company's journal *Point-to-Point* since 1965.

Ernest Milner, aged 45, has been appointed director of market development with A. B. Electronic Components Ltd, of Abercynon, Glamorgan. Mr. Milner joined A. B. Electronics 14 years ago as chief development engineer. He served his apprenticeship with G.E.C. and studied at the Bradford Technical College.

World of Amateur Radio

Television interference on u.h.f.

The description, in last month's 'World of Amateur Radio', of the Swedish tests on television receiver immunity—or lack of it—to high r.f. fields, resulted in a number of comments from readers. There can be no doubt that many British amateurs are concerned that so little attention has been paid in this country to the assessment and improvement of the immunity performance of television receivers; there is also little doubt that the former hopes that the spread of u.h.f. television might virtually eliminate television interference (TVI) as a serious threat to amateur operation are being rapidly dissipated. The tendency for front-end bipolar transistors to be easily overloaded; the ability of h.f. and v.h.f. signals to leak into the i.f. stages of current television sets; the use of high-frequency silicon planar transistors in a.f. stages—these and many other design factors appear to offset the reduced likelihood of serious harmonic radiation at u.h.f. Another problem which is making itself felt is the new hazard of interference at chroma and colour sub-carrier frequencies of colour receivers.

Whereas a few years ago interference to television reception on Bands IV and V was rare, it is now quite common. Ian Jackson, G3HOX, reports that recent surveys among members of the Echelford and Greenford, Middx, underline that TVI is still much more serious to individual amateurs than might be thought from the official Post Office statistics. Twenty-two Echelford members reported 48 cases: 34 affecting Band I, 16 affecting Band III and 11 affecting Bands IV & V. Nine Greenford members had similarly been concerned with 48 cases: 40 affecting Band I, 23 Band III and 20 Bands IV & V. Most of these cases were dealt with directly by the amateurs concerned and thus will never appear in P.O. statistics. Out of these 96 cases, only one could definitely be attributed to harmonics (actually from the receiver side of a transceiver!), the others are considered to be the result of television receiver design or receiver installation practices. Like many other amateurs, Ian Jackson believes that the set-makers could greatly reduce the susceptibility of u.h.f. receivers to strong local h.f. and v.h.f. signals at negligible cost. Extremely simple high-pass filters and isolating techniques to reduce the leakage of signals into TV receivers along the coaxial outer braiding or the mains leads are often sufficient to overcome the problem.

Unfortunately, British set-makers tend to shrug this off as very much of a minority problem. Indeed, the recently published B.R.E.M.A. annual report for 1970 states on interference that "although isolated complaints have occurred, there has been no widespread instances of interference to domestic TV and radio services during the current year; this may be due to some extent to the increasing use of the u.h.f. rather than the v.h.f. bands for television".

It is true that u.h.f. should be much less susceptible, but it is already clear that this will not be achieved in practice unless rather better immunity to h.f. and v.h.f. signals is built into the sets. It is interesting to note that in the United States a signifant number of American manufacturers and importers now supply high-pass filters at no charge in order to help clear up TVI problems. In Britain, many hundreds of amateurs still voluntarily close-down during television transmission times to avoid the hostility of neighbours who do not appreciate that the fault so often does not lie with the amateur.

V.H.F. notes and news

On May 26th, sporadic E conditions extended up to at least 144 MHz resulting in contacts between British amateurs and stations in Yugoslavia. To encourage more microwave activity, the R.S.G.B. is to issue awards to amateurs making contacts over distances exceeding 500 km on 13 cm; 400 km on 9 cm; 300 km on 6 cm; and 150 km on 3 cm or 15 mm. Minpostel has agreed that the beacon station at Lerwick, GB3LER, should be permitted to operate on 50.1 MHz during darkness after the close-down of television. There are now over 60 beacons operating in Region 1, including 40 in the 144-MHz band and 11 in the 432-MHz band. A recent addition is OE3XAA on 145.988 MHz located at a height of 865 metres on the Hoher Lindkogel in Austria. The American Electronics Industries Association has failed in its attempt to have the band 146 to 148 MHz re-allocated for Citizens' Band operation, but has now formally proposed to the F.C.C. that 220-222 MHz be diverted to a new "Class E" Citizens Radio service; this proposal is being strongly opposed by the A.R.R.L.

Licence figures

The latest Minpostel licence figures again emphasize the rapid increase in Class B (v.h.f. only, phone only) licences. In the 12 months to March 31st, 1971, Class A licences increased by 2.2% to 13,777; Class B by 21.8% to 2656; Class A/mobile by 2.3% to 2558; Class B/mobile by 46.2% to 389; amateur TV by 8.3% to 195. A small but significant number of Class B licencees subsequently take the morse test in order to obtain a Class A licence. To encourage morse training, over 100 morse training sessions are transmitted by British amateurs each week, under an R.S.G.B. agreement with the Ministry which normally forbids messages to be 'broadcast' by amateur stations. Most of the practice sessions are on the 1.8-MHz band, but some are on 3.5, 28, 70, 144 and 432-MHz bands. Organizer of this service is M.A.C. MacBrayne, G3KGU, 25 Purlieu Way, Theydon Bois, Essex.

In brief

C. G. ("Bert") Allen, G8IG, the first amateur ever to obtain a "Worked All Zones" award for telephony operation, died recently . . . Robert Skegg, G3ZGO, has now established two-way slow-scan television contacts with Greece, Italy, United States and Guadeloupe . . . Len Newnham, G6NZ, has recently been appointed "Society Historian" of the R.S.G.B. . . . The Baptist Missionary Society of Great Britain is to operate the special station GB3BMS on July 10 during the Baptist Church Garden Party—the equipment will later go to missionaries in the Congo. . . . A special Weymouth quatercentenary station, GB3WQC, will operate from the Weymouth Arts Centre on July 9-11 . . . GB2SS will operate from the Southern Steam Engine Rally, July 24-25, at Milton Gate, Lewes Road, Polegate, Hants. . . . Mobile rallies being held during July include: July 4 Truro and South Shields; July 11 Upton on Severn; July 17 Winchester; July 18 Scarborough; July 25 Stoney Cross Airfield, New Forest. . . . An Australian 1.8 MHz listener has logged about 30 British amateurs. . . . The prefix SZO instead of SV is being used during 1971 by Greek amateurs to commemorate the 150th anniversary of the Independence of Greece.

Pat Hawker, G3VA

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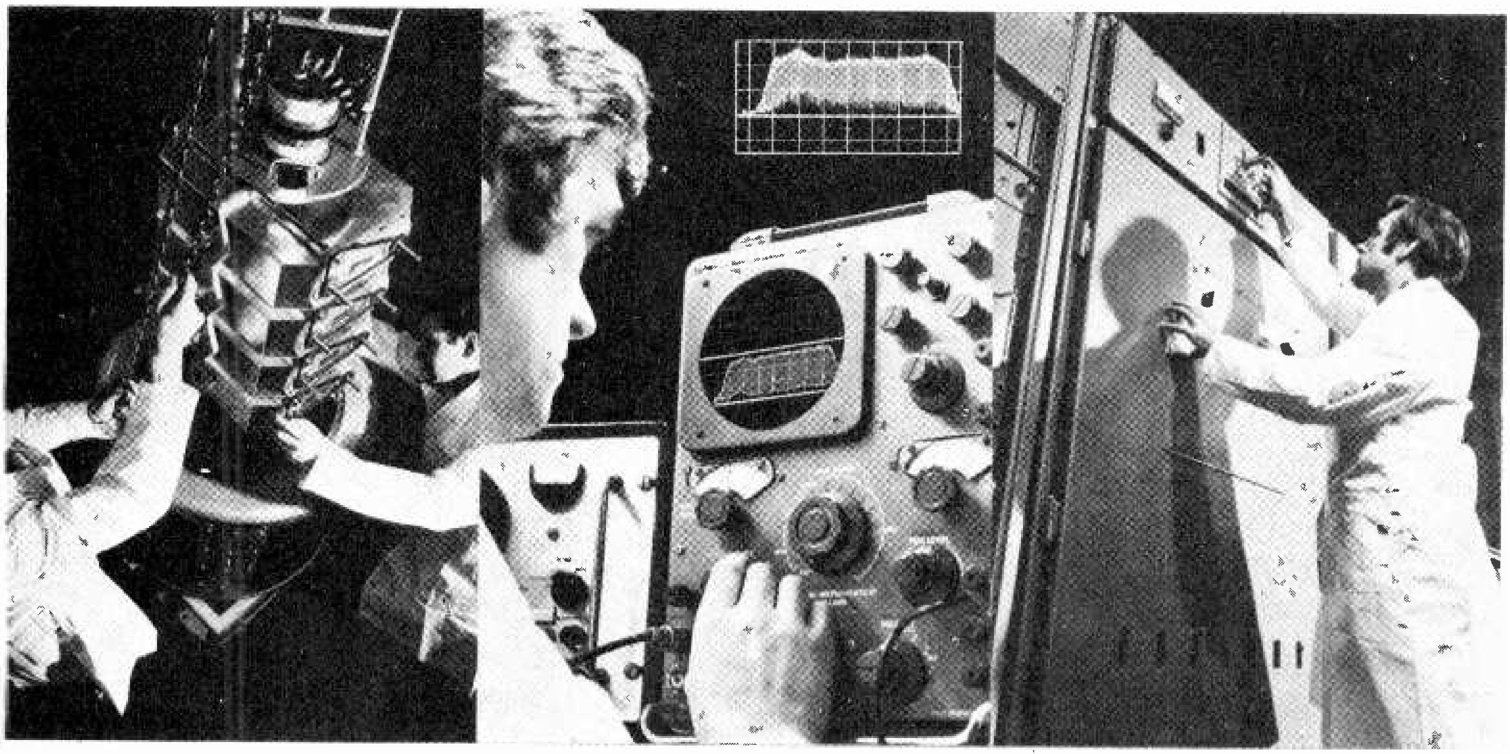

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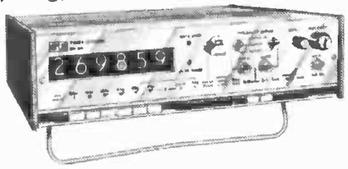

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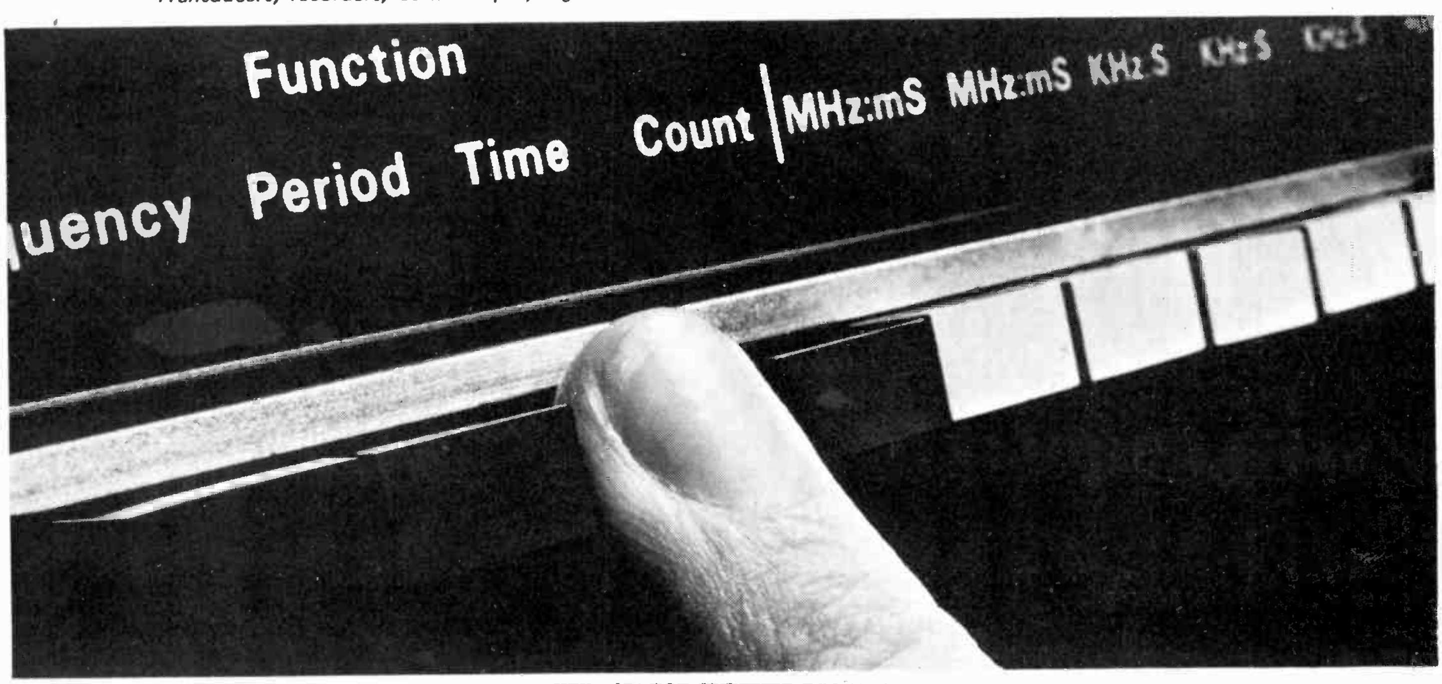


WW—074 FOR FURTHER DETAILS

New Products

TO-5 socket

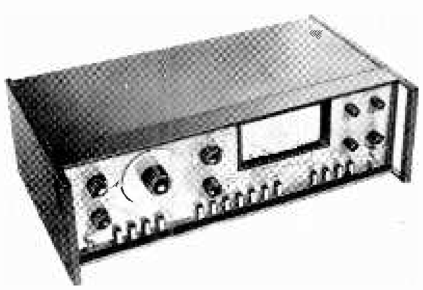
The A23-A2045 TO-5 3-lead socket from Jermyn is of octagonal shape and allows close packing on 0.40in pitch without danger of adjacent devices shorting. The overall height of 0.3in enables devices with leads up to 0.25in long to be fully inserted. The socket is moulded in glass-loaded nylon and is fitted with gold plated phosphor bronze contacts. Contact resistance is typically 11mΩ and capacitance between contacts is 0.7pF. Insulation resistance between the contacts is over 10^4MΩ. The solder tails are suitable for p.c. boards up to 0.125in thick and are arranged on a 0.20in p.c.d. Jermyn Industries, Manufacturing Division, Vestry Estate, Sevenoaks, Kent.
WW304 for further details

Recorder test set

Performance of tape recorders can be measured by the Ferrograph Recorder Test Set RTS 1, a portable instrument. Required characteristics–including frequency response, s/n ratio, distortion, crosstalk, erasure, wow and flutter, input sensitivity and output power–are measured by pressing push buttons which select appropriate sections of the instrument. One section is a signal generator variable from 15Hz to 150kHz with a response flat within $\pm$0.2dB and with distortion less than 0.08% between 100Hz and 20kHz. A level of +5.5dBm can be delivered into a load of 600Ω, and coarse and fine attenuators enable the output to be set precisely over a range of 65dB.

A second section is a millivoltmeter with accuracy within $\pm$2% f.s.d. from 30Hz to 20kHz and with a frequency response flat within $\pm$0.2dB between 10Hz and 150kHz. Its sensitivity can be varied in 10dB steps to give f.s.d. with inputs from 1mV to 100V. The wow and flutter section employs the same indicating instrument but in a circuit that makes it measure peak-to-peak weighted wow and flutter to C.C.I.R. and D.I.N. specifications. There are two ranges of sensitivity, giving f.s.d. for 0.3% or for 1%. An internal oscillator provides the necessary 3.15kHz test frequency. The fourth section enables measurements of total harmonic distortion to be made by the rejection of a fundamental frequency in the range 500 to 1,500Hz. Measurements down to 0.05% are possible with input signals of 100mV or more. There is provision for connecting an external oscilloscope.

The instrument will operate from mains supplies of 105-120V or 200-250V, 50 to 60Hz. It weighs approximately 6.4kg (14lb). Price: £250. The Ferrograph Co. Ltd., The Hyde, Edgware Road, London N.W.9.
WW301 for further details



Low-capacitance f.e.ts

Designed for low-noise applications in wideband amplifiers, the U273A-5A series of Siliconix f.e.ts have a C_{rss} of less than 0.5pF and a C_{iss} of less than 2pF. Noise figure is 20nV/$\sqrt{f}$ (Hz) at 1kHz reducing to half this at around 100kHz. Drain currents are 0.5 to 20mA, 1.0 to 4.0mA and 3.0 to 6.5mA for the three transistors which have a g_{fs} of 500, 600 and 800μmho. Encapsulation is TO-72. Siliconix Ltd, Saunders Way, Sketty, Swansea, SE2 8BA.
WW315 for further details

Stereo simulator

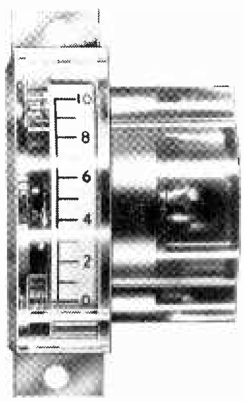
Kampel Electronics are producing a stereophonic source simulator (as a pre-amp function) to provide the left and right channels of a stereo amplifier with distinctly different signals derived from a mono source. According to the manufacturer the simulator is designed to position the instruments of a full symphony orchestra with mono input, avoiding the 'floating instrument' effect, and producing an image lacking only the 'presence' of two channel stereophonic reproduction. The unit is equipped to plug into the tape record/replay facility of a stereo amplifier —a 5-pin DIN plug connector is provided. An external tape socket and tape monitor control is provided on the simulator. When connected the simulator can be switched in or out of circuit.

Specification:
Bandwidth 20H-1MHz
input impedance 50kΩ
max. input 1V
output impedance 1kΩ
insertion gain 1:1 + 1

Power is supplied by a 9V (PP3) battery —current drain is 1mA. Simulator case measures 100 × 62 × 40mm. Price £10 plus 20p p. & p. Kampel Electronics Ltd, 99 Old Christchurch Road, Bournemouth, BH1 1EP.
WW312 for further details

Edgewise panel meters

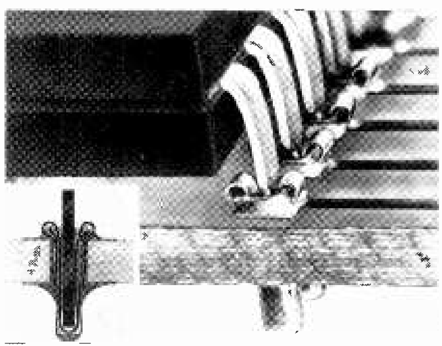
Risso Electronics Products announce a series of panel meters, in which there is the option of fitting either a taut-band or moving-coil movement. The Model 27ME has been designed to make maximum use of space without sacrificing readability. Scale length is 27mm (the earlier Model



47ME has a scale length of 47mm). The accuracy of both models exceeded the requirements of the class 5 category of the new B.S. 89/70 on a.c. and on d.c. is class 2.5 in accordance with B.S. 89/70. Risso Electronics Products Ltd., 137/139 Sandgate Road, Folkestone, Kent.
WW308 for further details

Printed circuit socket

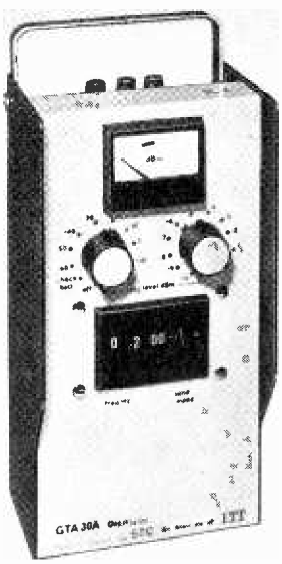
A socket for printed circuit mounting, made by Berg Electronics Inc., of Pennsylvania, has a square cup giving (it is



claimed) more reliable connection than presently available circular cups. A spring, soldered to the board, allows round leads from 0.014 to 0.022in diameter and flat leads 0.008 to 0.011in thick by 0.025in wide to be accepted. The sockets, called Minisert, are available separately or in strip form for use with an inserter machine. Berg Electronics Inc, New-Cumberland, Pennsylvania 17070.
WW303 for further details

Audio oscillators

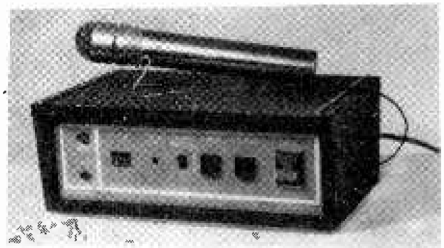
Two spot-frequency oscillators are being made at the Testing Apparatus and Special Systems Division of STC. The GTA-30A (shown) provides 39 spot frequencies from 100Hz to 3900 Hz, using edge switches to give a digital presentation of the frequency. The GTA-30B provides 12 spot frequencies from 200Hz to 3400Hz, using a rotary switch. Both oscillators will



deliver output levels of +10 to −70 dBm into impedances of 75, 140, 150 and 600Ω. Each instrument can be held in the hand while making measurements. The oscillators are powered by internal batteries (two PP7), and the battery life is at least 100 hours. Two sizes of leather carrying cases are available. Size is 114 × 216 × 102mm, and weight 1.6kg including the batteries. Standard Telephones and Cables Ltd., 190 Strand, London, W.C.2.
WW305 for further details

Radio microphone

Reslo-Audac transmitter type TX/100 is built into the microphone and operates with a free hanging wire 17in long. Operating at 174.8MHz, it provides an output of 10mW with a modulator amplitude response of 40Hz to 15kHz ±2dB. Distortion is given as less than 0.5%. A battery charger is built into the receiver RX/A which will feed any good-quality amplifier. Price is £98 each. A cheaper transmitter (type TX/T £60) is separate



from its neck microphone. Reslosound Ltd, 24 Upper Brook Street, London W.1.
WW314 for further details

Low-cost f.e.ts

Redhawk Sales are importing a range of epoxy encapsulated transistors including two f.e.ts having low noise, low capacitance and high gain. Types 2N3823 and 2N4416 (priced at 10p and 24p each in 1000 up quantities) are n-channel TO-18 style devices. Characteristics are:

	3823	4416
V_{gss} (V)	30	30
I_{dss} (mA)	4-20	5-15
$V_{gs(off)}$ (V)	1-7.5	1-5.5
I_{gss} (nA)	0.5	0.1
g_m (μmhos) at 1 kHz	3500-6500	4500-7500
200 MHz	>3200	
400 MHz		>4000
C_{iss} (pF)	6	4
C_{rss} (pF)	2	1
P_d (mW) at 25°C	250	250

Redhawk Sales Ltd., 33 Highfield Road, Flackwell Heath, Bucks.
WW307 for further details

Power NOR gate

The MIC 7428J from ITT Semiconductors is a quad 2-input power NOR gate, with each of its four outputs capable of driving forty standard t.t.l. inputs. Compatible with the MIC 7402J standard NOR gate, it has a typical power dissipation of 100mW, a typical propagation delay of 9ns, and a standard operating temperature range of 0-75°C. ITT Semiconductors, Footscray, Sidcup, Kent.
WW323 for further details

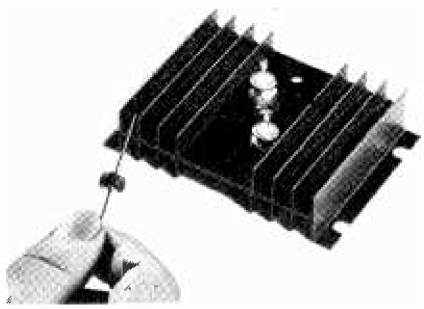
Radiotelephone for v.h.f./a.m.

Ultra Electronics are aiming to increase their share of the mobile radiotelephone market with the introduction of a 15-watt

transceiver. The modulator of the transmitter can be used as a p.a. amplifier with 15W output power when receiving; otherwise output is 3W (10% distortion). Ten channels can be used with either 12.5 or 25kHz spacing. Frequency stability is ±7.5 in 10^6 up to 70°C. Receiver sensitivity is 1μV for 12dB signal-to-noise ratio. Ultra Electronics Ltd, Western Avenue, London W.3.
WW302 for further details

6A rectifier in plastic pack

Motorola Semiconductors are making 6A silicon rectifiers in a plastic, axial lead case. Known as the MR 751 series, they are available in four peak reverse voltage ratings of 100, 200, 400, and 600V. The



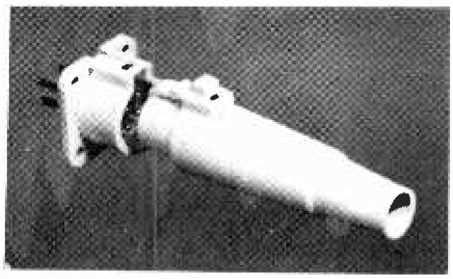
prices are about half those of their stud-mounted equivalents. The MR 751 series have a forward voltage drop of 0.9V (maximum) and a reverse current of 0.25 mA (maximum) at the rated d.c. voltage. Motorola Semiconductors Ltd., York House, Empire Way, Wembley, Middlesex.
WW306 for further details

High impedance voltmeter for a.c.

Model 188 digital voltmeter by G. & E. Bradley has the 'guarded' input circuit used on model 155 oscilloscope. With the guard ring technique a very high input impedance is possible (10,000MΩ) and common-mode rejection is improved. On d.c. ranges accuracy is 0.01%, which on the lowest (100mV) range gives a resolution of 10μV. on a.c. ranges accuracy vaires from 0.1% (up to 5kHz) to 2% (up to 100kHz). A standard cell with a temperature coeffceint of 0.0005% is used as a reference. Binary-coded decimal output is provided. Price £420. G. & E. Bradley Ltd, Electral House, Neasden Lane, London N.W.10.
WW319 for further details

Plastic shrouded connectors

The RPC series of shrouded connectors from Henry & Thomas, are designed to replace DIN types. Both the shell and the insulator are of grey plastic, and the mating parts have an automatic locking



mechanism easily released by press-button action. Male contacts are of gold-plated brass and the female contacts of gold-plated phosphor bronze. The connector has a proof voltage of 500V a.c., a current rating of 5A, insulation resistance of 1000MΩ at 500V d.c., and contact resistance of 5mΩ max at 1A d.c. Price per mated pair is 57p. Henry & Thomas Ltd., Yeo Street, Bow Common, London E.3.
WW310 for further details

Miniature regulated plug-in power supply

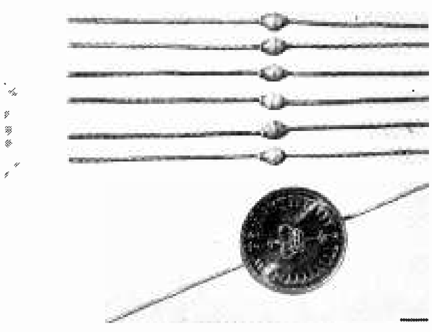
Weir's 5V 2A power supply unit meets the d.c. supply requirements of i.c. logic systems. The design incorporates safeguards including transient over-voltage protection, short circuit and overload protection, remote sensing facilities and rapid response to load change. S.C.R. 'crowbar' over-voltage protection is available as an optional extra (Type 5V 2A*). Price ranges from £12 to £16, depending on the quantity supplied. The specification includes:

output voltage regulation	< 0.05% for ± 10% supply line charge; < 0.1% for 100% load change
temperature coefficient	< 0.02%C typical
ripple and noise	< 2.5mV peak to peak
remote sensing	positive and negative rail sensing provided
operating temperature	−10°C to +55°C
dimensions	95 × 175 × 70mm

Weir Electronics Ltd, Durban Road, Bognor Regis, Sussex.
WW 327 for further details

Miniature rectifiers

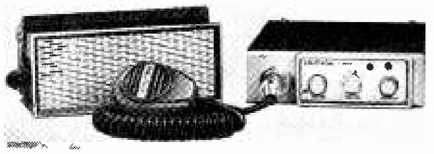
Concord Instrument Company, sole U.K. agents for Solid State Devices Inc., are marketing a range of miniature 2A rectifiers—1N5171 through to 1N5178,



1N4517 and SS009. The range exhibit a maximum forward voltage drop of 1.2V at 25μA. The peak inverse voltage rating ranges from 50V to 1200V and the price from 10p to 24p each (1-9). Concord Instrument Company, 28 Cricklewood Broadway, London N.W.2.
WW311 for further details

Radiotelephone for v.h.f./f.m.

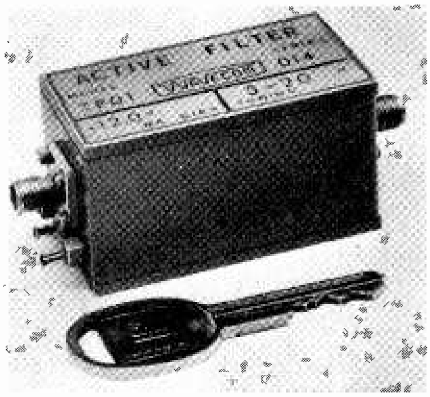
A portable transceiver for mobile use is made by Singer Products Co. Inc., of New York. Operating in the band 150 to 174MHz with five channels using narrow



band f.m., it is rated at 25W output power. When removed from its housing it operates from internal batteries at 8W output power. Singer Products Co. Inc., 30 Church Street, New York, NY10007.
WW313 for further details

V.H.F. active filter

The Wavecom model TP01 low-noise tunable active pre-selector from Wessex Electronics has a tuning range of 215-320MHz, a tuning voltage of 5-20V, a maximum noise figure of 3dB, an insertion



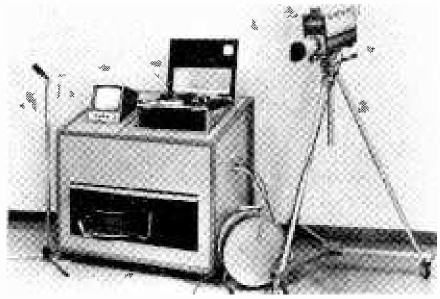
effect of 0-0.2dB, and a bandwidth of 5%. Selectivity is 12dB/octave with a minimum of 40dB out-of-band rejection. Bias requirements are −12V typically at 8mA. Frequency stability in the range −20 to +80°C is −0.1MHz max. Wessex Electronics Ltd., Storer Trading Estate, Yate, Bristol BS17 5QP.
WW309 for further details

Transistor and diode test set

Model T8BQ automatic transistor and diode test set from Lorlin Industries of U.S.A., available from Euro Electronic Instruments can perform up to 8 sequential tests automatically. It can check for breakdown voltage, leakage, gain and saturation voltage with an accuracy of 1%. Voltage and current test levels are set by front panel thumb-wheel controls and results are indicated by panel lights. Programming ranges for current and voltage are 0.1nA to 10A and 10mV to 600V. Test time is normally 16ms for each test. Price £3,900. Euro Electronic Instruments Ltd, Shirley House, 27 Camden Road, London N.W.1.
WW316 for further details

Video system trolley

The Video Systems Division of Bell & Howell A-V Ltd, are producing mobile closed-circuit television modules equipped for recording and replay. The 'Video Trundles' are steel trolleys with camera,



video recorder, and control and mixing equipment. The trolleys are 99.1 cm high and 68.6 cm deep, and available in two standard lengths, 81.3 cm and 122.0 cm Longer versions can be supplied. The 'Trundles' can be supplied 'blank', to be fitted with customer's equipment. Bell & Howell A-V Ltd., Alperton House, Bridgewater Road, Wembley, Middx. HAO 1EG.
WW 317 for further details

Colour camera

Colour c.c.t.v. Viewfinder Camera, model FPC-1000 from Shibaden (U.K.) employs a dichroic mirror optical system and a three-tube colour system. Varying lighting conditions are compensated for by automatic iris control. Also built-in is a 2:1 interlace sync system, a colour bar generator, a colour temperature compensation filter, a camera cable compensator allowing extension to 200m, and an intercom and tally system. Although provided with a 20-100mm f1.8 zoom lens, any 'C' mount lens can be used. Resolution is 400 lines vertically and 300 lines horizontally. Video output is 1V p-p composite (sync negative) and 0.7V p-p non-composite PAL encoded (N.T.S.C. version available). Shibaden (U.K.) Ltd., 61/63 Watford Way, Hendon, London NW4 3AX.
WW 318 for further details

Oscilloscope calibrator. The G. & E. Bradley calibrator, type 192, mentioned on p. 309 of the June issue, provides a 1 nanosecond edge at variable repetition frequencies and not 1ms as stated.

Literature Received

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

Philips have published an attractive little booklet called 'Experiments and measurements with oscilloscopes'. The explanatory text for each measurement is accompanied by a circuit diagram and a colour photograph showing the expected oscilloscope traces. The booklet may be obtained, price 75p from J. M. Wilson, The Philips Electronic Instrument Dept, Pye Unicam Ltd, York St, Cambridge CB1 2PX.

If you would like information on ultrasonic cleaning and ultrasonic plastic assembly Dawe Instruments Ltd, Concord Rd, Western Ave, London, W3 0SD., have some literature available WW435

ACTIVE DEVICES

A 32-page brochure covers the testing procedures used by the National Semiconductor Corp., 2,900 Semiconductor Drive, Santa Clara, California, 95051, on their monolithic and hybrid integrated circuits WW401

A range of epoxy encapsulated transistors, is briefly described in a data sheet from Redhawk Sales, 33 Highfield Rd, Flackwell Heath, Bucks. WW402

RCA Ltd, Sunbury-on-Thames, Middlesex, have available a wall chart showing 22 spectral response curves of the most popular photocathodes used in their range of photomultipliers WW403

We have received the following literature from the Westinghouse Brake and Signal Co. Ltd, 82 York Way, King's Cross, London N.1:

- Technical publication T1161, data on thyristors D1161 and D1161C WW404
- Technical publication TR1167, data on thyristors type D1167 ....WW405
- Data sheet thyristor D1184 (200A, 4.1 to 5.5kV). WW406
- Technical publication DCM 'Driver and controller modules for thyristor application' WW407

A price list is available from Ferranti Ltd, Gem Mill, Chadderton, Oldham, Lancs., covering integrated circuits, transistors, diodes, rectifiers, and opto-electronic devices WW408

IC Distributors, P.O. Box 38, Norwich NOR 95H, Norfolk, have sent us a price list for 74 series t.t.l. integrated circuits WW409

Thyristors and silicon and selenium rectifiers manufactured in Germany by Semikron are described in a brochure from Goodacre & Davenport Semiconductors Ltd, 179 Junction Rd, Burgess Hill, Sussex WW410

The latest addition to the series of mini-books published by the Mullard Educational Service is called thyristors. It may be obtained from the Mullard Educational Service, Torrington Place, London WC1E 7HB ....Price 35p

Toggle switches in all shapes and sizes, indicator lamps and push buttons are the subject of a catalogue from the Industrial Electronic Components Division of Guest International Ltd, Nicholas House, Brigstock Rd, Thornton Heath, Surrey CR4 7JA WW420

The Telephone Cable Division of BICC Ltd, P.O. Box 5, 21 Bloomsbury St, London WC1B 3QN, have produced a leaflet (No. 643) called 'Type 1.2/4.4 coaxial pairs for telephone and television systems' WW421

Electrolube, the well known product for switch cleaning, is described in a leaflet from Electrolube Ltd, Oxford Ave, Slough, Bucks SL1 4LB ..WW422

McArdle & Brainsby (Import & Export) Ltd, P.O. Box 2BB, Newcastle upon Tyne NE99 2BB, have available a leaflet which describes a range of instrument cases marketed under the brand name Impex WW423

A catalogue, called UK 71, from Erie Electronics Ltd, South Denes, Great Yarmouth, Norfolk, lists various types of capacitors, thick film resistors and potentiometers WW424

Extremely small capacitors are described in Engineering Bulletin 3516 which is called 'Solid electrolyte tantalex capacitors for ultra-miniature circuits' and is available from Sprague Electric Co. (UK) Ltd, Sprague House, 159 High St, Yiewsley, West Drayton, Middlesex WW425

A range of capacitors from 0.01 to 22 μF and from 63V. to 400V d.c. working is the subject of a leaflet from Waycom Ltd, Wokingham Road, Bracknell, Berks RG12 1ND WW426

'Inco Nickel No. 30', a magazine published by International Nickel Ltd, Thames House, Millbank, London S.W.1, describes how nickel is used in products from a bicycle to a radio telescope .WW427

The latest catalogue of West Hyde Developments Ltd, Ryefield Crescent, Northwood Hills, Northwood, Middlesex HA6 1NN, lists instrument cases, special tools, Neon indicator lamps, transformers, Pidam modules, etc. WW428

EQUIPMENT

Microphones, general audio equipment, and audio test equipment are listed in the Sennheiser catalogue which is available from Hayden Laboratories Ltd, East House, Chiltern Avenue, Amersham, Bucks., who now market Sennheiser products in the U.K. WW437

A comprehensive range of power supplies is featured in a leaflet from Lambda Electronics Ltd, Marshlands Rd, Farlington, Portsmouth PO6 1ST. WW439

We have received the following literature from Aim Electronics Ltd, The River Mill, St. Ives, Huntingdon, PE17 4EP:

- PSD122A. Phase sensitive detector WW440
- TPD149. Teleptype punch drive WW441
- DCA184A. Amplifier, d.c., intended for tracking filter applications WW442
- ADC 193. Analogue-to-digital converter, conversion time 5 μ s WW443
- PSA194. Phase shift amplifier WW444
- GOA219A. General purpose operational amplifier WW445
- MLS249A. Minilock. equipment for recovering signals from noise, 10μV sensitivity WW446
- FVC250A. Converter, *f* to V WW447

Grampian Reproducers Ltd, The Hanworth Trading Estate, Hampton Rd, West Feltham, Middlesex, have produced a leaflet describing power amplifiers with outputs of 100W and 50W WW450

Electronic counters, digital multimeters and data amplifiers are included in the short-form catalogue of Dana Electronics Ltd, Bilton Way, Dallow Rd, Luton, Beds. WW456

A 128-page catalogue which lists audio equipment and some other domestic items is being produced by KJ Enterprises, 33 Bridle Path, Watford, Herts, WD2 4BZ WW457

Also available from the same address is a musicassette catalogue ....Price 25p

Omron Precision Controls, 313 Edgware Rd, London W2 1BP, who manufacture timers, counters proximity switches, floatless switches etc. have published a price list WW458

A short-form catalogue lists the digital products and the literature available from Analogic, Audubon Road, Wakefield, Mass 01880, U.S.A. WW459

PASSIVE COMPONENTS

Reed switches manufactured in America by Hamlin are described in a catalogue from Inter-Market Services Ltd, 47A Hay's Mews, Berkeley Sq., London W.1. ....WW415

Screws, nuts and washers in metric sizes are the subject of a catalogue from C. W. Sheffield and Kenning Ltd, Wynford Rd, Industrial Estate, Acocks Green, Birmingham B27 6JU WW416

Plugs, sockets, edge connectors, terminal strips, printed circuit tags, micro switches, valve holders, screening cans, and voltage selector panels are among the items covered in a catalogue from United Car Supplies Ltd, Clifton Works, Frederick Rd, Stapleford, Nottingham WW417

A small leaflet lists the range of helical scan video tapes available from the 3M Co. Ltd, 3M House, Wigmore St. London W1A 1ET WW418

A 14-page catalogue called 'coaxial connectors and coaxial cables is available from Radiall Microwave Components Ltd, Romar House, The Causeway, Staines, Middlesex WW419

APPLICATION NOTES

SGS (UK) Ltd, Planar House, Walton Street, Aylesbury, Bucks., have prepared two technical bulletins giving circuit information and application details on two integrated circuits;

- LO45. A channel amplifier intended for use in f.d.m. telephone systems to provide audio power for driving a standard line through a matching transformer (Bulletin No. 107) WW431
- TBA651. An a.m. radio receiver i.c. combining the functions of r.f. amplifier, oscillator, mixer and i.f. amplifier (Bulletin No. 108) WW432

'A simple discussion of time series analysis' is the title of a publication from the General Radio Co. (Overseas), Helenastrasse 3, P.O. Box 8034, Zurich 34, Switzerland, which deals with the recovery of signals from noise, amongst other things WW433

Application report No. 8 from Brookdeal Electronics Ltd, Market Street, Bracknell, Berks., is called Auger Spectroscopy, and deals with surface analysis in industrial and research laboratories WW434

GENERAL INFORMATION

Tektronix UK Ltd, Beaverton House, Harpenden, Herts., have published another book in their measurement concepts series, this is called 'Spectrum Analyzer measurements' ....Price 50p

The Tin Research Institute have published a booklet called Tin and its Uses No. 88 which may be obtained from the Tin Research Institute, Fraser Road, Perivale, Greenford, Middlesex WW460

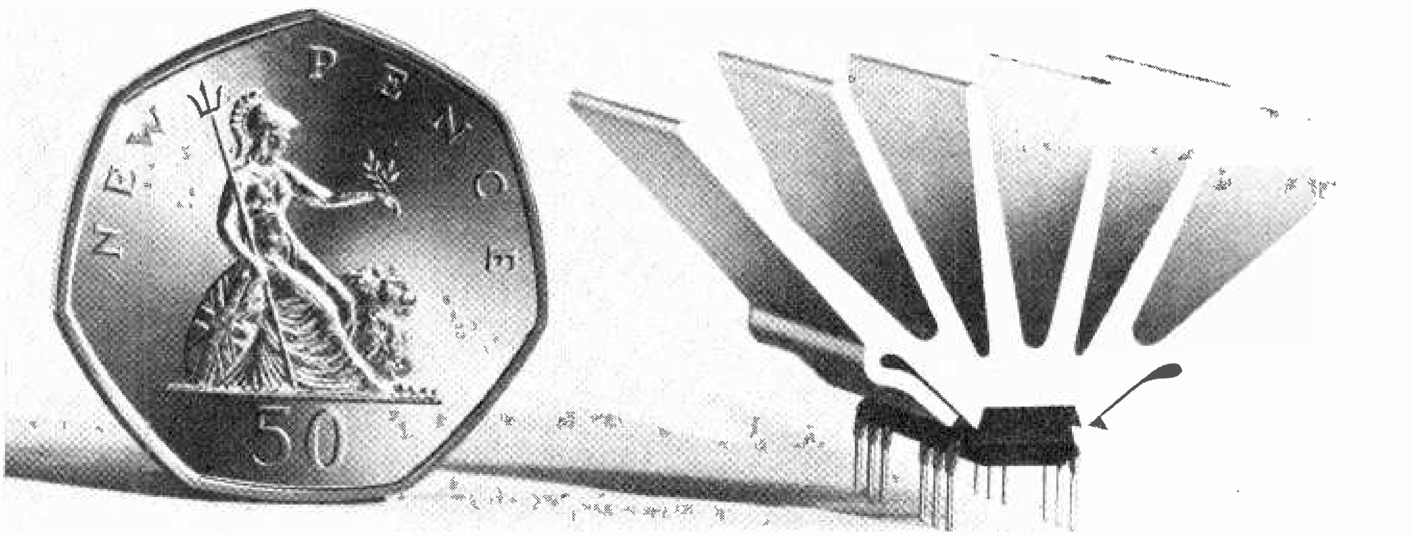
The 1971 issue of the Association of Public Address Engineers Directory may be obtained from the A.P.A.E., 394 Northolt Road, South Harrow, Middlesex HA2 8EY ....Price 25p

BS9210: 1971. 'Specification for radio frequency connectors of assessed quality: Generic Data and Methods of Test' may be obtained from BSI Sales Branch, 101 Pentonville Rd, London, N1 9ND. ....Price 1.60

B.B.C. engineering information sheet No. 4006 (3) deals with u.h.f. television reception, and is available from the Engineering Information Dept, Broadcasting House, London W1A 1AA WW461

new

Super IC-12



High fidelity Monolithic Integrated Circuit Amplifier

Two years ago Sinclair Radionics announced the World's first monolithic integrated circuit Hi-Fi amplifier, the IC.10. Now we are delighted to be able to introduce its successor the Super IC.12. This 22 transistor unit has all the virtues of the original IC.10 plus the following advantages:

1. Higher power.
2. Fewer external components.
3. Lower quiescent consumption.
4. Compatible with Project 60 modules.
5. Specially designed built-in heat sink. No other heat sink needed.
6. Full output into 3, 4, 5 or 8 ohms.
7. Works on any voltage from 6 to 28 volts without adjustment.
8. NEW 22 transistor circuit.

Output power 6 watts RMS continuous (12 watts peak).
Frequency Response 5 Hz to 100KHz ± 1dB.
Total Harmonic Distortion Less than 1% (Typical 0.1%) at all output powers and all frequencies in the audio band.
Load Impedance 3 to 15 ohms.
Power Gain 90dB (1,000,000,000 times) after feedback.
Supply Voltage 6 to 28 volts (Sinclair PZ-5 or PZ-6 power supplies ideal).
Size 22 x 45 x 28 mm including pins and heat sink.
Input Impedance 250 Kohms nominal.
Quiescent current 8mA at 28 volts.
Price: including FREE printed circuit board for mounting. **£2.98** Post free

With the addition of only a very few external resistors and capacitors the Super IC.12 makes a complete high fidelity audio amplifier suitable for use with pick-up, F.M. tuner etc. Alternatively, for more elaborate systems, modules in the Project 60 range such as the Stereo 60 and A.F.U. may be added. The comprehensive manual supplied with each unit gives full circuit and wiring diagrams for a large number of applications in addition to high fidelity. These include car radios, oscillators etc. The very low quiescent consumption makes the Super IC.12 ideal for battery operation.

Sinclair Radionics Ltd., London Rd, St. Ives
Huntingdonshire PE17 4HJ
Telephone St Ives (048 06) 4311

sinclair

WW—075 FOR FURTHER DETAILS

Sinclair Project 60

the world's most advanced high fidelity modules

Sinclair Project 60 presents high fidelity in such a way that it meets every requirement of performance, design, quality and value and now that the remarkable phase lock loop stereo FM tuner is available, it becomes the most versatile of high fidelity systems. With Project 60, it is possible to start with a modest mono record reproducer, and expand it to a sophisticated stereophonic radio and record reproducing system of fantastically good quality to hold its own with any other equipment, no matter how expensive. Project 60 is a unique high fidelity module system where compactness and ease of assembly are combined with circuitry that is far in advance of any other manufacturer in the world. Thus it is extraordinarily easy to assemble any combination of modules using nothing more complicated than the simplest of tools, and you certainly do not have to be experienced to build with complete confidence. The 48 page manual free with Project 60 equipment makes everything easy and you can house your assembly in an existing cabinet, motor plinth, free standing cabinet or virtually any arrangement you wish. Once you have completed your assembly you will have superlatively good equipment to give you years of service and enjoyment. You will have obtained superb value for money because Project 60 is the best selling modular system in Europe and can therefore be produced at extremely competitive prices and with excellent quality control.

	System	The Units to use	together with	Cost of Units
A	Simple battery record player	**Z.30**	Crystal P.U., 12V battery volume control	**£4.48**
B	Mains powered record player	**Z.30, PZ.5**	Crystal or ceramic P.U. volume control etc.	**£9.45**
C	20+20 W. R.M.S. stereo amplifier for most needs	**2 x Z.30s, Stereo 60, PZ.5**	Crystal, ceramic or mag. P.U., most dynamic speakers, F.M. tuner etc.	**£23.90**
D	20+20 W. R.M.S. stereo amplifier with high performance spkrs.	**2 x Z.30s, Stereo 60, PZ.6**	High quality ceramic or magnetic P.U., F.M. Tuner, Tape Deck, etc.	**£26.90**
E	40+40W. R.M.S. de-luxe stereo amplifier	**2 x Z.50s, Stereo 60 PZ.8, mains trsfrmr**	As for D	**£34.88**
F	Outdoor P.A. system	**Z.50**	Mic., up to 4 P.A. speakers controls, etc.	**£5.48**
G	Indoor P.A.	**Z.50, PZ.8, mains transformer**	Mic., guitar, speakers, etc., controls	**£19.43**
H	High pass and low pass filters	**A.F.U.**	C, D or E	**£5.98**
J	Radio	**Stereo F.M. Tuner**	C, D or E	**£25.00**

Sinclair Radionics Ltd., London Road, St. Ives, Huntingdonshire PE17 4HJ.
Tel: St. Ives (048 06) 4311

sinclair

WW—076 FOR FURTHER DETAILS

Sinclair Project 60

Z.30 & Z.50 power amplifiers

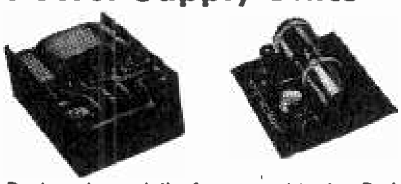
The Z.30 and Z.50 are of advanced design using silicon epitaxial planar transistors to achieve unsurpassed standards of performance. Total harmonic distortion is an incredibly low 0.02% at full output and all lower outputs. Whether you use Z.30 or Z.50 amplifiers in your Project 60 system will depend on personal preference, but they are the same size and may be used with other units in the Project 60 range equally well.

SPECIFICATIONS ***(Z50 units are interchangeable with Z.30s in all applications).***
Power Outputs
Z.30 15 watts R.M.S. into 8 ohms using 35 volts: 20 watts R.M.S. into 3 ohms using 30 volts.
Z.50 40 watts R.M S. into 3 ohms using 40 volts: 30 watts R.M.S. into 8 ohms, using 50 volts.
Frequency response: 30 to 300,000 Hz ±1dB.
Distortion: 0.02% into 8 ohms.
Signal to noise ratio: better than 70dB unweighted.
Input sensitivity: 250mV into 100 Kohms.
For speakers from 3 to 15 ohms impedance.
Size 3½ x 2¼ x ½ in.

Z.30
Built tested and guaranteed with circuits and instructions manual **£4.48**

Z.50
Built, tested and guaranteed with circuits and instructions manual. **£5.48**

Power Supply Units



Designed specially for use with the Project 60 system of your choice.
Illustration shows PZ.5 to left and PZ.8 (for use with Z.50s) to the right. Use PZ.5 for normal Z.30 assemblies and PZ.6 where a stablised supply is essential.

PZ-5 *30 volts unstabilised* **£4.98**
PZ-6 *35 volts stabilised* **£7.98**
PZ-8 *45 volts stabilised (less mains transformer)* **£7.98**
PZ-8 *mains transformer* **£5.98**

Guarantee

If within 3 months of purchasing Project 60 modules directly from us, you are dissatisfied with them, we will refund your money at once. Each module is guaranteed to work perfectly and should any defect arise in normal use we will service it at once and without any cost to you whatsoever provided that it is returned to us within 2 years of the purchase date. There will be a small charge for service thereafter. No charge for postage by surface mail. Air-mail charged at cost.

Stereo 60 pre-amp/control unit

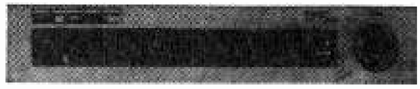
Designed for the Project 60 range but suitable for use with any high quality power amplifier. Again silicon epitaxial planar transistors are used throughout, achieving a really high signal-to-noise ratio and excellent tracking between channels. Input selection is by means of push buttons and accurate equalisation is provided for all the usual inputs.

SPECIFICATIONS
Input sensitivities: Radio–up to 3mV. Mag. p.u. 3mV: correct to R.I.A.A. curve ± 1dB: 20 to 25,000 Hz. Ceramic p.u.–up to 3mV: Aux–up to 3mV.
Output: 250mV
Signal-to-noise ratio: better than 70dB.
Channel matching: within 1dB.
Tone controls: TREBLE + 15 to —15dB at 10KHz: BASS + 15 to—15dB at 100Hz.
Front panel: brushed aluminium with black knobs and controls.
Size: 8¼ x 1½ x 4 ins.
Built, tested and guaranteed. **£9.98**

Active Filter Unit

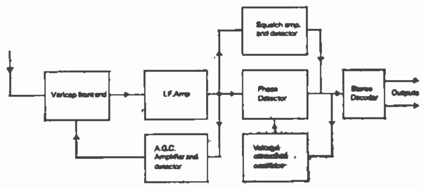
For use between Stereo 60 unit and two Z.30s or Z.50s, and is easily mounted. It is unique in that the cut-off frequencies are continuously variable, and as attenuation in the rejected band is rapid (12dB/octave), there is less loss of the wanted signal than has previously been possible. Amplitude and phase distortion are negligible. The A.F.U. is suitable for use with any other amplifier system. Two stages of filtering are incorporated—rumble (high pass) and scratch (low pass). Supply voltage – 15 to 35V. Current – 3mA. H.F. cut-off (–3dB) variable from 28kHz to 5kHz. L.F cut-off (–3dB) variable from 25Hz to 100Hz. Distortion at 1kHz (35V. supply) 0.02% at rated output.
Built, tested and guaranteed **£5.98**

Stereo FM Tuner



first in the world to use the phase lock loop principle
Before production of this tuner, the phase lock loop principle was used for receiving signals from space craft because of its vastly improved signal to noise ratio over other systems. Now, for the first time, the principle has been applied to an FM tuner with fantastically good results. Other original features include varicap diode tuning, printed circuit coils, an I.C. in the specially designed stereo decoder and squelch circuit for silent tuning between stations. Sensitivity is such that good reception becomes possible in difficult areas. Foreign stations can be tuned in suitable conditions and often a few inches of wire are enough for an aerial. In terms of a high fidelity this tuner has a lower level of distortion than any other tuner we know. Stereo broadcasts are received automatically as the tuning control is rotated, a panel indicator lighting up as the stereo signal is tuned in. This tuner can also be used to advantage with any other high fidelity system.

SPECIFICATIONS:
Number of transistors: 16 plus 20 in I.C.
Tuning range: 87.5 to 108 MHz
Capture ratio: 1.5dB
Sensitivity: 2μV for 30dB quieting: 7μV for full limiting.
Squelch level: 20μV.
A.F.C. range: ±200 KHz
Signal to noise ratio: >65dB
Audio frequency response: 10Hz—15KHz (±1dB)
Total harmonic distortion: 0.15% for 30% modulation
Stereo decoder operating level: 2μV
Pilot tone suppression: 30dB
Cross talk: 40dB
I.F. frequency: 10.7 MHz
Output voltage: 2 x 150mV R.M.S.
Aerial Impedance: 75 Ohms
Indicators: Mains on: Stereo on; tuning indicator
Operating voltage: 25-30 VDC
Size: 3.6 x 1.6 x 8.15 inches: 91.5 x 40 x 207 mm



Price: **£25** built and tested. Post free

To: SINCLAIR RADIONICS LTD LONDON ROAD ST. IVES HUNTINGDONSHIRE PE17 4HJ

Please send ______________________

Name ______________________

Address ______________________

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WW 7/71

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AC128	13p	OC201	25p
AC176	25p	2G301	13p
ACY17	15p	2G303	13p
AF239	37p	2N1302-3	40p
AF186	50p	2N1304-5	25p
AF139	37p	2N1306-7	30p
BC154	25p	2N1308-9	35p
BC171=BC107	13p	BC113	10p
BC172=BC108	13p		
BF194	15p	**Power Transistors**	
BF274	15p		
BFY50	20p	OC20	50p
BSY25	37p	OC23	30p
BSY26	13p	OC25	25p
BSY27	13p	OC26	25p
BSY28	13p	OC28	30p
BSY29	13p	OC35	25p
BSA95A	13p	OC36	37p
OC41	13p	AD149	30p
OC44	13p	2N3055	63p
OC45	13p	2SO34	25p
OC71	13p	**Diodes**	
OC72	13p	AAY42=OA5	10p
OC81	13p	OA91	9p
OC81D	13p	OA79	9p
OC139	13p	OA81	9p
OC140	17p	IN914	7p

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SL 403D Audio Amp. Latest Type	2.00	1.95	1.80
IC. 709C Linear Opp. Amp.	50p	40p	35p
A.E.I. Fully marked & tested Gates	25p	22p	20p
A.E.I. Fully marked & tested Flipflops	50p	40p	30p
OC71/72. Fully tested, unmarked	5p	5p	4p
Matched Sets, 1-OC44, 2-OC45. Per set	25p	20p	15p
Matched Sets, OC45, 1st & 2nd I.F. Per set	15p	12p	10p
TIC45 Thyristors, 6A, 60V, Texas	15p	15p	12p
OA47 Gold bonded Diodes, marked & tested	3p	3p	2p
1W Zener Diodes: 6.8V, 7.5V, 24V, 27V, 30V & 43V	5p	4p	3p
10W Zener Diodes: 7.5V, 11V, 13V, 20V & 100V	20p	17p	15p
Micro Switches, S/P, C/O. Popular size	25p	20p	15p
1 Amp. Bridge Rectifiers, 25V, RMS	25p	22p	20p

1 Amp Plastic Rectifiers: These are voltage, reverse Polarity and other rejects from the BY127 range. Ideal for low voltage Power Units etc. Price: £1 per 100.

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B81	10	Reed Switches, mixed types, large and small.	50p
B99	200	Mixed Capacitors. Post and packing 13p Approx. Quantity counted by weight.	50p
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H7	40	Wirewound Resistors. Mixed Values. Postage 7p.	50p
H9	2	OCP71 Light Sensitive Photo Transistors.	50p
H12	20	NKT155/259 Germ diodes, brand new stock clearance.	50p
H18	10	OC71/75 uncoded black glass type PNP Germ.	50p
H19	10	OC81/81D uncoded white glass type PNP Germ.	50p
H28	20	OC200/1/2/3 PNP silicon uncoded tolscan.	50p
H29	20	OA47 gold bonded diodes coded MCS2.	50p

F.E.T. PRICE BREAKTHROUGH
This field effect transistor is the 2N3823 in a plastic encapsulation; coded 3823E. It is an ideal replacement for the 2N3819. Data Sheet supplied with device.

1—10 = 30p each, 10—50 = 25p each, 50 + 20p each.

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PNP Silicon alloy, metal TO-5 can. 2S300 type, direct replacement for the OC200/203 range	**PNP Silicon** PLASTIC ENCAPSULATION, low voltage but good gain, these are of the 2N3702/3 and 2N4059/62 range.	**NPN Silicon** PLASTIC ENCAPSULATION Low Noise Amplifier of the 2N3707/8/9/10/11 Series.	**PNP Germanium** AF OR RF please state on order. Fully marked and tested.

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NPN/PNP Silicon Planar Transistors, mixed untested, similar to 2N706/6A/8, BSY26-29, BSY95A, BCY70 etc. £4.25 per 500. £8.00 per 1,000.

Silicon Planar NPN Plastic Transistors, untested, similar to 2N3707-11 etc. £4.25 per 500. £8.00 per 1,000.

Silicon Planar Diodes, DO-7 Glass, similar to OA200/202, BAY31-36. £4.50 per 1,000.

NPN/PNP Silicon Planar Transistors, Plastic TO-18, similar to BC113/4, BC153/4, BF153/160 etc. £4.25 per 500. £8.00 per 1,000.

OC44, OC45 Transistors, fully marked and tested. 500 plus @ 8p each. 1,000 plus @ 6p each.

OC71 Transistors, fully marked and tested. 500 plus @ 6p each. 1,000 plus @ 5p each.

3823E Field effect Transistors. This is the 2N3823 in plastic case. 500 plus @ 13p each. 1,000 plus @ 10p each.

1 Amp Miniature Plastic Diodes:
1N4001. 500 plus @ 3p each. 1,000 plus @ 3p each.
1N4004. 500 plus @ 5p each. 1,000 plus @ 4p each.
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B80	8	Dual Trans. Matched O/P pairs NPN. Sil. in TO-5 can	50p
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B86	50	Sil. Diodes sub. min. IN914 and IN916 types	50p
B88	50	Sil. Trans. NPN, PNP, equiv. to OC200/1, 2N706A, BSY95A, etc.	50p
B60	10	7 watt Xener Diodes Mixed Voltages	50p
H6	40	250mW. Zener Diodes DO-7 Min. Glass Type	50p
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2N3820	60p
2N4058	17p
2N4061	15p
2N5457	35p
2N5458	37p
2N5459	50p
28301	50p
2S302	50p
2S303	60p
2S304	75p
40250	50p
40361	55p
40362	60p
AAY30	10p
AAY42	15p
AAZ13	12p
AAZ17	10p
AC107	37p
AC126	25p
AC127	25p
AC128	25p
AC176	25p
AC187	30p
AC188	30p
ACY17	30p
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ACY20	22p
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ACY40	15p
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AD162	37p
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AF126	17p
AF127	17p
AF139	30p
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AF181	42p
AF186	40p
AF239	42p
ASY26	25p
ASY27	32p
ASY28	25p
ASY29	30p
ASY67	47p
ASZ21	42p
BA115	7p
BA164	10p
BAX13	6p
BAX16	7p
BAY31	7p
BAY38	17p
BC107	12p
BC108	12p
BC109	12p
BC113	25p
BC114	35p
BC115	32p
BC116	40p
BC116A	45p
BC118	37p
BC119	50p
BC134	37p
BC135	30p
BC136	35p
BC137	40p
BC138	40p
BC147	17p
BC148	12p
BC149	20p
BC154	37p
BC157	20p
BC158	17p
BC159	20p
BC169C	15p
BC177	25p
BC178	25p
BC179	27p
BC182L	12p
BC183L	12p
BC184L	15p
BC212	12p
BCY30	25p
BCY31	30p
BCY32	50p
BCY33	25p
BCY34	30p
BCY38	40p
BCY39	60p
BCY40	50p
BCY58	25p
BCY59	25p
BCY70	20p
BCY71	30p
BCY72	15p
BCY78	30p
BCY79	30p
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BF178	25p
BF179	40p
BF180	37p
BF181	30p
BF182	32p
BF184	25p
BF185	25p
BF194	17p
BF195	15p
BF196	15p
BF197	15p
BF200	37p
BF274	37p
BFX13	25p
BFX29	30p
BFX30	32p
BFX37	32p
BFX84	30p
BFX85	40p
BFX86	32p
BFX87	32p
BFX88	30p
BFY18	30p
BFY50	22p
BFY51	20p
BFY52	22p
BFY53	17p
BFY90	65p
BSX20	17p
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OA73	10p
OA79	10p
OA81	10p
OA85	12p
OA90	10p
OA91	7p
OA95	7p
OA200	7p
OA202	10p
OC16	50p
OC20	97p
OC22	50p
OC23	60p
OC24	60p
OC25	37p
OC26	25p
OC28	62p
OC29	62p
OC35	50p
OC36	62p
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7402	Quadruple 2-input Positive Nor Gates	23p	20p	15p	13p
7403	Quadruple 2-input Positive Nand Gates (with open collector output)	23p	20p	15p	13p
7404	Hex Inverters	23p	20p	15p	13p
7410	Triple 3-input Positive Nand Gates	23p	20p	15p	13p
7413	Dual 4-input Schmitt Trigger	35p	32p	29p	25p
7420	Dual 4-input Positive Nand Gates	23p	20p	15p	13p
7430	8-input Positive Nand Gates	23p	20p	15p	13p
7440	Dual 4-input Positive Nand Buffers	23p	20p	15p	13p
7441	BCD to decimal nixie driver	87p	77p	67p	60p
7442	BCD to decimal decoder (4-10 lines, 1 of 10)	87p	77p	67p	60p
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7450	Expandable dual 2-input And-Or-Invert	23p	20p	15p	13p
7451	Dual 2-wide 2-input And-Or-Invert Gates	23p	20p	15p	13p
7453	Quad 2-input Expandable And-Or-Invert	23p	20p	15p	13p
7454	4-wide 2-input And-Or-Invert Gates	23p	20p	15p	13p
7460	Dual 4-input Expander	23p	20p	15p	13p
7470	Single-phase J-K Flip-Flop	35p	32p	29p	25p
7472	Master-slave J-K Flip-Flop	35p	32p	29p	25p
7473	Dual Master-slave J-K Flip-Flop	43p	40p	37p	33p
7474	Dual O type Flip-Flop	43p	40p	37p	33p
7475	Quad latch	47p	45p	43p	40p
7476	Dual J-K with pre-set and clear	47p	45p	43p	40p
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7483	Quad Full Adder	87p	77p	67p	60p
7486	Quad 2-input Exclusive Or Gates	80p	70p	60p	50p
7490	BCD decade counter	87p	77p	67p	60p
7491	8-bit Shift Registers	£1·21	£1·00	87p	75p
7492	Divide-by-Twelve Counters	87p	77p	67p	60p
7493	4-bit Binary Counters	87p	77p	67p	60p
7494	Dual entry 4-bit shift register	87p	77p	67p	60p
7495	4-bit up-down Shift Register	87p	77p	67p	60p
7496	5-bit Parallel in Parallel out Shift Register	£1·10	£1·00	90p	80p
74100	8-bit Bistable Latches	£1·75	£1·65	£1·55	£1·35
74118	Hex Set-Reset Latches	£1·30	£1·20	£1·00	85p
74121	Monostable Multivibrators	87p	77p	67p	60p
74141	BCD-to-Decimal Decoder/Driver	87p	77p	67p	60p
74145	BCD-to-Decimal Decoder/Drivers	£1·80	£1·70	£1·60	£1·50
74151	8-bit Data Selectors (with Strobe)	£1·40	£1·30	£1·20	£1·05
74153	Dual 4-Line-to-1-Line Data Selectors/Multiplexers	£1·40	£1·30	£1·20	£1·05
74191	Binary Counter reversible	£3·50	£3·25	£3·00	£2·50

Devices may be mixed to qualify for quantity price.
Data available for above series in booklet form, price **10p.** *(Ref. No. 30.) Larger quantity prices Extn. 4.* Dual Inline 14 Pin Sockets **30p** each; 16 Pin **35p** each.

TRIACS

All stud mounting with accessories. *Larger quantity prices on application. Extn. 4.*

Type	P.I. volts	Current	1-49	50+	100+	500+
SC35A	100	3A	90p	75p	65p	60p
SC35B	200	3A	95p	80p	70p	65p
SC35D	400	3A	£1·00	85p	75p	70p
SC40A	100	6A	£1·00	85p	75p	70p
SC40B	200	6A	£1·20	£1·00	85p	80p
SC40D	400	6A	£1·25	£1·10	£1·00	90p
SC45A	100	10A	£1·25	£1·10	£1·00	90p
SC45B	200	10A	£1·35	£1·20	£1·10	£1·00
SC45D	400	10A	£1·50	£1·35	£1·20	£1·10
SC50A	100	15A	£1·65	£1·50	£1·35	£1·20
SC50B	200	15A	£1·75	£1·60	£1·45	£1·30
SC50D	400	15A	£2·00	£1·75	£1·60	£1·40
SC40E	500	6A	£1·50	£1·25	£1·10	£1·00
SC45E	500	10A	£1·75	£1·50	£1·35	£1·25
SC50E	500	15A	£2·25	£2·00	£1·75	£1·55
DIAC ST2			20p			

SILICON RECTIFIERS

1 AMP MINIATURE WIRE ENDED PLASTIC

Type	P.I.V.	1-49	50+	100+	500+	1000+
IN4001	50	8p	7p	6p	5p	4p
IN4002	100	9p	8p	7p	5½p	4½p
IN4003	200	10p	9p	7½p	6p	5p
IN4004	400	10p	9p	8p	7p	6p
IN4005	600	12p	10p	9p	7p	7p
IN4006	800	15p	14p	12p	11p	9p
IN4007	1000	20p	16p	13p	12p	10p

1·5 AMP MINIATURE WIRE ENDED PLASTIC

Type	P.I.V.	1-49	50+	100+	500+	1000+
PL4001	50	10p	9p	8p	7p	6p
PL4002	100	11p	10p	9p	8p	7p
PL4003	200	12p	11p	10p	9p	8p
PL4004	400	12p	11p	10p	9p	8p
PL4005	600	15p	13p	11p	10p	9p
PL4006	800	17p	15p	13p	12p	10p
PL4007	1000	20p	17p	15p	13p	11p

3 AMP PLASTIC WIRE ENDED RECTIFIERS

Type	P.I.V.	1-49	50+	100+	500+	1000+
PL7001	50	20p	18p	17p	16p	14p
PL7002	100	20p	19p	18p	17p	15p
PL7003	200	22p	20p	19p	18p	16p
PL7004	400	25p	23p	21p	20p	18p
PL7005	600	26p	24p	23p	22p	20p
PL7006	800	27p	25p	24p	23p	21p
PL7007	1000	30p	28p	26p	24p	22p

MINIATURE POTTED BRIDGE RECTIFIERS

(Silicon) Size ½ in. × ½ in. × ⅜ in.

Type	P.I.V.	Current	1-49	50+	100+	500+
1002	100	2 amps	60p	55p	50p	45p
2002	200	2 amps	70p	65p	60p	55p
4002	400	2 amps	80p	75p	70p	65p
6002	600	2 amps	90p	80p	75p	70p
1004	100	4 amps	70p	60p	55p	50p
2004	200	4 amps	75p	70p	65p	60p
4004	400	4 amps	80p	75p	70p	65p
6004	600	4 amps	90p	80p	75p	70p
1006	100	6 amps	75p	70p	65p	60p
2006	200	6 amps	80p	75p	70p	65p
4006	400	6 amps	£1·10	£1·00	90p	80p
6006	600	6 amps	£1·25	£1·10	£1·00	90p

INTEGRATED CIRCUITS

MFC4000P	£1·12	MC1304	£2·75
I.C. 12	£2·75	MC724P	60p
PA246	£2·45	741c/T05	85p
TAA263	75p	741c/DIL	85p
TAD100	£1·97	709c/T05	65p
TAD110	£1·97	709c/DIL	65p
MC1303	£2·60	Toshiba 20w Amp	£4·47
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Zener Diodes 3 Watt Plastic Wire Ends 5%
All voltages 6·8 -100 Volts. **30p** each.
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100 + ... 25p
500 + ... 23p
1000 + ... 21p
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Zener Diodes 10 Watt Stud Mounting 5%
All voltages 5·1-100 Volts. **40p** each.
25 + ... 35p
100 + ... 30p
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Stud Mounting 6 amp Range

	P.I.V.	1-49	50+	100+
BYZ10	800	40p	35p	30p
BYZ11	600	35p	30p	25p
BYZ12	400	30p	25p	20p
BYZ13	200	25p	20p	17p

10 amp Rectifiers

	P.I.V.	1-49	50+	100+
SK103	100	45p	40p	37p
SK203	200	50p	45p	42p
SK403	400	55p	50p	45p
SK603	600	60p	55p	50p
SK803	800	75p	70p	65p

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Ref. No.	VA (Watts)	Weight lb	oz	Size cm.	Qty. 1-24 £	Qty. 25-99 £	P.P. each Np
61	100	5	12	10·2 × 8·9 × 8·3	2·28	2·13	52
62	250	12	4	9·5 × 12·7 × 11·4	5·05	4·66	67
63	500	27	0	17·1 × 11·4 × 15·9	9·74	9·01	*
92	1000	40	0	17·8 × 17·1 × 21·6	17·94	16·59	*
128	2000	63	0	24·1 × 21·6 × 15·2	29·66	27·43	*
129	3000	84	0	21·6 × 21·6 × 20·3	46·38	42·90	*
190	6000	178	0	31·1 × 35·6 × 17·1	76·11	70·48	*

AUTO SERIES (NOT ISOLATED)

Ref. No.	VA (Watts)	Weight lb	oz	Size cm.	Auto Taps	Qty. 1-24 £	Qty. 25-99 £	P.P. each Np
113	20		11	7·3 × 4·3 × 4·4	0-115-210-240	0·74	0·69	20
64	75	1	14	7·0 × 6·4 × 6·0	0-115-210-240	1·44	1·33	30
4	150	3	0	8·9 × 6·4 × 7·6	0-115-200-220-240	1·74	1·61	36
66	300	6	0	10·2 × 10·2 × 9·5	,, ,,	3·38	3·13	52
67	500	12	8	14·0 × 10·2 × 11·4	,, ,,	5·03	4·65	67
84	1000	16	0	11·4 × 14·0 × 14·0	,, ,,	9·12	8·84	82
93	1500	28	9	13·5 × 14·9 × 16·5	,, ,,	13·22	12·23	*
95	2000	40	0	17·8 × 16·5 × 21·6	,, ,,	17·26	15·96	*
73	3000	45	8	17·4 × 18·1 × 21·3	,, ,,	23·47	21·73	*

LOW VOLTAGE SERIES (ISOLATED)

PRIMARY 200-250 VOLTS 12 AND/OR 24 VOLT RANGE

Ref. No.	Amps 12V	Amps 24V	Weight lb	oz	Size cm.	Secondary Windings	Qty. 1-24 £	Qty. 25-99 £	P.P. each Np
111	0·5	0·25		12	7·6 × 5·7 × 4·4	0-12V at 0·25A × 2	0·74	0·69	22
213	1·0	0·5	1	0	8·3 × 5·1 × 5·1	0-12V at 0·5A × 2	0·88	0·81	22
71	2	1	1	0	7·0 × 6·4 × 5·7	0-12V at 1A × 2	1·16	1·07	22
18	4	2	2	4	8·3 × 7·0 × 7·0	0-12V at 2A × 2	1·62	1·50	36
70	6	3	3	12	10·2 × 7·6 × 8·6	0-12V at 3A × 2	1·95	1·81	42
72	10	5	6	3	7·9 × 10·8 × 10·2	0-12V at 5A × 2	2·56	2·37	52
17	16	8	7	8	12·1 × 9·5 × 10·2	0-12V at 8A × 2	3·95	3·16	52
115	20	10	11	13	12·1 × 11·4 × 10·2	0-12V at 10A × 2	5·03	4·70	67
187	30	15	16	12	13·3 × 12·1 × 12·1	0-12V at 15A × 2	9·28	8·58	82

30 VOLT RANGE

Ref. No.	Amps.	Weight lb	oz.	Size cm.	Secondary Taps	Qty. 1-24 £	Qty. 25-99 £	P.P. each Np
112	0·5	1	4	8·3 × 3·7 × 4·9	0-12-15-24-30V	0·88	0·81	22
79	1·0	2	0	7·0 × 6·4 × 6·0	,, ,,	1·18	1·10	36
3	2·0	3	2	8·9 × 7·0 × 7·6	,, ,,	1·75	1·63	36
20	3·0	4	6	10·2 × 8·9 × 8·6	,, ,,	2·16	1·95	42
21	4·0	6	0	10·2 × 9·5 × 8·6	,, ,,	2·56	2·37	52
117	6·0	7	8	12·1 × 9·5 × 10·2	,, ,,	3·79	3·51	52
89	10·0	12	2	14·0 × 10·2 × 11·4	,, ,,	6·21	5·74	67

50 VOLT RANGE

Ref. No.	Amps	Weight lb	oz	Size cm.	50 VOLT RANGE	Qty. 1-24 £	Qty. 25-99 £	P.P. each Np
102	0·5	1	11	7·0 × 7·0 × 5·7	0-19-25-33-40-50V	1·16	1·07	30
103	1·0	2	10	8·3 × 7·3 × 7·0	,, ,,	1·69	1·57	36
104	2·0	5	0	10·2 × 8·9 × 8·6	,, ,,	2·34	2·16	42
105	3·0	6	0	10·2 × 10·2 × 8·3	,, ,,	3·18	2·94	52
106	4·0	9	4	12·1 × 11·4 × 10·2	,, ,,	4·20	3·89	52
107	6·0	12	4	12·1 × 11·1 × 13·3	,, ,,	6·21	5·74	67
118	8·0	18	9	13·3 × 13·3 × 12·1	,, ,,	8·10	7·49	97
119	10·0	19	12	16·5 × 11·4 × 15·9	,, ,,	10·15	9·39	97

60 VOLT RANGE

Ref. No.	Amps.	Weight lb	oz	Size cm.	60 VOLT RANGE	Qty. 1-24 £	Qty. 25-99 £	P.P. each Np
124	0·5	2	4	8·3 × 9·5 × 6·7	0-24-30-40-48-60V	1·18	1·09	36
126	1·0	3	0	8·9 × 7·6 × 7·6	,, ,,	1·64	1·52	36
127	2·0	5	6	10·2 × 8·9 × 8·6	,, ,,	2·56	2·37	42
123	4·0	10	6	11·4 × 9·5 × 11·4	,, ,,	5·03	4·65	67
120	6·0	16	12	13·3 × 12·1 × 12·1	,, ,,	7·28	6·73	82
122	10·0	23	2	16·5 × 12·7 × 16·5	,, ,,	12·05	11·15	*

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Ref. No.	Amps.	Weight lb	oz	Size cm.		Qty. 1-24 £	Qty. 25-99 £	P.P. each Np
45	1·5	1	9	7·0 × 6·0 × 6·0	Please note, these units do not include rectifiers	1·17	1·08	30
5	4·0	3	11	10·2 × 7·0 × 8·3		1·77	1·64	42
86	6·0	5	12	10·2 × 8·9 × 8·3		2·67	2·47	52
146	8·0	6	4	8·9 × 10·2 × 10·2		3·04	2·82	52
50	12·5	11	14	13·3 × 10·8 × 12·1		4·52	4·18	67

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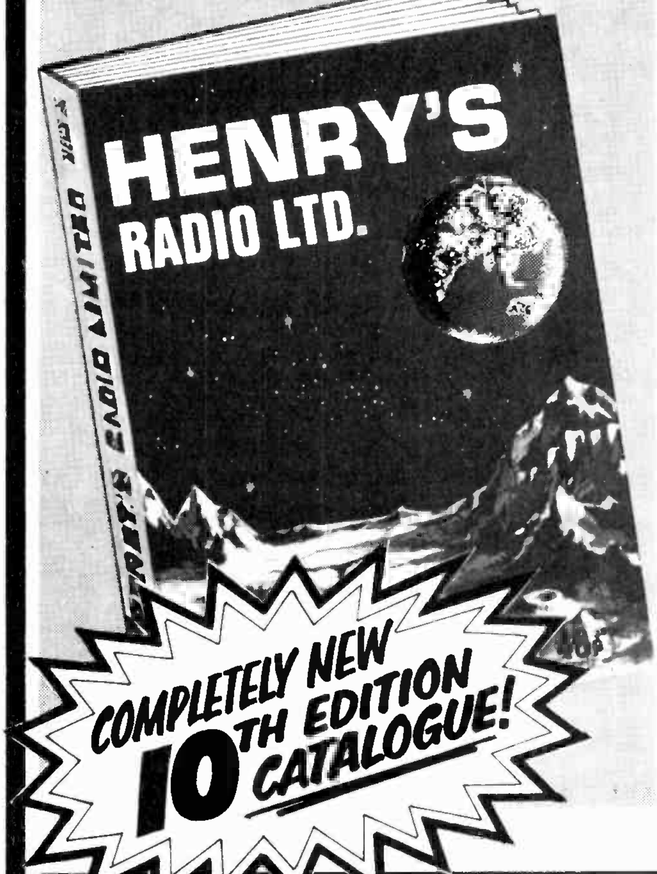

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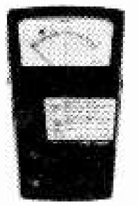

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Miniature solenoid driven wafer switches, type-Ledex single pole, 7 pos., 3 wafers. Primarily used for channel switching in Radio-Telephones. Wafers may be substituted for any type. Solenoid voltage, 12 or 24V. Brand new. **£1·50** each, p.p. 12½p.

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Range 15kHz to 160MHz very useful noise for factor measurements of receivers/wide band I.F. amplifiers etc., the instrument is directly calibrated in noise factor and displayed on panel meter, also output meter calibrated in dbs, for 115-250 vac operation offered in good used condition, small size low price only **£8** Carr. 50p.

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No waiting, straight off the shelf and into your equipment, the Catalogue Nos. are 2202A, 4/33A63/1; coil resistance is 250 ohms. Complete with base, and the price is **£5.** Limited quantity only available.
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American Manufacture
Suitable for aerial changeover and high frequency switching up to 1,000 MHz miniature Vacuum drawn type 110 v dc operation connections BNC and N types. Offered brand new, boxed. Price **£3·25.**

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Transparent casing. Size 2¼×5×7 in. Offered brand new and boxed, 2 batteries per box, complete with links and full instructions. Can supply voltages in the range from 2-20v. Price **£2·25,** inc. P.&.P.

BURNDEPT RF PLUGS still available. These hard to find plugs are used on a multitude of equipment, especially Londex aerial c/o relays. Offered new ex. equipment. 2 for **50p,** inc. p.p.

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Capacitance range 0 to 100 pf fully screened with engraved vernier sub-divided into 100 equal divisions complete with vernier index and original manufacturers seal offered brand new, at only **£25** each.

SOLARTRON PULSE GENERATOR GP1101.2: Period—2 microsecs to 100 msec; Pulse Duration—1 microsec to 100 msec; Delay time—1 microsec to 10 msec. All continuously variable in 5 ranges with fine control. Accuracy ±10%. Pulse Amplitude—0.5V-100V. Accuracy ±10% continuously variable in 4 ranges with fine control. Double Pulses; Pre-Pulse; Triggering; Square Wave O/put; Squaring Amplifier. Input—100-250V, 50-60 c/s. New condition with Manual. Price: **£85** each + £1·25 carr.

USM-24C OSCILLOSCOPE: 3 in. oscilloscope with 2c/s to 10Mc/s vertical response, and 8c/s to 800Kc/s horizontal response. Sensitivity 50 mv. rms/inch. Triggered sweep, built-in trigger pulses and markers. Mains input 115V, 50c/s. Complete with all leads, probes and circuit diagram. **£42·50** each, carr. £2.

OS-46/U OSCILLOSCOPE: A general purpose oscilloscope suitable for measuring signals from 0-1000V d.c. to over 50,000 c.p.s. (Further details on request, S.A.E.) **£35** each, carr. £1·50.

SIGNAL GENERATOR TS-510A/U: (Hewlett Packard). A general-purpose signal generator designed to furnish signals with a very low spurious energy content, suitable for alignment of narrow-band amplitude modulated receivers. It may be amplitude modulated by internally generated sine waves or by externally applied sine waves or pulses. Freq. Range—10-420 Mc/s in 5 bands, ±0.5% accuracy. Emission—AM, CW, Pulse. O/put Voltage—0.1V-0.5V, calibrated ±2 db accuracy. Modulation—Internal 400, 1000 c/s (0-90%). Built-in Crystal calibrator (1, 5 Mc/s). Price: **£150** each, complete with transit case, manual and all leads; OR **£125** each, Sig. Gen. only. Carr. both types £2.

SIGNAL GENERATOR TS-403B/U (or URM-61A): (Hewlett Packard). A portable, self-contained, general-purpose test equipment designed for use with radio and radar receivers and for other applications requiring small amounts of RF power such as measuring standing-wave ratios, antenna and transmission line characteristics, conversion gain, etc. Both the output freq. and power are indicated on direct-reading dials. 115V, AC, 50 c/s. Freq.—1800-4000 Mc/s. CW, FM, Modulated Pulse—40-4000 pulses per sec. Pulse Width—0.5-10 microsecs. Timing—Undelayed or delayed from 3-300 microsecs from external or internal pulse. O/put—1 milliwatt max., 0 to —127 db variable. O/put Impedance—50 Ω. Price: **£120** each + £2 carr.

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TEST SET TS-147C: Combined signal generator, frequency meter and power meter for 8500-9600 Mc/s. CW or FM signals of known freq. and power or measurement of same. *Signal Generator:* O/put —7 to —85 dbm. Transmission—FM, PM, CW. Sweep Rate—0-6 Mc/s per microsec. Deviation—0-40 Mc/s per sec. Phase Range—3-50 microsec. Pulse Repetition Rate—to 4000 pulses per sec. RF Trigger for Sawtooth Sweep—5-500 watts peak. 0.2-6 microsec. duration, 0.5 microsec pulse rise time. Video Trigger for Sawtooth Sweep—Positive polarity, 10-50V peak. 0.5-20 microsec duration at 10% max. amplitude, less than 0.5 microsec rise time between 90% and 10% max. amplitude points. *Frequency Meter:* Freq. 8470-9360 Mc/s. Accuracy—+2.5 Mc/s per sec. absolute, + 1.0 Mc/s per sec. for freq. increments of less than 60 Mc/s relative, ±1.0 Mc/s per sec. at 9310 Mc/s per sec. calibration point. Accuracy measured at 25° C and 60 humidity. *Power Meter:* Input: + 7 to + 30 dbm. Output — 7 to — 85 dbm. Price: **£75** each + £1 carr.

SIGNAL GENERATOR TS-418/URM49: Covers 400-1000 Mc/s range. CW, Pulse or AM emission. Power Range—0-120 dbm. Price: **£105** each + £1·25 carr.

TELEMETRY AUDIO OSCILLATOR TYPE 200T: (Hewlett Packard). Freq.— 250 c/s-100 Kc/s. 5 over-lapping bands. High stability. O/put 160 mw or 10V into 600 Ω Price: **£65** each + £1·25 carr.

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CT.54 VALVE VOLTMETER: Portable battery operated. In strong metal case with full operating instructions. 2.4V-480V. A.C. or D.C. in 6 Ranges, 1Ω to 10MegΩ in 5 Ranges. Indicated on 4in. scale meter. Complete with probe, excellent condition. **£12·50**, carr. 75p.

CT.381 FREQUENCY SWEEP SIGNAL GENERATOR: 85Kc/s-30Mc/s and response curve indicator with 6in. CRT tube and separate power supply. Fully stabilised. Price and further details on request.

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CONDENSERS: 40 mfd, 440 v A.C. wkg. **£5** each, 50p post. 30 mfd 600 v wkg. d.c., **£3·50** each, post 50p. 15 mfd 330 v a.c., wkg., 75p each, post 25p. 10 mfd 1000 v. 63p each, post 13p. 10 mfd 600 v. 43p each, 25p post. 8 mfd 2500 v. **£5** each, carr. 63p. 8 mfd 600 v. **43p** each, post 15p, 8 mfd. 1% 300 v. D.C. **£1·25**, post 25p, 4 mfd. 3000 v. wkg. **£3** each, post 37p. 4 mfd 2000 v. **£2** each, post 25p. 4 mfd 600 v., 2 for **£1.** 0·25 mfd, 2Kv, **20p** each, post 10p. 0·01 mfd MICA 2·5Kv. **£1** for 5, post 10p. Capacitor 0·125 mfd, 27,000 v. wkg. **£3·75** each, 50p post.

TCS MODULATION TRANSFORMERS, 20 watts, pr. 6,000 C.T., sec. 6,000 ohms. Price **£1·25,** post 25p.

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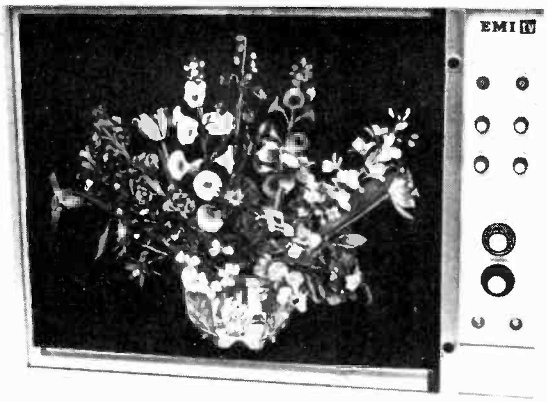

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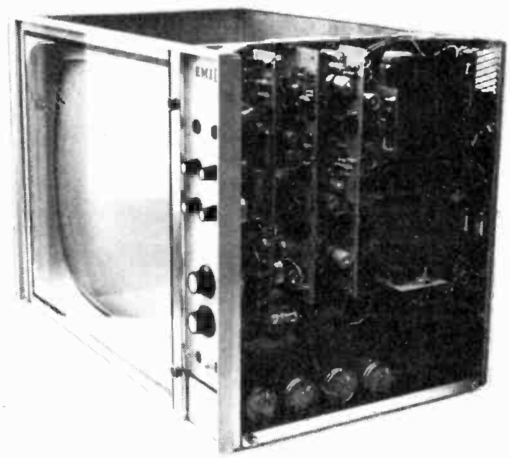

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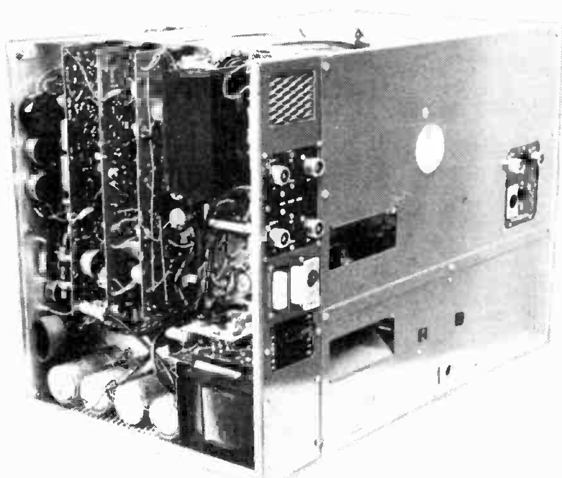

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70 watt kit .. .. £12·60 nett

INDICATOR LAMPS
NEON chrome bezel, round red NR/R, **24p**; chrome bezel, round amber NR/A, **24p**; chrome bezel, round clear NR/3, **24p**. Neon, square red type LS5C/R, **18p**; amber type LS5C/A, **18p**; clear type LS5C/C, **18p.** All above are for 240v. mains operation.
Filament types: 6v. 0·04A square red type LS5C/R-6v., **30p**; 6v. 0·04A amber type LS5C/A-6v., **30p**; 6v. 0·04A clear type LS5C/C-6v., **30p**; 6v. 0·04A green type LS5C/G-6v., **30p**; 12v. 0·04A LS5C/R-12v., **34p**; 28v. 0·04A LS5C/R-28v., **45p.** Other colours available in 12 and 28 volts.

DIN CONNECTORS

Pole		Plug	Socket
2	(Spkr)	12p	10p
3		13p	10p
4		14p	12p
5	180°	15p	12p
5	240°	15p	12p
6		15p	13p

ENAMELLED COPPER WIRE
Even No. SWG only: 2 oz. reels: 16-22 SWG **25p**; 24-30 SWG **30p**; 32, 34 SWG **33p**; 36-40 SWG **35p.** 4 oz. reels: 16-22 SWG only **41p.**

S-DECS
Components just plug in—saves time—allows re-use of components. S-Dec (70 points), **£1·00** T-Dec, may be temperature-cycled (208 points), **£2·50.** Also μ-Decs and IC carriers.

TYGAN SPEAKER MATERIAL
7 designs, 36 × 27 in. sheets, **£1·58** sheet.

THERMISTORS
VA1039, VA1040, VA1055, VA1066, VA1077, CZ·6, K151-1K, **15p.** E24, R53, **£1·35.**

LIGHT DEPENDENT RESISTORS
Cadmium Sulphide type TPMD (equiv. ORP.12), **40p.**

LATEST LIST
Send large SAE for latest Electrovalue list of semi-conductors, capacitors, resistors and components of all types.

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FREE on orders over £2. Please add 10p if orders under £2. Overseas orders welcome: carriage and insurance charged at cost.

BARGAINS IN NEW SEMI-CONDUCTORS

MANY AT NEW REDUCED PRICES • ALL POWER TYPES WITH FREE INSULATING SETS

40361	55p	2N2905	44p	2N4291	15p	BC148	9p	BFX87	29p
40362	68p	2N2905A	47p	2N4292	15p	BC149	10p	BFX88	26p
2N696	20p	2N2924	20p	AC107	46p	BC153	19p	BFY50	23p
2N697	22p	2N2925	22p	AC126	20p	BC154	20p	BFY51	20p
2N706	12p	2N2926	11p	AC127	20p	BC157	12p	BFY52	23p
2N930	29p	2N3053	27p	AC128	20p	BC158	11p	BSX20	16p
2N1131	36p	2N3055	60p	AC153K	22p	BC159	12p	C407	17p
2N1132	40p	2N3702	13p	AC176	16p	BC167	11p	MC140	25p
2N1302	19p	2N3703	13p	ACY20	20p	BC168	10p	MPS6531	35p
2N1303	19p	2N3704	13p	ACY22	16p	BC169	11p	MPS6534	30p
2N1304	23p	2N3705	13p	AD140	56p	BC177	14p	NKT211	25p
2N1305	23p	2N3706	13p	AD142	50p	BC178	13p	NKT212	25p
2N1306	33p	2N3707	13p	AD149	58p	BC179	14p	NKT214	23p
2N1307	33p	2N3708	10p	AD161	33p	BC182L	11p	NKT274	18p
2N1308	36p	2N3709	11p	AD162	36p	BC183L	10p	NKT403	65p
2N1309	36p	2N3710	13p	AF114	30p	BC184L	11p	NKT405	79p
2N1613	23p	2N3711	13p	AF115	30p	BC212L	16p	OC71	29p
2N1711	26p	2N3819	23p	AF117	28p	BC213L	16p	OC81	25p
2N1893	54p	2N3904	35p	AF124	30p	BC214L	16p	OC83	20p
2N2147	95p	2N3906	35p	AF127	28p	BCY70	19p	ZTX300	14p
2N2218	34p	2N4058	13p	AF139	33p	BCY71	33p	ZTX301	16p
2N2218A	43p	2N4059	10p	AF239	36p	BCY72	15p	ZTX302	22p
2N2219	38p	2N4060	11p	ASY26	27p	BF115	23p	ZTX303	22p
2N2219A	53p	2N4061	11p	ASY28	27p	BF167	18p	ZTX304	27p
2N2270	62p	2N4062	12p	BC107	12p	BF173	19p	ZTX500	18p
2N2369A	19p	2N4124	18p	BC108	11p	BF194	14p	ZTX501	21p
2N2483	35p	2N4126	27p	BC109	12p	BF195	15p	ZTX502	25p
2N2484	42p	2N4284	15p	BC125	15p	BFX29	31p	ZTX503	22p
2N2646	54p	2N4286	15p	BC126	22p	BFX84	25p	ZTX504	52p
2N2904A	42p	2N4289	15p	BC147	10p	BFX85	34p		

RESISTORS—10%, 5%, 2%

Code	Power	Tolerance	Range	Values available	to 9	10 to 99 (see note below).	100 up
C	1/20W	5%	82Ω–220KΩ	E12	9	8	7
C	1/8W	5%	4·7Ω–470KΩ	E24	1	0·8	0·7
C	1/4W	10%	4·7Ω–10MΩ	E12	1	0·8	0·7
C	1/2W	5%	4·7Ω–10MΩ	E24	1·2	1	0·9
C	1W	10%	4·7Ω–10MΩ	E12	2·5	2	1·8
MO	1/2W	2%	10Ω–1MΩ	E24	4	3·5	3
WW	1W	10% ± 1/20Ω	0·22Ω–3·9Ω	E12	7	7	6
WW	3W	5%	12Ω–10KΩ	E12	7	7	6
WW	7W	5%	12Ω–10KΩ	E12	9	9	8

Codes: C = carbon film, high stability, low noise.
MO = metal oxide, Electrosil TR5, ultra low noise.
WW = wire wound, Plessey.

Values:
E12 denotes series: 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82 and their decades.
E24 denotes series: as E12 plus 11, 13, 16, 20, 24, 30, 36, 43, 51, 62, 75, 91 and their decades.

Prices are in pence each for quantities of the same ohmic value and power rating. NOT mixed values. (Ignore fractions on total value of resistor order.)

CARBON TRACK POTENTIOMETERS, long spindles. Double wiper ensures minimum noise level.
Single gang linear 100Ω to 2·2MΩ, **12p**; Single gang log, 4·7KΩ to 2·2MΩ, **12p**; **Dual gang** linear 4·7kΩ to 2·2MΩ, **42p**; Dual gang log, 4·7KΩ to 2·2MΩ, **42p**; Log/antilog, 10K, 47K, 1MΩ only **42p**; Dual antilog, 10K only, **42p.** Any type with ½A D.P. mains switch, **12p** extra.
Only decades of 10, 22 & 47 available in ranges quoted.

CARBON SKELETON PRE-SETS
Small high quality, type PR, linear only: 100Ω, 220Ω, 470Ω, 1K, 2K2, 4K7, 10K, 22K, 47K, 100K, 220K, 470K, 1M, 2M2, 5M, 10MΩ. Vertical or horizontal mounting, **5p each.**

COLVERN 3 watt Wire-wound Potentiometers. 10Ω, 15Ω, 25Ω, 50Ω, 100Ω, 150Ω, 250Ω, 500Ω, 1K, 1·5K, 2·5K, 5K, 10K, 15K, 25K, 50K, **32p each**

ZENER DIODES 5% full range E24 values: 400mW: 2·7V to 30V, **15p each**; 1W: 6·8V. to 82V, **27p each**; 1·5W: 4·7V to 75V, **60p each.**
Clip to increase 1·5W rating to 3 watts (type 266F), **4p.**

Appointed Distributors for
SIEMENS (UK) LTD.
Appointed Stockists for
NEWMARKET TRANSISTORS
RADIOHM POTENTIOMETERS

CAPACITORS

MULLARD polyester C280 series
250V 20%: 0·01, 0·022, 0·033, 0·047 **3p each**; 0·068, 0·1, **4p each**; 0·15, **4p**; 0·22, **5p.** 10%: 0·33, **7p**; 0·47, **8p**; 0·68, **11p**; 1μF, **14p**; 1·5μF, **21p**; 2·2μF, **24p.**

MULLARD SUB-MIN ELECTROLYTICS
C426 range, axial lead .. .. .. 6p each
Values (μF/V): 0·64/64; 1/40; 1·6/25; 2·5/16; 2·5/64; 4/10; 4/40; 5/64; 6·4/6·4; 6·4/25; 8/4; 8/40; 10/2·5; 10/16; 10/64; 12·5/25; 16/10; 16/40; 20/16; 20/64; 25/6·4; 25/25; 32/4; 32/10; 32/40; 32/64; 40/16; 40/2·5; 50/6·4; 50/25; 50/40; 64/4; 64/10; 80/2·5; 80/16; 80/25; 100/6·4; 125/4; 125/10; 125/16; 160/2·5; 200/6·4; 200/10; 250/4; 320/2·5; 320/6·4; 400/4; 500/2·5.

LARGE CAPACITORS
High ripple current types: 1000/25, **28p**; 1000/50, **41p**; 1000/100, **82p**; 2000/25, **37p**; 2000/50, **57p**; 2000/100, **£1·44**; 2500/64, **77p**; 2500/70, **98p**; 5000/25, **62p**; 5000/50, **£1·10**; 5000/100, **£2·91**; 10000/50, **£2·40.**

HANDBOOK OF TRANSISTOR EQUIVALENTS & SUBSTITUTES 40p (Post 3p if ordered alone.)

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Not allowed on nett price items
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15% on orders for components for £15 or more.
Prices subject to alteration without prior notice.

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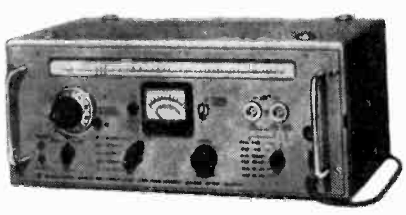
Hours: 9-5.30, 1.0 p.m. Saturdays. ***Phone: Egham 5533 and 4757 (STD 0784-3) Telex 264475***



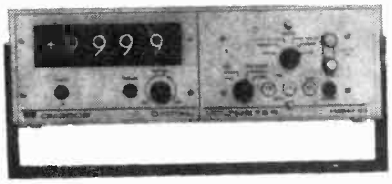
ROHDE & SCHWARZ POWER SIGNAL GENERATOR Type SMLR (BN41001)

100 KHz-30 MHz in 5 ranges. ±1%. O/P 1·7 w. MAX O/P volts 0-10 into 60 ohms and 1 micro-volt—3 v. A.M. Modulation to 90%. This is a high quality laboratory instrument currently priced at £583. ELECTRONIC BROKERS PRICE **£300**. C/W Calibration certificate.

DYNAMCO 2010 DIGITAL VOLTMETER

Fully overhauled, Calibrated (Certified) and Guaranteed.

Specification:
Scale: 109999. D.C. Accuracy: 0·001% F.S.D. Range: 10 micro V-1·1 kV; I/P Z greater than 25,000 M ohm; C.M.R. D.C. 160 dB. 50 Hz 130 dB O/P. Parallel B.C.D. Inductive potentiometric system for excellent stability. Price: **£850** (new price over £1,600).

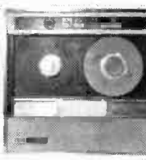


DIGITAL VOLTMETER DYNAMCO 2006

Scale 9999. D.C. range. 10 micro-volt—1 kV. I/P. Z. greater than 10,000 Mohms. B.C.D. Parallel O/P (isolated). Supplied with D.2 Module. Overhauled Calibration certificate. To maker's specification. New price £765. Our price **£400**. Carriage extra.

7-TRACK DIGITAL MAGNETIC TAPE STORAGE DECK (Ref. 13)

These machines, originally ex-computer, are multi-track recording units, ideal for data storage. Record and Replay heads encased in one common unit. Low resistance heads. Frequency response approximately 0 Kc/s. to 50 Kc/s. Bit density 557 b.p.i. ½ in., 10½ in. spools 230 v. to 380 v. A.C. Capstan Motor speed 1,500 r.p.m. 48 v. D.C. Rewind motors. Finished in brush aluminium and matt-black. Size 27 in. × 26 in. × 8 in. Weight 90 lb. Price **£65**. Carriage extra.



MEMORY PLANES (Ref. C4)

Ferrite core memory planes with wired Ferrite cores. Used for building your own computer or as an interesting exhibit in the demonstration of a computer. Mounted on plastic material, frame 5×8 in. Consisting of matrices 40×25×4 cores each one individually addressable and divided into 2 halves with independent sense and inhibit wires. **£6·65**. P. & P. inclusive.

BRAND NEW COMPUTER TAPES AND EMPTY SPOOLS

Made by well known manufacturers

½ in. certified 2,400 ft. 800 b.p.i.	£8·50
½ in. 2,400 ft.	£6·50
½ in. Highest grade 2,400 ft.	£3·00
½ in. 10½ in. dia. spool and cassette	£1·50
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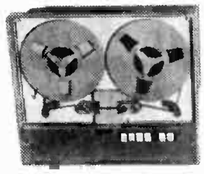
1 in. metal 10½ in. dia. spool and cassette	£2·50
½ in. N.A.B. centres 10½ in. spool only	£1·00

HONEYWELL MODEL 6200 INCREMENTAL DIGITAL RECORDER

Records digital (binary) data on 7 track ½ in. tape in steps of 0·005 in. with a packing density of 200 bits/inch. Almost new and in excellent condition. This recorder offers excellent value for many applications involving date, logging. One only available. Price: **£750**.



TEXAS BALL BONDER. Overhauled. **£250**.

50 MHz. 8 DIGIT FREQUENCY COUNTER SYSTRON-DONNER Model 1037-5

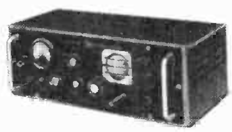
D.C. I/P 0-50 MHz. A.C. I/P 10-50 MHz. Gate time 1 micro-second—10 seconds in Decade steps. Accuracy ± 1 count ± time base accuracy. Reads in KHz or MHz with positioned decimal point. Sensitivity 100 Mv. r.m.s. B.C.D. O/P. PRINT COMMAND. OVERLOAD PROTECTION. DIMENSIONS: H. 5¼ in., W. 17¼ in., D. 17¾ in. Wt. 42 lbs. Mains I/P. This instrument has been overhauled and calibrated and is offered in excellent condition. **£350**. Carriage extra.

EYELET BONDER PLANER B801

V.G. condition. C/W stand. Overhauled. **£750**.

5 KV IONISATION TESTER AIRMEC 732

Non-destructive insulation testing. Audible indication of ionisation currents. Variable voltage from 250-5 kV. High impedance source. Mains I/P. **£35**.



MODEL 1706 VISICORDER

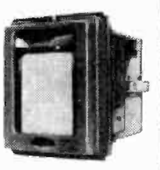
In almost new condition. This direct reading U/V Recorder can record up to 6 channels simultaneously from D.C. 5000 Hz at writing speed of 30,000 in. per sec.

Recording range:	D.C.—5000 Hz.
Paper width:	4½ ins. wide.
Optical Arm:	19 cm.
Paper Speeds:	Eight speeds from 0·25-32 in./sec. and 6-800 mm/sec.
Dimensions:	H. 10½ in., W. 12 in., Depth 14 in.

Complete with 4 3k Hz Galvos. **£400**

SINGLE PEN RECORDER By Record Electrical (R3)

3 in. chart, sensitivity 1 mA. Coil resistance 1·53k. Fully interchangeable gears available to make a wide range of chart speeds. 200/250V. Size: 8×11×6 in. List over £100.
Our price .... **£49·50**



FACSIMILE RECORDERS

D649 K 18 in. Chart Recorder. Helix speed: 60, 90, 120 rev./min. Transmission speed: ⅜ in.; 15/16 in.; 1⅞ in. per min. Scanning rate 96 lines/in.
Ref. C3.........Price **£350**. Completely overhauled plus carriage.

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We are now able to offer the following Recorders in an overhauled and tested condition:

1. MOSELEY AUTOGRAF MODEL 2A

Table size: 11 in. × 17 in. Dimensions: W. 24 in., H. 9 in., D. 16 in. Wt. 55 lbs. Power I/P: 115 v. 1 phase 100 w. Signal I/P: X Axis 0-7½, 15, 75, 150, 750 mV; 0-1½, 7½, 15, 75, 150 v. Y Axis 0-5, 10, 50, 100, 500 mV; 0-1, 5, 10, 50, 100 v. Sensitivity not less than 200 k ohms/V. Accuracy: 0·25% FS on all ranges. Response speeds: 1 sec. for full scale. Supplied complete with copy of handbook. **£310·00**. Carriage extra.

2. HOUSTON INSTRUMENTS MODEL HR 934

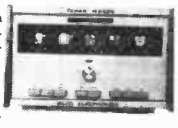
Table size: 8½ in. × 10½ in. Dimensions: W. 14 in., H. 8 in., D. 16 in., Wt. 30 lb. Power I/P: 115 v. 1 phase. Signal I/P: "X" and "Y" Axis. 0-7, 7-8, 10, 19, 68 mV and 0-5 v. Switched Attenuators on both Axis. Response speeds: 2 sec. for full scale. **£195·00**. Carriage extra.

DIGITAL INDICATORS KGM Type M3

A neat compact indicator providing selective display 0-9. Fig. height 18 mm. panel mounting. 6 mm. tubular midget flange lamps. Supplied with 28 v. bulbs. Finished matt black anodized. W. 1 in., H. 2 in. Wt. 4 ozs. Price **£3·25**. P. & p. Free.

TRANSISTORISED TIMER Ekco M5220

An extremely versatile timer for use with high stability pulse counting systems. Less power supply. **£45**. Carriage extra.



TRANSISTORISED SCALER M5200

£45. Carriage extra.
This unit can be used to power the Timer M5220.

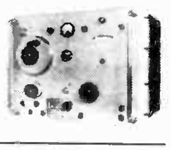
SOLARTRON OSCILLATOR CO546

25Hz-500K Hz. Attenuator and O/P meter. Very good condition. **£55** (carriage extra).

HB ELECTRONIC

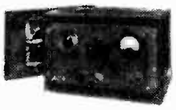
SIGNAL GENERATOR "X" BAND

SANDERS MODEL CT 480 (SG 480) and CT 478 (SG 478). Specifications: CT 480 8-11·5 KMHz; CT 478 1·3-4·2 KMHz. O/P of 1mW from 8·0-11·0 KMHz (CT 480) and 1·5-4·0 KMHz (CT 478). These high grade generators comprise a klystron oscillator in a co-axial cavity fed from a stable power source. Provision for application of square wave or pulse modulation internal or external sources. Attenuator calibrated from 0-100 db below 1 mW. I/P 110-250 v. 50-500 Hz. 200 w. Rack mounting. W. 19 in., H. 14 in., D. 15 in. Wt. 74 lb. Supplied complete with copy of handbook. Tested before despatch. **£275**. Carriage extra.



DEVIATION METER Marconi TF 928

20-100 MHz. Can be used to 500 MHz. Measurement of deviation up to 400 KHz. Crystal Standard. Used in setting up deviation in VHF Wide Band Multi Channel FM Systems and Radar. I/P 100-150 v. and 200-250 v. 40-100 Hz 120 w. H. 14", W. 20½", D. 17" Wt. 70 lb. **£95·00**. Carriage extra.



NUMICATORS

End Reading	Quantity	Price Each (less Base)	Price
GRIOM/U (Clear)	1– 3	£1·40	Bases
	4– 10	£1·35	20p
	11– 25	£1·30	Each
	26–100	£1·20	

Side Reading			Quantity	Less Bases
XN3/FA	38 m/m lead	(Amber)		
XN3/F	38 m/m lead	(Red)	1– 3	£1·15
XN3A/F	6 m/m lead	(Red)	4– 10	£1·10
XN3A	6 m/m lead	(Clear)	11– 25	£1·05
XN11/F	38 m/m lead	(Red)	26–100	£0·95
XN23/FA	38 m/m lead	(Amber)		

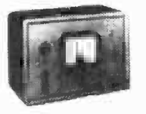
Post Free.

RCA U.H.F. SIGNAL GENERATOR Type 710A

Frequency range 370-560 MHz. Modulation facility. I/P 117 v. 50/60 Hz 50w. Overhauled and supplied complete with auto transformer for 230/250 v. I/P. **£85** (carriage extra).

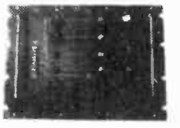
VIBRON ELECTROMETER MODEL 33B

An exceptionally stable laboratory instrument for the measurement of very small d.c. voltages and currents derived from a high impedance source. The Vibron Electrometer has input ranges of 10 mV, 30 mV, 100 mV, 300 mV and 1 V and the output is 1 mA full scale on all ranges. The zero drift does not exceed 100 microvolts in 12 hours and the input resistance is 10 to the power of 13 ohms. **£75** (carriage extra).



ADVANCE STABILISED POWER SUPPLY Model D.C. 207A 24 v. 8A

Built to the highest specifications for continuous use in computor installations. 19 in. rack mounting: 200/250 v. 50 Hz I/P: o/p 24 v. 8 amp floating; —20 v. 2 amp; —10 v. 3 amp; +10 v. 5 amp; +20v. 9 amp w.r.t. common. Price: **£69**.



IF YOU CANNOT FIND THE INSTRUMENT YOU WANT IN

PERKINS ELMER MODEL 240 ELEMENTAL ANALYZER

This precision instrument accurately determines the carbon, hydrogen and nitrogen content of organic compounds by detecting and measuring their products of combustion. This equipment has only had one user and is offered c/w a Leeds and Northrup Speedomax Recorder. Excellent condition. Manufacturers overhaul. 6 month guarantee. **£3,000** (representing a saving of £1,000).

POWER SUPPLIES

We specialise in all kinds of POWER SUPPLIES. Current stock includes the following Modular units. All have mains I/P.

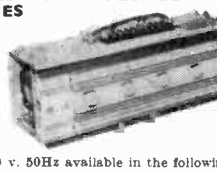
Volts	*Current*	*Make*	*Type*	*Price*
6	½A	Roband	T.98	£10·00
6	2	Roband	T.98	£12·00
12	6			£15·00
15	5	Advance	P.M7	£15·00
17	6	Farnell	88U 17/6	£18·00
28	1	Roband	T109	£25·00
32	2	APT	10459/14	£25·00
150	200mA	Farnell	8PU 150	£14·00
55/60	1A	Roband		£22·00
7½-9U	10A	I.E.		£19·50
7½-9U	10A	Farnell		£25·00

Most of the above are adjustable within a limited range.

MULTI OUTPUT UNITS AND SPECIALS

O/PV	*A*	*I/PV*	*Make*	*Price*
335 / 6·3 A.C.	½ unstabilised / 2A (400Hz)	115 v. 400Hz	Farnell (PU.335)	£10·00
—12—0+12 +24	½	240	Livingstone (LM050)	£9·50
0-10 v. Unstabilised Variable	2A	240		£18·00
160-300 / 6·3 v. A.C. / Variable (Voltmeter and ammeter)	150mA / 3A	240	I.E.	£35·00
30 A.C. / 400 Hz adjustable	300mA	240		£36·00
175-260 Adjustable (Metered) 3·15-0-3·15 A.C. 3A	80mA	240	Smiths	£30·00
Universal Labpack HT & LT Supply Unstabilised adjustable			Radford	£20·00

EX-COMPUTER HIGHLY STABILISED TRANSISTORISED LOW VOLTAGE POWER SUPPLIES



These modular units incorporate, Overload protection on both INPUT and OUTPUT. LOAD regulation of 1% or better. Low Ripple and a fast response time. All units checked and O/H before despatch.

I/P VOLTAGE 120-130 v. 50Hz available in the following types:

Volt	Amp	Price
6 volt	8 amp	£12·00
6 volt	12 amp	£17·00
6 volt	16 amp	£20·00
12 volt	4 amp	£20·00
12 volt	12 amp	£22·00
12 volt	20 amp	£24·00
12 volt	26 amp	£25·00
20 volt	6 amp	£18·00
20 volt	15 amp	£24·00
30 volt	7 amp	£19·00
48 volt	6 amp	£20·00

These units are in great demand. ORDER NOW while stocks last.

BARGAIN D.C. STABILISED POWER SUPPLY UNIT £9·50

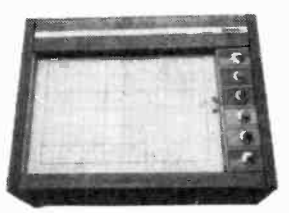
Brand new solid state modular unit. I/P 110 v.-240 v. 50 Hz. O/P+12 v. D.C.-12 v. D.C.-24 v. D.C. w.r.t. common. All at 500 mA. I/P on/off switch. Fuse and warning light. Stabilisation 100/1 for + 10%-15% mains charge. Equivalent O/P resistance less than 50 M ohms. Ripple and noise less than 10 mV. Ambient Temp. Range 0-50°C. Dimensions: L. 9½ ins., H. 4½ ins., D. 4½ ins. Wt. 6½ lbs.

CONSTANT VOLTAGE TRANSFORMERS

Advance CVH 1500 A. Harmonic filtered. I/P 190-260 v. 50 Hz., 1 phase. O/P 230 v. 1500 w. Unity PF. **£50·00**. Carriage extra.

ADVANCE MT 285ZA

I/P 190-260 v. 50 Hz., 1 phase. O/P 230 v. 2 kW. Unity P.F. **£35·00**. Carriage extra.



ELECTRONIC ASSOCIATES VARIPLOTTER 1100E

X-Y plotter, suitable for recording analogue information. Table size 15 in. × 10 in.; slow speed 20 in./sec.; I/P sensitivity for F.S.D. 0·05-20 v. in 9 ranges. Basic I/P sensitivity. Arm 10 m.v./in. Pen 1 v./in. Fully overhauled, tested, guaranteed and in new condition. Price: **£350**.

DECADE VOLTAGE AND CURRENT GENERATOR

Ekco Type 1482A. Provides accurate test voltages and currents which can be varied by small increments 0-1 v. in steps of 0·0001 v. 0-10 v. in steps of 0·001 v. Current O/P 1 v. range. 10^{-5} to 10^{-13} amps on 10 v. Range 10^{-4}-10^{-12} amps. Mains I/P. 19 in. Rack Mounting C/W Manual. **£45**.

GRESHAM INSULATION FLASH-TESTER Mk 6

0·5-2·5 kV. Mains I/P. Overhauled **£35**. Carriage extra.

R.C. POWER OSCILLATOR (Associated Electronic Eng. A1302)

Frequency range: 20 Hz to 200 KHz, in 4 ranges. *Output power:* 0-250v., 4-5 watts r.m.s. *Output impedances:* 15 ohms, 1,000 ohms, 4,000 ohms; 600 ohms attenuator adjustable. Loaded 600 ohms, 0·6 ohms. *Output terminations:* High impedance, earthed; low impedance, isolated. *Output level:* Output level control 0-10 div. *Meter ranges:* Switched 10 v., 50 v., 250 v. *Input voltage:* 200-250 v. A.C. 50 Hz. *Output terminal switch:* Switchable to High or Low impedance output.
O/H. Very good condition. **£95**. Carriage extra.

NUCLEONIC INSTRUMENTS

High Accuracy Metal Wall Gauge Ekco Type N563B. Portable transistorised gamma back scatter gauge up to 18 mm. in 2 ranges. Indicator only. NO probe. **£15**. Carriage extra.
Field Ratemeter Ekco Type N645A. 0-1,000 counts/sec. in 5 ranges. Portable transistorised. C/W Dipping Probe N675A for Beta counting in liquids. C/W Manual. **£105**. Ratemeter ONLY **£35**.
Amplifier Logarithmic D.C. Part of Monitor Gamma Reactor. Type N638A. **£25**. Carriage extra.

MUIRHEAD-WIGAN L.F. DECADE OSCILLATOR D-638A

0·1 Hz-11·1 KHz. O/P Meter. Mains I/P. Good working order. **£40**. Carriage extra.

BRAND NEW NIMTEC AMPLIFIER 151 ...... £30

Timing Unit 219 .... **£25**.

DISCRIMINATOR 95/2127-1/6 .... £10

CURRENT & RESISTANCE MEASURING UNIT A33B

To extend the range of the ELECTROMETER to measure very small currents and high insulation resistances. **£15**.

VIBRATION EQUIPMENT

1. AUTOMATIC L.F. SWEEP OSCILLATOR PYE-LING ACO I (DAWES 444D)

An automatic unit providing motorised sweep facilities and automatic changeover from displacement to acceleration characteristic. Applications Resonance Search and Endurance testing.

5 Hz-5 KHz 21 sweep speeds from 0·1-10 octaves/minute. Variable O/P up to 10 v. r.m.s. Mains I/P. Excellent condition. **£95**. Carriage extra.

2. POWER OSCILLATOR 5VA by PYE-LING

5 Hz-50 KHz. Overhauled. **£49**. Carriage extra.

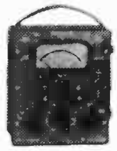
3. CATHODE FOLLOWER. GOODMANS E506

7 channel. Very good condition. **£45**. Carriage extra.

4. PHASE SHIFTER MODEL E556 (GOODMANS)

19 in. Rack Mtg. Mains I/P. Very good condition. **£56**. Carriage extra.

MULTIMETER TYPE CT471B



Fully transistorized multi-range instrument for measurement of voltage up to 1000 MHz (1500 MHz with reduced accuracy) and current up 2 KHz and D.C. Resistance A.C. and D.C. voltage and current divided into 11 ranges.
A.C./D.C. Volts 12mV-1200V.
A.C./D.C. Current 12 micro A-1·2A.
D.C. Resistance 5 ranges 0·1 ohm-1000 M ohm.
R.F. Voltages 5 range 40mV to 4V.
Battery powered. Offered in excellent condition. Tested before despatch. Complete with handbook. **£54**. Carr. 50p.

MIDGET POWER RELAY Type Mk 1

(OMRON), 230 v. 50 Hz Coil, 1 pole double throw. Unused. Faulty plating on frame. 5 for **£1·50**. (P. & P. included.)

BROKERS

49-53 PANCRAS ROAD, LONDON, N.W.1.
Tel: 01-837 7781/2. Cables: SELELECTRO
Telex: 267307 (Open Mon-Fri. 9 a.m.-6 p.m.)

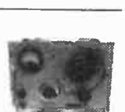
SINE COSINE POTENTIOMETER 47K

Precision component by Pye. Model 2002. Manufactured to rigid Ministry specification. The assembly consists of three units mounted in one frame. Each unit contains two sine and two cosine potentiometer sections, the sliders being ganged together. Electrical connections, 2 end taps, slider and centre tap. Mechanical I/P: 30 r.p.m. Max torque: 3½ oz./in. Dimensions: W. 6½ in., H. 5 in., D. 7½ in. Wt. 7½ lb. Ex equipment. Good condition. **£10·00** each. Carriage extra.

WELDING POWER SUPPLY—Hughes Model

MCW 550. Constant voltage. Weld voltage and duration controls. Mains input. Price **£125**.

SIGNAL GENERATOR Advance D1/D



Advance D1/D. 10 MHz-300 MHz in 6 ranges. Modulation at 1 KHz 30 Ω. Square Wave 1 KHz 100 Ω Modulation. Attenuator 1 micro v.-10 mV in 5 steps. Fine attenuator 0-10 db. I/P 80-240 v. 40/2000 Hz. W. 13½ in., H. 7½ in., D. 12½ in. Tested and in very good condition. **£45·00**. Carriage extra.

PH METER

Pye Model 11071. Portable battery operated. Rugged wooden case construction. Range 2-12 pH. Min. Scale Division: 0·2 pH. Temp. compensation. Manual 0-100 deg. C. Dimensions: W 12 in., D. 9 in., H. 5 in. Wt. 9 lb. Very good condition. **£42·00**. P. & p. £1·00.

Industrial & Scientific Instruments Ltd.

Model 6A. Mains I/P. Very good condition. Can also be used as Millivoltmeter. Supplied in wooden carrying case. Complete with Electrode Stand. W. 23 in., H. 13½ in. D. 11 in. **£30·00**. Carriage extra.

PORTABLE FREQUENCY METERS

TF1026/1. A direct reading absorption meter, employing a concentric line closed at one end and turned by variable capacitor at the other end of the line, giving a frequency range: 250 MHz-500 MHz, on an almost linear scale approx. 9 in. in length. Complete in polished wooden case. Price **£17·50**. Carriage extra.

E.M.I. INSTRUMENT L.F. TAPE RECORDER

Portable equipment consisting of 3 units (Deck, Amplifier and P.S.U.) in transit cases. Four speeds using standard ¼ in. tape. Exceptional value, two only available. Price **£75**.

R.F. ATTENUATOR MARCONI TF 1073A

DC—150 MHz 1dB steps 75 Ohms. Double Screened construction. Tested and in VG condition. **£25**.

VHF ADMITTANCE BRIDGE

Wayne Kerr B801A. 1-100 MHz. Conductance 0-100 milliohms. Capacitance 0-230 pF and 0 to —230 pF. **£120** (40% of new price). Also B901. Indicates parallel components of conductance and positive or negative capacitance for lines, antennas and feeders. 0-100mohm. 0. to ± 75 pF and —75 pF. Accuracy 2% up to 250 MHz. **£115** (40% of new price).

BRAND NEW CAPACITOR REVERSIBLE SINGLE PHASE PARVALUX MOTORS

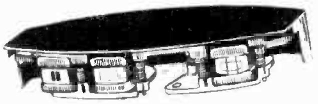
230/250 v. 50 Hz 2,800 r.p.m. 1/30 h.p. Cont. rated. $\frac{5}{16}$ in. shaft dia. × 3½ in. long. Foot mounting. Weight 6 lb. **£3·50** post free.

COAXIAL LINE OSCILLATOR

By Saunders. Type CLC 7-12. The Oscillator is adjustable from 7-12 MHz. A high reset accuracy with no backlash having ± ·1%. The instrument is supplied with a calibration chart and valve, and is suitable to be coupled to any waveguide size by using a coaxial to waveguide transformer. Price **£55**.

THIS ADVERTISEMENT PLEASE PHONE US 01—837 7781

Special offer of AMPEX professional tape heads, mu-metal shrouded. (Designed for model AG20). Full track record, or playback, **£3·00**. Erase head **£2·00**. Set of 3 with mounting bracket and cover **£7·50**. Half track record or playback only, **£3·00** each or **£5·50** per pair with bracket and cover. Carriage paid.



AMPEX. Dynamic stick microphone, high impedance low noise. Offered well below makers price at **£6·50**. P. & P. 25p.

Three only as new. "AMPEX" AG20 Portable Tape Recorders. Full track heads. Remote control facility. Power pack, etc. Cost £450. **Our price £175.** PERSONAL CALLERS ONLY.

"DECCO" MAINS SOLENOID.—Compact and very powerful. 16 lb. pull. ⅝" travel which can be increased to 1" by removing captive-end-plate. Overall size 2"×2½"×2¾" high. **£1·50.** P. & P. 25p.

WEBBER MAINS SOLENOID. Robust and strong. On this item the plunger travel is 1¾". Performance: 6 lb. pull at 1½"; 8 lb. at 1"; 10 lb. at ½". The non-captive plunger has a fixing eye to take up to $\frac{3}{16}$" bolt. Size: 2⅛" high × 2" × 2". **£1·25** plus 25p P. & P.

SPECIAL OFFER

MAINS SOLENOID BY MAGNETIC DEVICES LTD. A beautifully constructed solenoid at half normal price. A two-sided bracket is incorporated for vertical or horizontal mounting. Size: 2" × 1½" × 1½". Pull is approx. 2 lb., plunger travel 1¼". Fixing eye takes up to ¼" bolt. Plunger non-captive. New in original makers boxes. **75p** each, plus 25p P. & P. Large number available, special price for quantity.

RELAYS

Perspex enclosed, plug in, with base. Size 1¼" × 1½" × ¾"
MQ 308 600Ω 24v. 4 c/o. **60p** ea., **£5·00** per doz.
MQ 508 10,000Ω 100v. 4 c/o. **50p** ea., **£4·50** per doz.

SIEMENS. High speed type 89L. 1,700Ω + 1,700Ω, **63p** ea.

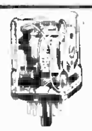
"B. & R." 3 c/o. 10 amp. contacts (silver) operates on 2 volts D.C. Draws approx. 1 amp. Size: 2" × 1¾" × 1⅛". **£1·00.**

"OMRON" OCTAL BASE. A.C. mains. 2 × 15 amp. C/O contacts. Perspex enclosed. **88p.**

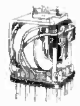
A.E. Perspex enclosed, plug in, 50Ω 6v. 2 c/o. **63p** ea. 470Ω 12v. 4 c/o. **73p** ea. 2,780Ω 48v. 4 c/o. **73p** ea. 1,260Ω 48v. 6 c/o. **83p** ea.

SCHRACK. Octal base 24v. 2 HD c/o. Perspex enclosed. **63p.**

E.R.G. 1,000Ω 6v. DC. 1 make encapsulated reed type. Size: ⅝" × $\frac{7}{16}$" × 1⅝". 4 for **£1·00.**

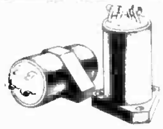


NEW "F.I.R.E." PLUG-IN RELAY.—115v. Coil 50/60 c.p.s. 3 heavy duty silver change-over contacts. Very robust. **63p.**



NEW "ISKRA" 240v. A.C. RELAY.—3 heavy duty silver change-over contacts. **63p.**

SEIMENS HIGH SPEED RELAY, Type 89L. 1,700Ω + 1,700Ω coil. New **63p** each.



MINIATURE "LATCH-MASTER" RELAY 6, 12, or 24v. D.C. operation One make one break, contacts rated 5 amps. at 30v. Once current is applied, relay remains latched until input polarity is reversed. Manufactured for high acceleration requirements by Sperry Gyroscope Co. Size: Length , dia. $\frac{7}{16}$" (including mount). Please state vertical or horizontal mount and voltage. **£1·63** each.

ELECTROLYTIC CAPACITORS MULLARD. 900µF 100v. heavy ripple screw terminals 1$\frac{7}{16}$" dia.×3½", **70p** eac., **£6·00** per doz. 1,600µF 64v. 1⅜" dia. × 3" **38p** ea., **£3·50** per doz. 10,000µF 10v. 1⅜" dia. × 3". **38p** ea., **£3·50** per doz. 1,250µF 25v. 1" dia. × 2". **50p** ea., **£4·50** per doz.

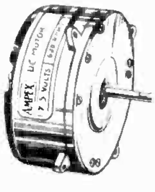
HUNTS 1,000µF 50v. 1⅜" dia. × 2", **25p** ea., 10,000µF 6v. 1⅜" dia. × 2", **30p** ea., **£3·00** per doz. 16µF 350v. $\frac{9}{16}$" × 1½" wire ends, **£2·00** per doz. 1,000µF 50v. 1" dia. × 3", **30p** ea., **£3·00** per doz. 32-32µF 275v. 1" dia. × 2", **38p** ea. 100µF 100v. 1" dia. × 2", **25p** ea.

ERIE. Ceramicon capacitor. Type CHV411P. 500 P.F. 30KV Size 1·5" dia. × 1·44" long. **50p** ea. Carriage paid.

"TANSITOR" (U.S.A.) TANTALUM WET SINTERED ANODE POLARISED CAPACITORS. DC size: 1½" long × ⅜" dia. 200µF. 25v. DC size: ⅞" long × ⅜" dia. 180µF. 25v. DC size: ⅞" long × ⅜" dia. 150µF. 30v. DC size: ⅞" long × ⅜" dia. 2·5µF. 300v. DC size: ⅝" long × $\frac{3}{16}$" dia. One wire each end. Also few only, Tansistor "MICRO-MODULE" capacitors 0·2 mfd. 15v. wire-ended, size: $\frac{3}{32}$" dia. (disc). **T.A.G. and Union Carbide** 15 mfd. 10v. All types **£1·25** per doz. (mixed or as required). Carriage paid.

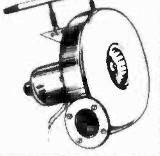
WHERE NO CARRIAGE CHARGE IS INDICATED PRICE IS INCLUSIVE. PERSONAL CALLERS WELCOME.

MOTORS

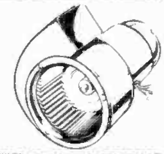


AMPEX 7.5v. D.C. MOTOR. This is an ultra-precision tape motor designed for use in the AMPEX model AG20 portable recorder. Torque 450GM/CM. Stall load at 500ma. Draws 60ma on run. 600 rpm ± 5% speed adjustment, internal AF/RF suppression. ⅛" dia. × 1" spindle, motor 3" dia. × 1·⅜". Original cost £16·50. **Our price £3·25.** P. & P. 25p. Large quantity available (special quotations). Mu-metal enclosure available **75p** each.

Brand New "DISCUS" Centrifugal Blower by Watkins & Watson. 240v. 50 Hz. Powered by A.E.I. continuous rating 2850 rpm motor. Cowl diameter 10". Outlet flange 2" I.D. Coupling flange supplied. These superb precision units are ideally suited for **Organ construction.** Offered at approx. half makers price **£12·50**. Carriage £1·50.



POWERFUL DUAL VOLTAGE. 110/240v. 50Hz. Blower by Fanmanco Ltd. A compact powerful unit with 3" dia. × 1⅞" wide impeller giving powerful thrust. 2" × 1⅞" outlet. Weight 3½lb. These units are unused and offered at only **£3·50**. P.&P. 30p.



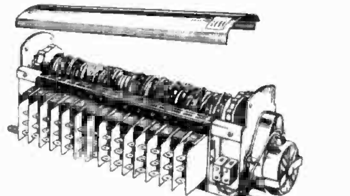
SPECIAL SUMMER OFFER

LIMITED PERIOD ONLY FROM NOW UNTIL 31st AUG. 1971 A DISCOUNT OF 20% WILL BE DEDUCTED ON ALL ORDERS OF £7·50 AND OVER

We welcome orders from established companies, educational depts., etc. (To cover invoicing costs minimum £2·50, please.)

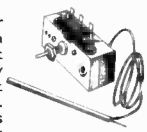
PROGRAMME TIMER BY HONEYWELL

A bank of 15 micro-switches are each independently operated by 15 pairs of cams which in turn are individually adjustable to give switching periods of zero to 12 seconds with infinitely variable combinations. A mains synchronous motor drives the cam shaft at 1 rev. per 12 seconds (5 R.P.M.). Designed originally for vending machines at a cost of **£15·00** plus. Many applications where continuous sequence programmes are required, such as lighting effects etc. New in original makers cartons. First class value at **£5·75** plus 25p P. & P.

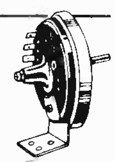


DEAC. RECHARGEABLE PERMA-SEAL Nickel-Cadmium Batteries Type 900B. 1·22v. at 900 mA (10-hr. rate). Size 90 mm. × 13·5 mm. Weight 40 gr. Unused **63p** ea. P. & P. 12p.

"TEDDINGTON" CONTROLS THERMOSTAT.—Adjustable between 75° and 100°C. A further internal adjuster takes the maximum up to 120°C. Circuit cuts in again at 3° below cut-out setting. 42" capillary and sensor probe. The thermostat actuates a 15 amp. 250v. c/o switch. A second single pole on/off switch is incorporated in the adjustment mechanism. **88p.**



"GOYEN" PRESSURE SWITCH.—Incorporating differential adjustment between 2" and 12" water gauge (a max. of approx. ½ p.s.i.). A single pole change-over switch rated 15 amps. 250v. is actuated. Air inlet tube $\frac{3}{16}$" dia. Projection $\frac{11}{16}$". Overall size: dia. 3⅛", depth 2" plus $\frac{11}{16}$" (air tube). **£1·25.**



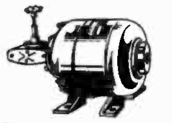
VINKOR POT CORE ASS. TYPE LA.2103. Normal price £1·48. Our price **75p** each. Special quote for quantity.

UNISELECTORS. 8 Bank 25-way 24v. Double sweep. Brand new in maker's boxes. **£5·25.** P. & P. 25p.

HEAVY DUTY PORTABLE BATTERIES. New ex WD. 12v. 75 AH. Built in stout metal cases with carrying handles and nifam socket outlet. Size 15¼" × 7¼" × 10¼" high, weight 73lb. **£8·75.** Carriage £2.

L.T. TRANSFORMER. Prim. 0-110-240v. Sec. 4.5v.-0-4.5v. at 2A. Size 1⅝" × 1¼" × 1$\frac{5}{16}$" **60p.** P.&P. 15p.

GEARED MOTORS



"Parvalux" Reversible 100 RPM Geared Motor. Type S.D.14, 230/250v. A.C. 22 lb./in. ⅜" spindle. 1st class condition. **£7·50** each. P. & P. 50p. Also limited number only as above. **Brand New. £12·50** each P. & P. 50p.

ELECTRO CONTROL (CHICAGO). Shaded pole 240v. 50 Hz. 110 rpm, 16 lb./in. **£2·25.** P. & P. 25p. 200 rpm 10 lb./in. **£2·50.** P. & P. 25p.

MYCALEX. Open frame, shaded pole motors. 240v. 50 Hz, 7 rpm. 28 lb./in. 80 rpm. 12 lb./in. **£2·25** each. P. & P. 25p.

SMITHS SYNCHRONOUS MOTORS. 12 r.p.h. 240v., 50 Hz, 2 watts. **88p** each. P. & P. 25p.

"CROUZET" TYPE 965. 115/240v. 50Hz. 47/68 Watts. 50 rpm. Stoutly constructed. Size: 2$\frac{11}{16}$" dia. × 3¼" long plus spindle 1"×¼" dia. Anti-clock. **£2·75.** P. & P. 25p.

MYCALEX MAINS. Shaded pole, 1425 rpm. $\frac{3}{16}$" spindle. 2 for **£1·25.** Carriage Paid.

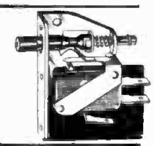
MAINS INDUCTION MOTOR. Open frame, $\frac{3}{16}$" spindle, weight ⅞ lb. Powerful. **88p** each. P. & P. 12p

E.M.I. PROFESSIONAL TAPE MOTOR. 110/240 v. 50 Hz. 3000 rpm, reversible, silent running. 4½" dia. × 4½" long. Spindle $\frac{3}{16}$" × 2". Weight 6 lbs. **£3·50** each or **£6·00** per pair. P. & P. 50p each.

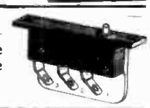
SYLVANIA CIRCUIT BREAKERS gas filled providing a fast thermal response between 80° and 180°C. Will withstand pressures up to 2,000 lb. sq./in. rated 10 amp. at 240v. continuous. Fault currents of 28 amps. at 120v. or 13 amp. at 240v. silver contacts. Supplied in any of the following opening temperatures (degs. cent.) 95, 100, 120, 130, 135, 140, 145, 150, 155, 160, 170, 175. **Price 3 for £1** or **£3·50** per dozen.

SYLVANIA MAGNETIC SWITCH—a magnetically activated switch operating in a vacuum. Switch speed—4ms. temperature —54 to +200°C. Silver contacts normally closed rated 3 amps. at 120v. 1·5 amp. at 240v. **Price 4 for £1; £2·50** per doz. P. & P. 10p. Special quotations for 100 or over. Reference magnets available **8p** each.

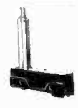
"HONEYWELL" TYPE 23AC-NE.—15 amp. change-over switch is fitted on angled metal mount with spring-loaded plastic rod operating cam. **50p** each.



"HONEYWELL" V3 SERIES.—Flush micro-switch 10 amp. c/o. The side panel is insulated. End-plate size: 2"×⅜". **£1·50** per dozen.

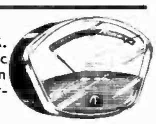


PYE MICROSWITCH. Otehall type. This switch has a 1⅜" × $\frac{13}{16}$" dia. column plus ½" plunger. Minimum travel operates switch. **45p** each. P. & P. 10p. Special discount for quantities.



METERS

ERNEST TURNER 800µa METER. 160Ω movement, 2" case, eliptic plastic front. Green-Red-Green uncalibrated scale **£1·50** each. Carriage Paid.



MINIATURE B.P.L. 500-0-500 MICRO-AMMETER. $\frac{13}{16}$" dia. scale. Through panel mounting. Hermetically sealed. **£1·63.** Carriage paid.

"TAYLOR" AMMETER 0-1 amp. Modern design 3½" × 3½". Plastic front. Calibrated 50 × 20 ma Divs. **£2·50** plus 25p P. & P.

"ATLAS" SUB-MINIATURE LAMPS (Capped).—Ratings 5v. 60ma. ·35 ±25% Lumens. Life Expectancy 60,000 hours or at 6v. 70 ma. ·75±25% Lumens, 5,000 hours. Size: 9·1 × 3·1 mm. **£1·50** per doz. **£5·00** box of 50..

HONEYWELL (USA) Sub-miniature 2 bank panel mounting micro-switch, positive toggle action giving 2 change-overs. Size: $\frac{7}{16}$" × $\frac{7}{16}$" × ⅜". **63p** each. Carriage paid.

OXLEY P.T.F.E. BARB TERMINALS. Stand off $\frac{11}{32}$" or ½". **£2·75** box of 100.

HARWIN. Tapped (6 Ba) high voltage "stand off" insulators, length ⅞", tapped (8 Ba) ⅜" long. **£2·00** per 100. Carriage Paid.

K.L.G. SEALED TERMINALS. Type TLSI AA, overall length $\frac{11}{16}$", box of 100, **£1·00** Type TLSI BB, overall length, 1", box of 100, **£1·50** Carriage Paid.

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BCY70	**18p**	2N1711	**25p**
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OC43	**20p**	2N3055	**75p**
OC44	**15p**	2N3702	**18p**
OC45	**10p**	2N3703	**13p**
OC46	**15p**	2N3704	**18p**
OC141	**22p**	2N3707	**15p**
OC139	**22p**	2N3877A	**40p**
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OC204	**25p**	7410	**40p**
2G345	**10p**	7430	**40p**
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Spot Face Cutter **38p.** Pin Insert Tool **48p.** Terminal Pins (0·1 or 0·15) 36 for **18p.** Special Offer Pack consisting of 5 2½in × 1in boards and a Spot Face Cutter—**50p.**

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1,000pf, 1,200pf, 1,500pf, 1,800pf, 2,200pf, **15p** per dozen (all 400V working). 0·15µf, 0·22µf, 0·27µf, **30p** per dozen (all 160V working). 25% discount for lots of 100 of any one type.

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An aerosol spray providing a convenient means of producing any number of copies of a printed circuit both simply and quickly.
Method: Spray copper laminate board with light sensitive spray. Cover with transparent film upon which circuit has been drawn. Expose to light. (No need to use ultra-violet.) Spray with developer, rinse and etch in normal manner.
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DK96	0·41	ECL83	0·65
DL92	0·32	ECL86	0·42
DL94	0·40	EF36	0·45
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DM70	0·30	EF39	0·40
DY86	0·30	EF40	0·50
DY87	0·32	EF41	0·62
DY802	0·48	EF80	0·25
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EABC80	0·32	EF91	0·15
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ECC81	0·30	EL84	0·23
ECC82	0·28	EL85	0·40
ECC83	0·30	EL86	0·40
ECC84	0·30	EL90	0·35
ECC85	0·40	EL95	0·35
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ECC88	0·37	EM31	0·25
ECC189	0·52	EM80	0·40
ECF80	0·35	EM84	0·35
ECF82	0·35	EM87	0·55
ECF83	0·75	EY51	0·40
ECF801	0·62	EY86	0·35
ECF802	0·62	EY81	0·35
ECH35	0·60	EY88	0·40
ECH42	0·65	EZ41	0·42
ECH81	0·28	EZ80	0·25
ECH83	0·42	EZ81	0·27
		GZ34	0·52
		KT66	1·60

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PCC84	0·37	U26	0·75	UCL82	0·35	1S4	0·25
PCC89	0·45	U27	0·50	UCL83	0·60	1S5	0·24
PCC189	0·55	U191	0·70	UV41	0·50	1T4	0·22
PCE800	0·75	U801	1·00	UF80	0·36	1X2A	0·40
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PCF82	0·33	UAF42	0·50	UL41	0·60	3A4	0·30
PCF84	0·46			UL84	0·30	3D6	0·15
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PCF801	0·48			VR105/30	0·35		
PCF802	0·48						
PCF805	0·72						
PCF806	0·65						
PCF808	0·72						
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PCL81	0·47						
PCL82	0·37						
PCL83	0·65						
PCL84	0·42						
PCL85	0·42						
PCL86	0·42						
PFL200	0·57						
PL36	0·53						
PL81	0·50						
PL82	0·40						
PL83	0·42						
PL84	0·35						
PL500	0·73						
PL504	0·75						
PY33	0·60						
PY80	0·35						
PY81	0·27						
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5R4GY	0·60	6A86	0·37	6CH6	0·55	6K25	0·70
5U4G	0·32	6A87G	0·80	6CL6	0·49	6SA7	0·40
5V4G	0·40	6AT6	0·30	6D6	0·20	6SA7GT	0·32
5Y4G	0·40	6AU6	0·25	6EA8	0·55	6SC7GT	0·25
5Y3GT	0·35	6AX4GT	0·40	6F23	0·75	6SG7	0·35
5Z4	0·75	6AX5GT	0·65	6F33	1·50	6SJ7	0·37
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6AC7	0·15	6BA6	0·25	6J5	0·40	6SL7GT	0·32
6AH6	0·50	6BE6	0·30	6J5GT	0·25	6SN7GT	0·35
6AK5	0·30	6BG6G	0·55	6J6	0·20	6SQ7	0·39
6AK8	0·32	6BJ6	0·45	6J7G	0·35	6SQ7GT	0·35
6AL5	0·15	6BQ7A	0·35	6J7M	0·40	6V6G	0·17
6AL5W	0·40	6BR7	0·80	6K6GT	0·56	6V6GT	0·35
6AM6	0·30	6BW6	0·80	6K7	0·32	6X4	0·27
6AN8	0·50	6BW7	0·70			6X5G	0·25
						6X5GT	0·32
						6Y6G	0·60
						6-30L2	0·70
						6Z4	0·32
						7B7	0·45
						7C5	0·65
						7C6	0·40
						7·7	0·32
						7Y4	0·60
						9D6	0·37
						11E2	2·50
						12AT6	0·30
						12AT7	0·30
						12AU7	0·29
						12AV6	0·30
						12AX7	0·30
						12BA6	0·35
						12BE6	0·35
						12BH7	0·27
						12C8	0·32
						12E1	1·25
						12K5	0·55
						12K7GT	0·40
						12K8GT	0·45
						12Q7GT	0·30
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						19G6	1·50
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30F5	0·84	6080	1·37
30FL1	0·70	6146	1·50
30FL12	0·92	8020	2·25
30FL13	0·50	9001	0·20
30FL14	0·75	9002	0·25
30L15	0·85	9003	0·50
30L17	0·80	9004	0·15
30P12	0·80	9006	0·15
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30PL13	0·92	VCR517R	5·50
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35W4	0·30	88D	9·00
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42	0·45	88L	9·00
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50CD6G	1·60	CMG25	2·75
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803	3·25	K301	5·00
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807	0·50	K308	16·00
813	3·75	K337	16·00
832A	0·40	KRN2A	3·50
866A	0·75	WL417A	1·50
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955	0·25	5C22	18·00
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OA10	0·30	OC38	0·42	1N25	0·60	40362	0·65	AF139	0·38	CRS1/35	0·43
OA70	0·10	OC44	0 20	1N43	0·10	82303	0·50	AF178	0·48	CRS1/40	0·48
OA71	0·10	OC45	0 12	1N70	0·07	3F100	0·62	AF186	0·45	CRS3/05	0·30
OA73	0·10	OC70	0 12	1N702-725	0·36	3FR5	0·32	AFY19	0·13	CRS3/20	0·38
OA74	0·10	OC71	0 15	1N823A	1·30	3N128	0·87	ASY26	0·28	CRS3/30	0·43
OA79	0·08	OC72	0 25	1ZMT5	0·35	3N139	1·75	ASY28	0·28	CRS25/025	0·75
OA81	0·07	OC73	0 30	1ZMT10	0·33	3N140	0·97	ASY67	0·48	CRS3/40	0·50
OA91	0·06	OC75	0 22	1ZT5	0·67	3N154	0·95	BAW19	0·28	GET103	0·20
OA200	0·08	OC76	0 25	1ZT10	0·63	3N159	1·45	BC107	0·15	GET115	0·45
OA202	0·10	OC81	0 25	2G385	0·51	6FR5	0·45	BC108	0·15	GET116	0·50
OA210	0·25	OC81D	0 20	2G403	0·51	12FR60	0·73	BC113	0·30	GEX66	0·75
OA211	0·37	OC81DM	0 20	1N4785	0·55	10D1	0·16	BC118	0·38	NKT222	0·20
OAZ200	0·55	OC82	0 25	2N918	0·65	40954	1·37	BCY72	0·37	NKT304	0·35
OAZ201	0·50	OC82DM	0 30	2N1304	0·25	40595	1·37	BF115	0·25	SD918	0·26
OAZ202 to OAZ206	0·42	OC83	0 22	2N1306	0·25	40636	1·45	BF173	0·30	SD928	0·31
OAZ207	0·47	OC83B	0 15	2N1307	0·25	40668	1·35	BFY51	0·22	SD938	0·32
OAZ208 to OAZ213	0·32	OC84	0 25	2N2147	0·75	40669	1·45	BFY52	0·23	SD94	0·21
OAZ223 to OAZ225	0·50	OC122	0 50	2N2904A	1·25	AC126	0·21	BSO5	0·38	SD988	0·46
OC16	0·42	OC139	0 25	2N3053	0·25	AC127	0·23	BS	0·45	V405A	0·38
OC22	0·42	OC140	0 37	2N3054	0·50	AC128	0·20	BS2	0·47		
OC25	0·37	OC170	0 25	2N3055	0·75	AC176	0·25	BSY29	0·18		
OC26	0·25	OC171	0 30	2N2730	2·75	ACY17	0·25	BU100	1·80		
OC28	0·62	OC172	0 37	2N3731	2·75	ACY28	0·20	BYZ13	0·20		
OC29	0·62	OC200	0 37			AD149	0·55	BYZ16	0·63		
		OC201	0·47			AD161	0·35	CRS1/10	0·25		
		OC206	0 50			AO162	0·35	CRS1/20	0·38		
		1N21	0·17			AF118	0·68				

ZENER DIODES

All preferred voltage

¼W	0·17
1W	0·37
1.5W	0·25
7W	0·37

MANY OTHERS IN STOCK include Cathode Ray Tubes and Special Valves. U.K. P. P.: Up to £1, 10p; over £1, 13p in £, over £3 post free. C.O.D. 20p extra.

VALVE VOLTMETER TYPE TF 958 Measures AC 100mV; 20 c/s to 100 mc/s, DC 50mV to 100V, multiplier extends ac range to 1.5kV. Balanced input and centre-zero scale for DC. AC up to 100MHz. **£32·50.**

VIDEO OSCILLATOR TF 885A & 885A I 25Hz to 5MHz and 25Hz-12MHz respectively, fine and square wave output up to 31v. **£55** and **£85** resp. Carriage £1·50.

MARCONI VHF OSCILLATOR TYPE TF 924/1. Complete with power unit Type TM 4230. Frequency range 2,100 MHz to 3,750 MHz, output power 10 to 50mW, Klystron Osc with automatic tracking Facilities for reflection modulation. **£125.** Carriage £2.

MARCONI VHF ALIGNMENT OSCILLOSCOPE TF 1104. Combined sweep generator and CRO for VHF, IF and VF analysis. RF ranges 41-216kHz. IF range 10-40MHz. VF range 5kHz to 10MHz. Output 10uV to 250MV continuous at 50 ohms. Sweep 500kHz to 10MHz. **£89·50.** Carr. £1.

MARCONI R/C OSCILLATOR TYPE TF 1101. Frequency range 20Hz to 200kHz. Accuracy ± 1%, distortion less than 0·5%. Stabilised Oscillator, no zero setting required. **£72·50.** Carriage £1·50.

HEWLITT PACKARD AUDIO SIGNAL GENERATOR MODEL 206A £89·50. Carriage £1·50. Full specification for S.A.E.

REMSCOPE TYPE 741 STORAGE OSCILLOSCOPE. On trolley, complete with plug-in trace shifter and two plug-in Y amplifiers. Price on application.

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MANY OTHERS IN STOCK

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CA 3005 wide band R.F. Ampl. 300mW diss .... **£1·35**
CA 3012 wide band ampl. 150mW diss .... **£1·10**
CA 3020 Audio power ampl. .... **£1·37**
CA 3036 Audio pre-ampl. .... **£0·95**

STC

MIC 9301B Digital dual 4 input gates **£4·30**
MIC 709-1C Linear operational ampl. **£9·50**
MIC 9005D High speed flip-flop .... **£2·70**

General Electric

PA 230 **£1·12**; PA 234 **£1**; PA 237 **£1·87**

Mullard

TAA 300 **£1·92**: TAA 320 **£0·57**

Plessey SL402A 2·5W **£2·12**; SL403A 3·5W **£2·67**

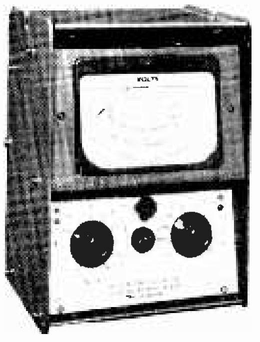
REDIFON

Twinplex combiner type AFS 13 **£65**
Twinplex converter type AFS 12 with P.S.W. **£85**
F.S.K. unit type GK185A **£58·50.**

VALVES & TRANSISTORS PHONE 01-743 4946

PLEASE NOTE Unless offered as "as seen" ALL EQUIPMENT ordered from us is completely overhauled mechanically and electrically in our own laboratories

MARCONI TEST EQUIPMENT

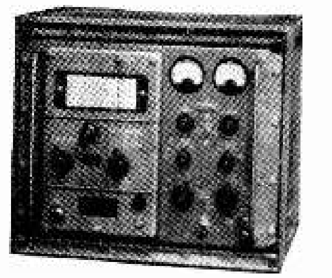


TF 144G SIGNAL GENERATOR. To clear. In very good "as seen" condition. Complete with mains and battery cables, etc. **£15.**

TF1041C VTVM A.C. voltage range 300 MV to 300V in 7 ranges. 20 Hz-1500 MHz. D.C. voltage ranges 300 MV-1000V in 8 ranges. D.C. resistance 50 ohms to 500 Mohms. Price **£62·50.**

TF144H SIGNAL GEN. Freq. range 10 KHz-72 MHz, R.F. output 2uV to 2V at 50 ohms 400 and 1000 Hz internal mod. Limited qty. only available. Full spec and price on request.

SIGNAL GENERATOR TF 801/A. 10-300 Mc/s. in 4 bands. Internal at 400 c/s. 1 kc/s. External 50 c/s to 10 kc/s. Output 0-100 db below 200 mV from 75 ohms source. **£85.** DITTO but **801/A/1** with additional high level output. **£89.** Both P. & P. £1, including necessary connectors, plugs, and instruction manual.



AM/FM SIGNAL GENERATOR TF 937 (CT 218) Frequency range 85kHz-30mHz. 8 bands. Main dial total 56 foot. Built in crystal calibrator 200kHz and 2mHz. RF output ·1μV to ·1V. Four internal mod. freq. FM deviation up to 9kHz. **£115.** Carriage £1/5/0.

F.M. DEVIATION METER TYPE TF934. Frequency range 2.5-100MHz. Can be used up to 500MHz. Deviation range 0-75kHz **£67·50.** Carriage £1·50.

SOLARTRON EQUIPMENT

Regulated and stabilised **P.S.U. SRS 151A,** 20 to 500V positive at 300mA in two ranges. Variable and fixed 170V negative output, **£35.** Carriage £1.
CD 711S.2. Double beam, DC to 7MHz 'scope, **£85.** Carriage £1·50.
CD 643.2. Single beam Laboratory Model, DC to 14MHz price upon application.

SIGNAL GENERATOR TYPE CT 480. 7-12kMHz in one range, square and pulse modulation and C.W. **£65.**

SIGNAL GENERATOR TYPE CT 478. As above but 1.3-4.2kMHz in two ranges **£55.**

1½in. DIA. PANEL METERS. 7½-15v —ideal for "Battery Condition" indicators for cars **£0·77.**

BOONTON Q METER TYPE 160A. Freq. range 50kHz to 75MHz, main capacitor 30 to 500pF. Vernier capacitor ± 3pF; q range. 0-250 with 2.5× multiplier. **£85** plus carriage.

VALVE CHARACTERISTIC METER complete with manual **£57·50.** Carriage £1·50.

MULLARD PRECISION VARIABLE CAPACITOR TYPE F.2 15 pF to 336 pF. Supplied with individual calibration certificate. Brand new in original packing. **£17.** Carriage 75p

SUSPENSION GALVANOMETERS Pye **£25.** P. & P. £0·60. Cambridge instruments **£12.** P. & P. £0·60.

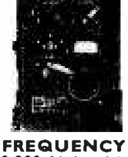
VACUUM CONDENSERS 12, 50, 55pF each 20,000v 30/-. P. & P. 4/-.

BRADLEY PORTABLE ELECTRONIC MULTIMETER TYPE CT471B. This instrument operates from three 1½V cells, is fully transistorised and measures A.C. and D.C. current, A.C. and D.C. voltage and D.C. resistance. Built-in battery check and calibration check. Full spec. and price on request.
As above but MODEL CT 471A manufactured by AVO, full spec and price on request.

4, 5 and 8 bank 25 way uniselectors, 24V, guaranteed perfect, **£3·75; £4·50; £6·87** respectively.

AR88 SPARES. We hold the largest stock in U.K. Write for list.

AERIAL TUNING UNIT BC 939



Originally made to work with Hallicrafters BC 610E transmitters. 2mc to 18mc, for output up to 450 watts. Brand new **£8·50.** Carriage £1.

PRECISION VHF FREQUENCY METER TYPE 183. 20-300 Mc/s with accuracy 0.03% and 300-1,000 Mc/s with accuracy 0.3%. Additional band on harmonics 5.0-6.25 Mc/s with accuracy + —2×10⁻⁴. Incorporating calibrating quartz 100 kc/s + —5×10⁻⁶ 120/220 v. A.C. mains. **£85.** Carriage £2.

MUIRHEAD-WIGAN DECADE OSCILLATORS. TYPE 650A 9650B. Frequency range 1 to 111,100 Hz. Accuracy ± 0.2%. Power supply 100-250 v. D.C. £65 and £75 respectively. carr. £1.75.

HARNESS "A" & "B" control units, junction boxes, headphones, microphones, etc.

29/41FT. AERIALS each consisting of ten 3ft., ⅞in. dia. tubular screw-in sections. 11ft. (6-section) whip aerial with adaptor to fit the 7in. rod, insulated base, stay plate and stay assemblies, pegs, reamer, hammer, etc. Absolutely brand new and complete ready to erect; in canvas bag, **£4.** P. & P. £0·50.

FOR EXPORT ONLY
53 TRANSMITTERS. All spares available. COLLINS TCS. Complete installations and spare parts. **COLLINS TYPE 231D 5KW TRANSMITTERS.** 10 channel, autotune and manual tuning. Complete with very comprehensive spares. Full specification and price on application. Complete installations and all spares. No. 19 WIRELESS SETS. H.P. SETS and all spares R 210 RECEIVERS with all necessary accessories.
PYE PTC 2002N A.M. Ranger Mobile Radio Telephone, brand new and complete, **£45.**

★ **Open 9-12.30, 1.30-5.30 p.m. except Thursday 9-1 p.m.** ★

TELEPHONE ENQUIRIES relating to **TEST EQUIPMENT** should be made to 01-748 8006 Extension 23. To view **TEST EQUIPMENT** please phone for appointment

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170 Goldhawk Rd., London, W.12
Tel. 01 - 743 0899

Modern **TELEPHONES** type 706. Two-tone grey and two-tone green. **£3·50** ea. P. & P. 25p ea. Brand new **£6** ea. P. & P. 25p ea.
STANDARD GPO DIAL TELEPHONES (black) with internal bell. **87p.** P. & P. 25p. Two for **£1·50.** P. & P. 37p.

SURVEY METER RADIAC No. 3. Hand portable size 9½ × 5 × 5¼ ins. 3 ranges (scale changes) 0.03; 0.3; 3 R/H. Internal Ion Chamber. Nice condition **£3** ea. P. & P. 50p.

PHOTOMULTIPLIERS. EMI 6097X at **£8·50** ea. 6097B—**£5** ea. Type 931A—**£2·25** ea.
TRANSISTOR OSCILLATOR. Variable frequency 40 c/s to 5 kc/s. 5 volt square wave o/p. for 6 to 12v DC input. Size 1⅛ × 1⅛ × 1⅛in. Not encapsulated. Brand new. Boxed. **57p** ea.
CRAMER TIMER 28V DC Sweep 1/100th sec & sweep 60 secs. 4" dial. Remote control stop/start reset **£5·00.**

RELAYS
G.E.C. Sealed Relays High Speed 24V. 2m 2b—**23p** ea. S.T.C. sealed 2 pole c/o, 2,500 ohms. (okay 24v) **13p** ea; 12v **35p** ea.
CARPENTERS polarised Single pole c/o 20 and 65 ohm coil as new, complete with base **37p** ea.
Single pole c/o 14 ohm coil **33p** ea; Single pole c/o 45 ohm coil **33p** ea. Single pole c/o 4000 ohm coil **33p** ea.
Varley VP4 Plastic covers 4 pole c/o 5K—**30p** ea. 15K—**33p** ea.

POTENTIOMETERS
COLVERN Brand new. 50; 100; 250; 500 ohms; 1; 2.5; 5; 10; 25; 50k all at **13p** ea. Special Brand new.
MORGANITE 2.5K; 250K; 500K 2.5 meg. 1" sealed. **17p** ea.
STANDARD 2 meg Log pots. Current type. **5p** ea.
INSTRUMENT 3" Colvern. 5; 25 ohms **35p** ea.
BOURNE TRIM POTS. 10; 20; 50; 100; 200; 250; 5 00 ohms; 1; 2.5 5; 25K at **35p** ea.
ALMA precision resistors 100K; 400K; 497K; 998K; 1 meg—0·1.. **27p** ea.; 3·25K—0·1.. **20p** ea.
DALE heat sink resistors, non-inductive 50 watt. Brand new 8.2K at **13p** ea.
SILVER ZINC Non-spill. Brand new. Single cell 1.5V 4AH size 1⅞ × ⅞ × 3½. 4oz. weight **£1** ea.
MALLORY CELLS. **25p** per set of 5.

CAPACITORS
ERIE feed through ceramicons 2200 pf—**4p** ea.
Sub-min. **TRIMMER** ⅜ square. 8, 5pf. Brand new **13p** ea.
Concentric **TRIMMER** 3/30 pf. Brand new **7p** ea.
ELECTROLYTICS. Brand new. 250 mfd. 70V **23p** ea.
E.H.T. 2 mfd 5 KV. Brand new **£1·50** ea.
E.H.T. 0.1 mfd 7 KV at **40p** ea.; 0.1 mfd 5 kv at **35p** ea. Brand new 0.25mfd 5 KV. Dubilier **50p** ea. P. & P. 15p. Rapid discharge 1mfd 5.6KV **£1** ea. P. & P. 15p.

DECADE DIAL UP SWITCH. Finger-tip. Engraved 0/9. Gold plated contacts. Size 2¼" high, 2¼" deep ½" wide. **75p** ea. Bank of 4 with escutcheon plates, etc. 2¼" high, 2¼" deep, 2¼" wide **£2·50.**

PHOTOCELL equivalent OCP 71 **13p** ea.
Photo-resist type Clare 703. (TO5 Case). Two for **50p.**
BURGESS Micro Switches V3 5930. Brand new **13p** ea.
HONEYWELL. Sub-min. Microswitches type 11SM3-T. Brand new. **17p** ea.
PANEL mounting lamp holders. Red or green. **9p** ea.

BRAND NEW PLUGS AND SOCKETS
CANNON. 50 way DDM50P **75p** ea.; DDM50S **50p** ea. **£1** per pair.
As above but 25 way **50p** ea. plug; **35p** ea. socket; **75p** per pair; 9 way **33p** ea. plug and socket. **50p** per pair.
U.H.F. Plugs fit UR57, 59, 65 etc., **40p** ea.
B.N.C. to U.H.F. Adaptor **£1·25** ea.; Min. B.N.C. to U.H.F. **£1·50** ea.; 'T' junction B.N.C. **£1** ea.; B.N.C. plug to B.N.C. plug **£1** ea.; B.N.C. Right angle **£1** ea.; Min. B.N.C. right angle **£1·25** ea.; Min. socket round **50p** ea. Standard B.N.C. round **35p** ea. Many others too numerous to list. All prices quoted for 'one off.'

TRANSFORMERS. All standard inputs.
STEP DOWN ISOLATING trans. Standard 240v AC to 120V tapped 60-0-60 700W. Brand new. **£5** ea.
As above 55-0-55V 300W. **£3** ea. P. & P. 35p.
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Multi 6.3Volts to give 48V 3.5Amps etc. **£3·50** incl. post.
Transformer 0-215-250 120 MA; 6.3V 4A CT × 2; 2 × 6.3v 0.5A and separate 90v 100 MA **£1·25** ea. P. & P. 20p.
Matching contact cooled bridge rectifier **37p** ea.
4.5V 40 amp (180Va) **£1·75** ea. incl. postage or 3 for **£4·50** incl. postage. Designed to be Series paralleled.
Parmeko 6.3v 2 amp × 4—**£1·13** ea.
Gard/Parm/Part. 450-400-0-400-450. 180 MA. 2 × 6.3v. **£3** ea.
Transformer 250-80MA; 13V-1.2A and 6.3V 5A. **£1·50.** P. & P. 25p.
CHOKES. 5H; 10H; 15H; up to 120mA. **42p** ea. P. & P. 17p. Up to 250mA **63p.** P. & P. 35p.
Large quantity LT. HT. EHT transformers.
GROUND PLANE ANTENNA. Ex-admiralty. Brand new boxed. Adjustable 90-160 megs. (Like umbrella) **£6·50.** Carr. £1.

NUCLEONIC INSTRUMENTS
Pulse analyser N101; Scaler 1009E; Coincidence unit 1036C; Anti coincidence unit Panax AU460; Amplifier N567; A/B/G Radiation Monitor 1257A; complete 1339A system A/B/G; EHT Potentiometer unit 1007; 1430 amplifier CF and head; Some scintillation castles; radiation monitor 1320C and 1320X (X-ray), survey meters no. 2 and 3; Ratemeter scintillation 1368A; Fast neutron 1262C; Fluori-meter 1080A and many others. Also 2000 SERIES. Amp 2002A; Low level amp 2024; PU's 2004; 2005B; nanosec time amplitude convertor 2011A; pulse amplitude analyser 2010B; discriminator 2007B; high level amp 2025 and others. Information available.

MARCONI Wide Range Oscillator TF1370's and TF1370A's. 10c/s—10mc/s from **£140.**

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E.M.I. WM 2 DC—13 mc/s **£25**
SOLARTRON CD1014 DB. DC—6 megs. **£55.**
SOLARTRON 711S.2 D.B. DC—9 mc/s. In fine condition **£50.**
SOLARTRON 643 DC—15 mc/s Brand new **£85** Good condition **£50.**
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SOLARTRON CT316 (D300 range) DC—6 megs. **£17·50.**
SOLARTRON Storage scope QD910 **£150.**
COSSOR 1049 Mk. 3. DB. **£25**
HARTLEY 13A DB. **£25.**
CT52. Min. scope. **£17·50.**
All carefully checked and tested. Carriage £1·50 extra.

MARCONI
Noise gen. TF1301. **£40.** Carr. £1·50.
Vacuum tube Voltmeter TF1041A, **£35**; 1041B, **£45.**
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Better grade **£55** ea. Carr. £1·50.
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TF 369 N. 5 Impedance Bridge from **£50** ea. Carr. £1·50.
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Laboratory amplifier AWS51A. 15c/s—350kc/s **£35** Carr. £1
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Oscillator type OS 101. **£30.** Carr. £1·50.
D.C. Amplifier type AA900. **£30.** Carr £1.

AVO
Testmeter No. 1 **£12** ea. Carr. 75p.
Electronic Testmeter CT 38. Complete **£20** Carr. £1

CINTEL
Square and Pulse gen. PW 0·05 to 0·3 micro secs. 15mV to 50V; rep rate 5 hz to 250 kz **£20.** Carr. £1.

AIRMEC
Signal Generator type 701. **£25.** Carr. £1·50.
AIRMEC Generator type 210 **£120.** Carr. £1·50.

MARCONI TF 1277. Colour studio scope, will line select. In superb condition. **£120.**

E.M.I. Oscilloscope type WM16. Main frame **£125.** Choice of Plug in 7/2 DC—24 mc/s x 2 **£35**; 7/1 DC—40 megs **£25.** Differential unit available from **£40.**
E.M.I. WM8. DC to 15 mc/s. Complete with plug in pre-amp. from **£40.**

BRADLEY ATTENUATORS 0/500 meg cycles. 0/12 db and 0/120 db—**£20** per pair.

BECKMAN MODEL A. Ten turn pot complete with dial. 100k 3% Tol 0.25%—only **£2·13** ea.

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DVM's BIE 2114 **£50** ea.; BIE 2116 **£50** ea. Carr. £1·50.
BC221—Brand new **£35** ea. Carr. £1.
NAGARD Double pulse gen type 5002 **£50.** Carr. £1·50.

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FIBRE GLASS PRINTED CIRCUIT BOARD. Brand new. Single side ½p per sq. in. Double sided **1p** per sq. in. Cut to size (Max. 2⅞" × 15"). Postage 5p per order.
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Standard **240V MOTORS** by **CITENCO** reduction gearbox to 19 r.p.m. reversible. **£5** ea.
Single pole 3-way 250 V AC 15 amp switch. **8p** ea. P. & P. 5p. Large discount for quantity.
Modern replacement for VCR 138 tube. Flat face 3 in. **£1·63.** P. & P. 25p. Bases 17p.
FERRITE rods complete with LW, MW and coupling coils. Brand new. **25p** ea. P. & P. 7p.
Squirrel cage **BLOWER ASSEMBLY** complete with standard mains input motor. Size 7" × 2¼" dia. only **80p** ea. P. & P. 25p ea.
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Double Bay complete with doors. Fine condition. **£25.** Carriage at cost.
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Signal Generator CT53. Complete with charts **£15.** Carr. £1·50.
TIME CALIBRATOR unit by Cawkell any or all time intervals from 0.5 microsecond to 1,000 microsecond. Internal calibration; gate generation **£40.** Carr. £1·50.
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MUIRHEAD Swept Audio Oscillator **£50** ea. Carr. £1·50.
EMI Swept Audio Oscillator type SRO2 **£40** ea. Carr. £1·50.
Travelling **WAVE** oscilloscopes—Sweep speed from 10 micr secs to 10 nano secs. **£150** ea.

4 DIGIT RESETTABLE COUNTERS. 1000 ohm. coil. Size 1⅛ × ⅞ × 4⅛in. As new, by Sodeco of Geneva. **£2·50** ea.
As above but 350 ohm. **£3·50** ea.

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SANGO 50 micro amp 4" round. Brand new boxed. **£1·38.** P. & P. 38p.
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SEEING IS BELIEVING!
First come, first served
AT LAST. BC221 complete with correct charts, circuit diagrams, in fine condition for **ONLY £13·34.** Carr. £1.
C.R.T.'s 5" type CV1385/ACR13. Brand new with spec. sheet. **63p** ea. P. & P. 35p.
MARCONI Valve Voltmeter 428B/1 **£5** ea. Carr. £1.
RESISTORS by **PIHER.** Carbon Film. 1 and 2 watt. All 5%. Brand new Perfect. Mixed values. Only **50p** per 1-lb. weight P. & P. 12p.
COSSOR D.B. Scopes—some models from **£15.**
MARCONI Absorption Wattmeter 1 micro watt to 6 watts. Type TF956. FANTASTIC at **£7** ea.
SOLARTRON Stab. PU AS516 & AS517. Circuits supplied. Fantastic value at **£2** and **£4** each.
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BP 20 = 7420	Dual 4-input Positive NAND Gates	23p	20p	15p
BP 30 = 7430	8-input Positive NAND Gates	23p	20p	15p
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BP 54 = 7454	4-wide 2-input AND-OR-INVERT Gates	23p	20p	15p
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PAK No.		PAK No.		PAK No.	
UIC00 = 12 × 7400N	50p	UIC42 = 5 × 7450N	50p	UIC80 = 5 × 7480N	50p
UIC01 = 12 × 7401N	50p	UIC50 = 12 × 7450N	50p	UIC82 = 5 × 7482N	50p
UIC02 = 12 × 7402N	50p	UIC51 = 12 × 7451N	50p	UIC83 = 5 × 7483N	50p
UIC03 = 12 × 7403N	50p	UIC60 = 12 × 7460N	50p	UIC86 = 5 × 7486N	50p
UIC04 = 12 × 7404N	50p	UIC70 = 8 × 7470N	50p	UIC90 = 5 × 7490N	50p
UIC05 = 12 × 7495N	50p	UIC72 = 8 × 7472N	50p	UIC92 = 5 × 7492N	50p
UIC10 = 12 × 7410N	50p	UIC73 = 8 × 7473N	50p	UIC93 = 5 × 7493N	50p
UIC20 = 12 × 7420N	50p	UIC74 = 8 × 7474N	50p	UIC94 = 5 × 7494N	50p
UIC40 = 12 × 7440N	50p	UIC75 = 8 × 7475N	50p	UIC95 = 5 × 7495N	50p
UIC41 = 5 × 7441AN	50p	UIC76 = 8 × 7476N	50p	UIC96 = 5 × 7496N	50p

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DTL 930 SERIES

Type No.	Function	Price 1-24	25-99	100 up
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BP932	Expandable dual 4-input NAND buffer	25p	23p	20p
BP933	Dual 4-input expander	25p	23p	20p
BP935	Expandable Hex Inverter	25p	23p	20p
BP936	Hex Inverter	25p	23p	20p
BP944	Dual 4-input NAND expandable buffer without pull-up	25p	23p	20p
BP945	Master-slave JK or RS	35p	32p	29p
BP946	Quad, 2-input NAND	23p	20p	15p
BP948	Master-slave JK or RS	35p	32p	29p
BP951	Monostable	90p	85p	80p
BP962	Triple 3-input NAND	23p	20p	15p
BP9093	Dual Master-slave JK with separate clock	80p	75p	70p
BP9094	Dual Master-slave JK with separate clock	80p	75p	70p
BP9097	Dual Master-slave JK with Common Clock	80p	75p	70p
BP9099	Dual Master-slave JK Common Clock	80p	75p	70p

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UIC930 = 12 × µA 930	50p	UIC948 = 8 × µA 948	50p
UIC932 = 12 × µA 932	50p	UIC951 = 5 × µA 951	50p
UIC933 = 12 × µA 933	50p	UIC961 = 12 × µA 961	50p
UIC935 = 12 × µA 935	50p	UIC9093 = 5 × µA 9093	50p
UIC936 = 12 × µA 936	50p	UIC9094 = 5 × µA 9094	50p
UIC944 = 12 × µA 944	50p	UIC9097 = 5 × µA 9097	50p
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BP701C—SL701C	TO-5	8	OP Amp.	63p	50p	45p
BP702C—SL702C	TO-5	8	OP Amp Direct O/P	63p	50p	45p
BP702—72702	D.I.L.	14	G.P. O.P. Amp (Wide Band)	53p	45p	40p
BP709—72709	D.I.L.	14	High Gain OP Amp...	53p	45p	40p
BP709P—µA709C	TO-5	8	High Gain OP Amp...	53p	45p	40p
BP741—72741	D.I.L.	14	High Gain OP. Amp (Protected	75p	60p	50p
µA703C—µA703C	TP-5	6	R.F.—IF Amp	43p	35p	27p
TAA263	TO-72	4	A.F. Amp	70p	60p	55p
TAAA293	TO-74	10	G.P. Amp	90p	75p	70p

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Q30	7	Sil. switch trans. 2N706 NPN	50p
Q31	6	Sil. switch trans. 2N708 NPN	50p
Q32	3	PNP Sil. trans. 2 × 2N1131, 1 × 2N1132	50p
Q33	3	Sil. NPN trans. 2N1711	50p
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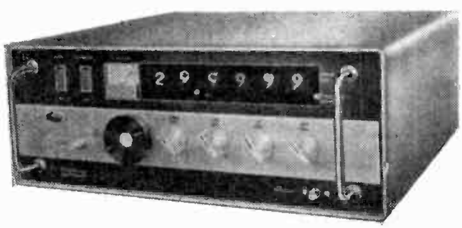
'S' Meter.
Mains Input 100/125 or 200/250v. 50/60Hz 70W.
Dimensions 9" high, 19·2" wide, 18·75" deep, suitable for 19" rack mounting.



THE SYNTHESIZERS TYPE RC460/S have the following main characteristics:—

- **FREQUENCY COVERAGE 1MHz to 29·9999 MHz in 100Hz steps**
- **FACILITY FOR USING EXTERNAL FREQUENCY STANDARDS OF 5MHz, 1MHz, 200KHz or 100KHz AS WELL AS THE INTERNAL STANDARD of 5MHz**
- **FREQUENCY STABILITY OF BETTER THAN 1 PART IN 10^6 PER 100 DAYS, 3 PARTS IN 10^8 PER DAY**
- **OUTPUT 0·3-lv r.m.s. INTO 50 OHMS (metered)**

The Mains supply to the unit is 100/125 or 200/250v. 50/60Hz 60W.
The dimensions 7" high, 19·2" wide, 18" deep, suitable for rack mounting.

PRICES OF THE ABOVE INSTRUMENTS ARE:— **RC410/R £300, RC411/R £350** (List £1,500 approx.)
RC460/S (Bench or Rack Mounting version) **£150**

All instruments supplied complete with handbooks.

Carriage extra at cost but we would recommend customers to arrange to collect from any of the addresses below by appointment at all of which the equipments can be demonstrated. Alternatively, delivery to U.K. Mainland can be arranged by special carrier at a cost of £5 per item (England) or £10 per item (Scotland). (Plus insurance £1.) TERMS: Strictly C.W.O. or supply against official order from approved customers.

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SN74164	£2·20
SN74165	£2·25
SN74192	£2·25
SN74193	£2·25
TAA241	£1·62
TAA242	£4·25
TAA243	£1·50
TAA263	75p
TAA293	97p
TAA300	£1·75
TAA310	£1·25
TAA320	72p
TAA350	£1·75
TAA435	£1·47
TAA521	£1·32
TAA522	£3·60
TAA530	£4·95
TAA811	£4·45
TAB101	97p
TAD100	£1·97
TAD110	£1·97
SL403A	£2·25
SL702C	£1·47
UA702A	£2·80
UA702C	77p
UA703C	£1·37
UA709C	£1·25
UA710C	£1·25
UA716	£1·87
UA723C	£1·62
UA730C	£1·60
UA741C	87p

BRIDGE RECTIFIERS PLASTIC ENCAPSULATED

600 PIV 1A	50p	200 PIV 4A	75p
50 PIV 2A	55p	400 PIV 4A	80p
100 PIV 2A	60p	50 PIV 6A	62p
200 PIV 2A	67p	100 PIV 6A	75p
400 PIV 2A	80p	200 PIV 6A	85p
50 PIV 4A	60p	400 PIV 6A	£1·10
100 PIV 4A	70p		

SILICON RECTIFIERS MINIATURE WIRE ENDED PLASTIC

	IN Series 1 amp	PL Series 1·5 amp	CL Series 3 amp
4001 50PIV	8p	10p	19p
4002 100PIV	9p	11p	20p
4003 200PIV	10p	12p	22p
4004 400PIV	10p	12p	25p
4005 600PIV	12p	15p	26p
4006 800PIV	15p	17p	27p
4007 1000PIV	20p	20p	30p

50+ less 15%; 100+ less 20%

SILICON RECTIFIERS STUD MOUNTING

	6A	10A	17·5A	35A
100PIV	—	45p	50p	£1·22
200PIV	25p	50p	55p	£1·42
400PIV	30p	55p	62p	£1·77
600PIV	32p	60p	72p	£2·12
800PIV	35p	75p	87p	£2·47
1000PIV	40p	85p	*1·05	£2·77

50+ less 15%; 100+ less 20%

DIODES AND RECTIFIERS

1N34A	10p	BA154	12p	GJ7M	37p
1N914	7p	BAX13	12p	OA5	17p
1N916	7p	BAX16	12p	OA6	12p
AA119	7p	BAY31	7p	OA10	22p
AA129	10p	BAY38	25p	OA9	10p
AAZ13	10p	BY100	15p	OA47	7p
AAZ15	12p	BY103	22p	OA70	7p
AAZ17	12p	BY122	37p	OA73	10p
BA100	15p	BY124	15p	OA79	9p
BA102	22p	BY126	15p	OA81	7p
BA110	32p	BY127	17p	OA85	7p
BA111	27p	BY164	57p	OA90	7p
BA112	70p	BY210	35p	OA91	7p
BA115	7p	BYZ11	32p	OA95	7p
BA141	32p	BYZ12	30p	OA200	10p
BA142	32p	BYZ13	25p	OA202	10p
BA144	12p	BYZ16	40p	OA210	17p
BA145	20p	FST3/4	22p		

THYRISTORS

PIV	50	100	200	300	400
1A	25p	27p	37p	40p	47p
4A	—	47p	55p	57p	77p
5A	—	55p	65p	—	75p
7A	—	55p	65p	—	97p

REDPOINT HEATSINKS

W-type	1·25" × 5·1"	W-type	1·25" × 5·1"
2W 2"	22p	4W 4"	37p
3W 3"	30p	6W 6"	55p

P. & P. 15p

TO5 and TO18 Finned 5p

VALVES

OA2	38p
OB2	45p
OZ4	30p
1L4	20p
1R5	35p
1S5	25p
1T4	25p
1U4	27p
1U5	50p
2D21	35p
3Q4	40p
3S4	35p
3V4	45p
5R4	60p
5U4	33p
5V4	42p
5Y3	32p
5Z4G	40p
6/30L2	75p
6AC7	25p
6AG7	40p
6AK5	30p
6AK6	57p
6AL5	20p
6AM6	33p
6AQ5	35p
6AS6	37p
6AT6	30p
6AU6	25p
6AV6	30p
6BA6	25p
6BE6	30p
6BH6	45p
6BJ6	45p
6BQ7A	40p
6BR7	85p
6BR8	65p
6BW6	85p
6BW7	70p
6BZ6	35p
6C4	33p
6CD6	£1·15
6CL6	50p
6CQ4	63p
6F1	62p
6F6G	30p
6F13	38p
6F14	65p
6F15	65p
6F18	45p
6F23	80p
6H6	20p
6J4	50p
6J5	20p
6J5GT	30p
6J6	20p
6J7	45p
6K8G	35p
6L6GT	45p
6LD20	40p
6Q7	40p
6SA7	40p
6SG7	35p
6SJ7	40p
6SK7	35p
6SL7	35p
6SN7	35p
6SQ7	40p
6U4	60p
6V6G	25p
6V6GT	32p
6X4	30p
6X5G	30p
6X5GT	27p
10C2	50p
10F1	90p
10P13	55p
10P14	£1·10
12AT6	30p
12AT7	30p
12AU7	30p
12AX7	30p
12AV6	33p
12BA6	35p
12BE6	35p
12BH7	40p
19AQ5	35p
20D1	45p
20F2	75p
20L1	£1·10
20P1	50p
20P3	60p
20P4	£1·10
20P5	£1·20
25L6	45p

25Z4	30p
25Z5	42p
25Z6	65p
30C15	80p
30C17	85p
30C18	75p
30F5	85p
30FL1	70p
30FL12	92p
30FL14	75p
30L15	85p
30L17	80p
30P12	80p
30P19	60p
30PL1	70p
30PL13	93p
30PL14	90p
35L6	50p
35W4	30p
35Z4	30p
35Z5	40p
50B5	45p
50C5	40p
80	50p
85A2	40p
807	50p
1625	50p
5763	70p
6146	£1·50
AZ31	50p
CY31	35p
DAF91	25p
DAF96	42p
DF91	25p
DF96	42p
DK91	35p
DK92	50p
DK96	42p
DL92	35p
DL94	45p
DL96	42p
DM70	32p
DY86	33p
DY87	35p
E88CC	65p
E180F	95p
EABC80	35p
EAF42	35p
EB91	20p
EBC41	55p
EBC81	30p
EBF80	40p
EBF83	40p
EBF89	32p
EBL21	60p
EC86	60p
EC88	60p
ECC40	60p
ECC84	30p
ECC85	60p
ECC88	40p
ECF80	35p
ECF82	35p
ECF86	85p
ECH21	57p
ECH35	60p
ECH42	70p
ECH81	30p
ECH83	40p
ECL80	40p
ECL82	35p
ECL83	65p
ECL86	40p
EF37A	60p
EF39	40p
EF40	50p
EF41	65p
EF42	70p
EF80	25p
EF85	35p
EF86	30p
EF89	28p
EF91	33p
EF92	40p
EF183	30p
EF184	35p
EH90	40p
EL34	50p
EL33	£1·25
EL41	55p
EL42	58p
EL81	55p
EL84	25p
EL85	43p
EL91	32p

EL95	35p
EM80	40p
EM81	50p
EM84	35p
EM85	£1·00
EM87	43p
EY51	40p
EY86	40p
EY87	42p
EZ140	45p
EZ41	45p
EZ80	25p
EZ81	28p
GZ32	48p
GZ34	60p
KT66	£2·05
KT88	£2·00
MU14	60p
PABC80	40p
PC86	60p
PC88	60p
PC97	45p
PC900	48p
PCC84	40p
PCC85	40p
PCC88	55p
PCC89	50p
PCC189	55p
PCF80	30p
PCF82	34p
PCF84	50p
PCF86	60p
PCF800	80p
PCF801	50p
PCF802	50p
PCF805	75p
PCF806	70p
PCF808	75p
PCL82	35p
PCL83	65p
PCL84	45p
PCL85	40p
PCL86	45p
PFL200	70p
PL36	55p
PL81	50p
PL82	45p
PL83	45p
PL84	40p
PL500	75p
PL504	80p
PY32	55p
PY33	63p
PY80	35p
PY81	30p
PY82	30p
PY83	38p
PY88	40p
PY800	50p
PY801	50p
U25	75p
U26	75p
U50	32p
U52	33p
U191	75p
U281	40p
U282	40p
U301	40p
U801	£1·00
UABC80	35p
UAF42	55p
UBC41	50p
UBC81	40p
UBF80	40p
UBF89	35p
UCC84	49p
UCC85	40p
UCF80	55p
UCH21	60p
UCH42	70p
UCH81	35p
UCL82	35p
UCL83	60p
UF41	60p
UF80	35p
UF85	40p
UF89	35p
UL41	65p
UL84	30p
UY41	45p
UY85	30p
VR105/30	38p
VR150/30	35p

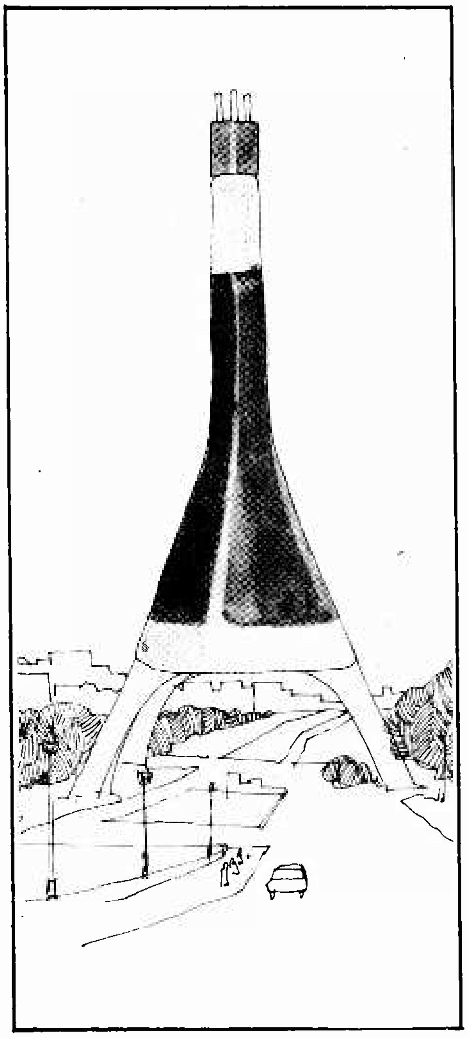
ZENER DIODES

400 MW	1·5 watt	10 watt
3·3-33 Volt	2·4-100 Volt	3·9-100 Volt
15p each	20p each	25p each

25 + less 15%; 100+ less 20%

2N3055	75p	AF239	37p
25+	62p	25+	32p
100+	50p	100+	28p
		500+	25p
		1000+	20p
BC113	15p	BC148	11p
25+	13p	25+	9p
100+	12p	100+	8p
500+	10p	500+	7p
1000+	8p	1000+	6p
BYZ13	25p	BC168C	15p
25+	20p	25+	12p
100+	17p	100+	10p
500+	15p	500+	8p
1000+	13p	1000+	6p
BC107/8/9	10p	BC169C	15p
25+	9p	25+	12p
100+	8p	100+	10p
500+	7p	500+	8p
1000+	6p	1000+	6p
OC71	12p	AD161/AD162	35p
25+	10p	25+	30p
100+	9p	100+	25p
500+	8p	500+	22p
1000+	7p	1000+	20p
OC72	12p	BF194	17p
25+	10p	25+	15p
100+	9p	100+	13p
500+	8p	500+	12p
1000+	7p	1000+	10p

← See previous page • **G. W. SMITH & Co. (RADIO) LTD** • Also see opposite page →



APPOINTMENTS VACANT

HUDDERSFIELD RAMSDEN TECHNICAL COLLEGE

NEW NORTH ROAD, HUDDERSFIELD

Principal: Dr. H. T. Taylor, B.Sc., M.Sc.(Tech.), F.R.I.C., M.B.I.M.

EDUCATIONAL TELEVISION SERVICE

Applications are invited for the post of

LECTURER I

for the College E.T.V. Service

The person appointed will eventually be responsible for the organisation of E.T.V. in the College and will be expected to further develop the use of the studio. He will assist in the preparation of educational material being integrated into curriculum development programmes and therefore appropriate experience of studio procedures together with a flair for script writing for E.T.V. is desirable.

Salary (Burnham Scale): Lecturer Grade I—£1,230-£2,075 p.a. (under review)

Additions may be given for approved qualifications and industrial experience.

Application forms and further particulars are obtainable from the Principal to whom applications should be returned within fourteen days from the appearance of this advertisement. **(Please quote R.T.C. 142).**

H. GRAY
Clerk to the Governors

1250

The HATFIELD POLYTECHNIC

Senior Technician for PSYCHOLOGICAL LABORATORY

to be responsible for maintenance and construction of a variety of electronic and other equipment. The post is a new one and offers scope for individual responsibility. Applicants should hold an appropriate National Certificate or City and Guilds qualification. Salary scale: Grade T3/T4 £1089-£1515, according to experience and qualifications.

Apply to the Secretary and Academic Registrar, The Hatfield Polytechnic, PO Box 109, Hatfield, Herts. Quote ref: 535/WW.

1252

The Royal Fleet Auxiliary

requires

Radio Officers

Rate of pay on entry depends on experience but as examples, a newly qualified officer would receive £1116 and one with 3 year sea-service would receive £1656.

Regular increments are awarded for Company service thereafter and there are excellent prospects for promotion into the Senior grade with salaries rising to £3348 per annum.

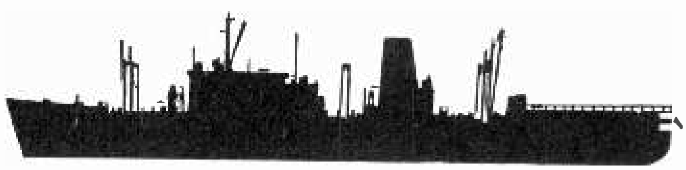
There are additional allowances for officers in possession of extra technical qualifications.

* Leave 116 days per annum served
* Paid study leave
* Generous sick leave and welfare arrangements.
* Non-contributory pension
* Special training courses on full pay
* Opportunities for wives to travel

The Royal Fleet Auxiliary is a career service offering an interesting and exciting way of life to young men of above average ability who seek a more challenging technical job at sea.

For further particulars, write or telephone:-

The Director of Fuel, Movements and Transport (Naval) 74A, Room 2125, Empress State Building, London SW6. Telephone: 01-385 1244 Ext. 3213



1217

Opportunities with Redifon in Radio Communications

Experienced Test Engineers are invited to write to Redifon with regard to vacancies in our Test Department at Wandsworth.

The salary range for these positions is £1,248–£1,749 plus. The Company is engaged in the design and manufacture of a wide range of radio communications and allied equipment from military pack-set to broadcast transmitter, including communications receivers, M.F. beacons, teleprinter terminals, complete radio office installations for the Merchant Marine and mobile H.F. S.S.B. stations. Our Test Engineers have sound technical knowledge coupled with good practical experience in the alignment and test of H.F. and V.H.F. Communications equipment.

The work is varied and interesting and offers excellent opportunity to broaden experience in semiconductors S.S.B. and Frequency Synthesis.

Please write in the first instance to
Norman Manion,
The Recruitment Officer, Redifon Limited
Broomhill Road, Wandsworth, S.W.18

REDIFON
A Member Company of the Rediffusion Organisation 1970

1174

WORK AS A
RADIO TECHNICIAN
ATTACHED TO SCOTLAND YARD

You'd be based at one of the Metropolitan Police Wireless Stations. 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: £1,161 (age 21) rising by increases to £1,590 plus a London Weighting Allowance. Promotion to Telecommunications Technical Officer will bring you more.

For full details of this worthwhile and unusual job, write to:

METROPOLITAN POLICE
Room 733 (RT/WW), New Scotland Yard
Broadway, London, SW1
or telephone 01-230 1212 extension 2605

1046

UNIVERSITY OF BATH
School of Chemistry and Chemical Engineering

EXPERIMENTAL OFFICER–COMPUTER SYSTEMS

(Re-advertisement)

Applications are invited for the above post, tenable within a group concerned with the development of computer-based systems for for the control and automation of laboratory experiments. This project is supported by the Science Research Council.

Duties include the design and construction of special-purpose electronic equipment and the development of on-line programmes for a PDP8/K70 computer system.

Candidates should possess a degree or equivalent qualification in a branch of Engineering or Physics. Practical experience in analogue and digital electronics, modern wiring and construction techniques is essential, whilst experience in computer systems and programming will be an advantage.

The starting salary for suitably qualified applicants will be within the range £1,536-£2,182.

Informal enquiries can be made of Mr. P. E. Sawyer, School of Chemistry and Chemical Engineering, (Bath 6941 Extension 501).

Application forms should be obtained from the Registrar (S), The University, Claverton Down, Bath, quoting reference 71/1(R).

1228

LEEDS (ST. JAMES'S) UNIVERSITY HOSPITAL MANAGEMENT COMMITTEE

GRADE III MEDICAL PHYSICS TECHNICIAN

Interesting post in busy department. Applicants should have at least three years experience in electronics as applied to medicine. St. James's Hospital has recently acquired University status and the department is going through an intensive process of development. The appointment will be regarded as Deputy Head of the Medical Electronics Department.
Applications, stating, age, experience etc. and the names of two referees to the Group Secretary, St. James's Hospital, Leeds LS9 7TF.

1232

PLYMOUTH POLYTECHNIC

Department of Electrical and Electronic Engineering

The following vacancies exist in the Department of Electrical and Electronic Engineering:

SENIOR TECHNICIAN (2 posts)

Minimum qualifications are the successful completion of the AI year of the Higher National Certificate in Electrical Engineering or the City and Guilds Final Certificate in an appropriate subject. Candidates should have had experience of one of the following:

(a) Operation, maintenance and repair of all apparatus and equipment in the Television Transmitter Laboratory;

(b) Maintenance and repair of all apparatus and equipment in the Colour Television Engineering, Television Research and Development Laboratories.

Salary Scale: Senior Technician TIII £1,089-£1,272 p.a. plus additions for appropriate qualifications. Further particulars and application forms can be obtained from the Clerk to the Governors, Plymouth Polytechnic, Plymouth PL4 8AA, to whom they should be returned as soon as possible

1235

CHALLENGING OPPORTUNITIES in CANADA

Radio and Electronic Technicians with a desire to see more of the world can find rewarding work with Canadian Marconi Company. Technicians are required for maintenance duties at remote sites in Labrador and the Northwest Territories.

Successful applicants will enjoy starting salaries of $8,400 plus first class prospects for rapid advancement and further substantial rises during the first year. There are also genuine opportunities for promotion to supervisory grades with salary ranges of over $14,000 per annum.

Food and accommodation is provided free for the employee (there is no family accommodation) in addition to heavy duty clothing. Assistance with air passage is available.

A chance of a lifetime is offered to accrue substantial savings.

Formal training and experience in maintenance of communications-type equipment is required with special emphasis on:

Microwave
Tropospheric Scatter
Communications Systems
Telephone and Carrier (Multiplex)

If you have three or more years experience in installation or maintenance on this type of equipment together with recognized qualifications, i.e. City and Guilds, Higher National or equivalent, the answer is YES! Interviews will be held in London in the near future. Please send brief career details to:

Canadian Marconi Company, Special Services Division, 2442 Trenton Avenue, Montreal 301, Quebec, Canada. Attention: Mr. D. S. Howell

CAN YOU QUALIFY?

CMC CANADIAN MARCONI COMPANY

CANADIAN MARCONI COMPANY

Engineering Officer (Training) Malawi

* Salary up to £2,165
* Low taxation
* 25% gratuity on completion of 30 month tour
* Appointments Grant
* Contract 24-36 months
* Education and outfit allowances
* Subsidised accommodation

Required to undertake the field training of local technical officers in all aspects of installation and maintenance of HF and VHF radio equipment particularly HF—Marconi; S.T. and C.; Plessey; Racal; VHF-GEC; Pye; A.T. and E. The officer selected may also be required to lecture at the Post Office Training School at a basic level on transmission principles. Candidates must hold appropriate City & Guilds Certificates or an equivalent qualification and have considerable experience in the installation and maintenance of the above mentioned 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 M2K/700416/WF.

1218

Sea-going Radio Officers can now make sure of a shore job and good pay.

If you'd like a job ashore, at a United Kingdom Coast Station, the Post Office will start you off on £1,080—£1,360, depending on age, with annual rises up to £1,850. There are good prospects of promotion to higher posts, opportunities exist for overtime and you would receive additional remuneration for attendance during the late evenings, at night and on Saturday afternoons and Sundays.

You will need to be 21 or over, with a 1st Class Certificate of Competence in Radiotelegraphy issued by the Postmaster General or the Ministry of Posts and Telecommunications, or a Radiocommunication Operator's General Certificate issued by the Ministry of Posts and Telecommunications, or an equivalent certificate issued by a Commonwealth administration or the Irish Republic.

Find out more by writing to:
The Inspector of Wireless Telegraphy,
I.M.T.R.
Wireless Telegraph Section (L. 4 .)
Union House,
St. Martins-le-Grand,
London,
EC1A 1AR.

Post Office Telecommunications

93

ASSISTANT ENGINEERS GRADE II—BOTSWANA

- ★ **Salary up to £2,387**
- ★ **25% gratuity on basic salary**
- ★ **Low taxation**
- ★ **Appointments grant payable in certain circumstances**
- ★ **Contract 24-36 Months**
- ★ **Subsidised accommodation**
- ★ **Education Allowances**

Required by the Posts and Telecommunications Department for the following posts:—

(i) the installation and maintenance of HF and MF broadcasting equipment up to 10 KW.

(ii) the installation and maintenance of open-wire carrier systems up to and including 12 channel systems and multiplex equipment.

The selected officers will also be required to supervise and train local technical staff.

Candidates should be aged 30-45 and must possess the City & Guilds Intermediate Certificate (Telecommunications) or equivalent and have had five years experience, excluding any period of approved training, or relevant duties.

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/690420/WF.

1256

BAC Preston Division

RADIO PERSONNEL

We have immediate vacancies at our Flight Test Centre at Worton Aerodrome near Preston, for the following experienced personnel:

AIR REGISTRATION BOARD LICENSED RADIO ENGINEERS
(Preference will be given to applicants with HS 125 experience.)

AIRCRAFT RADIO TECHNICIANS

GROUND RADIO TECHNICIANS

These are weekly staff appointments with a 40-hour week in pleasant working conditions and good rates of pay. Sick pay, pension and life assurance schemes are in operation.

Applicants should apply to:—

B. A. Wharton,
Chief Personnel Officer,
British Aircraft Corporation,
Preston Division,
Strand Road, Preston, PR1 8UD.

1260

BRITISH AIRCRAFT CORPORATION
the most powerful aerospace company in Europe

NEVE ELECTRONIC LABORATORIES LTD.

Specialising in the design and manufacture of sound control consoles and the supply of complete installations for professional sound studios in the fields of recording, broadcasting, television and films, require a:

SENIOR TEST ENGINEER

to accept responsibility for projects during the test and studio commissioning stages. Must be experienced in customer relations.

Attractive salary negotiable at interview.

Apply to: Personnel Manager,
Neve Electronic Laboratories Ltd.,
Melbourn, Royston, Herts.

Tel: Melbourn (Cambs) 776

1257

SITUATIONS VACANT

A FULL-TIME technical experienced salesman required for retail sales; write giving details of age, previous experience, salary required to—The Manager, Henry's Radio, Ltd., 303 Edgware Rd., London, W.2. [67

AUDIO-VISUAL ENGINEER required for varied duties primarily in London area. Preference given to applicants with documented previous experience in the operation of professional motion picture and/or audio equipment. Company supplied vehicle but clean driving licence essential. Basic salary within the range of £1,200-£1,400 according to qualifications. Age 20-35. Box WW 1233, Wireless World.

DRAUGHTSMEN. Mechanical and Electrical required by expanding electronics company specialising in lighting control and audio visual products. This position is salaried and gives ample opportunity for advancement. Please apply Electrosonics Ltd., 47 Old Woolwich Road, Greenwich, London, S.E.10. Tel. 858 4754. [22

EXPERIENCED Electronics Test and Service Engineer for work on professional sound recording and film equipment. Progressive appointment, good salary and working conditions. Apply in writing stating qualifications and experience in detail to Mr. R. M. Wardrop, Evershed Power-Optics Limited, 214 Harlequin Avenue, Brentford, Middx. [1239

HANIMEX (UK) LIMITED, require Audio Engineer for their new Toshiba servicing section. Salary according to experience. Please contact Service Manager, Hanimex (UK) Ltd., 15-24 Gt. Doves Street, London, S.E.1. Tel.: 01-407 8161. [1225

SALESMAN with good connections with wholesale trade, full or part time, salary and commission. Required by Hill Bros., 11 Finsbury Square, London, E.C.2., importers of electronic equipments and parts. Tel.: 01-606 4558. [1248

TV Retail Business of the highest standing, established over 40 years N.W. London. Owner requires PERSONAL ASSISTANT with servicing experience. Good position and prospects for keen and capable man. State age and details of experience. Box WW 1192 Wireless World.

UNIVERSITY OF OXFORD, Department of Nuclear Physics, has a vacancy for a Senior Technician to join a group designing building and maintaining advanced experimental electronic equipment for use by researchers in nuclear structure employing a twenty million volt accelerator. Experience in electronics is essential and a formal qualification an advantage. Starting salary in the range £1,305 to £1,712 with six weeks' paid leave per year. Write to T. L. Green, Nuclear Physics Laboratory, Keble Road, Oxford. Mentioning Reference A.133. [1221

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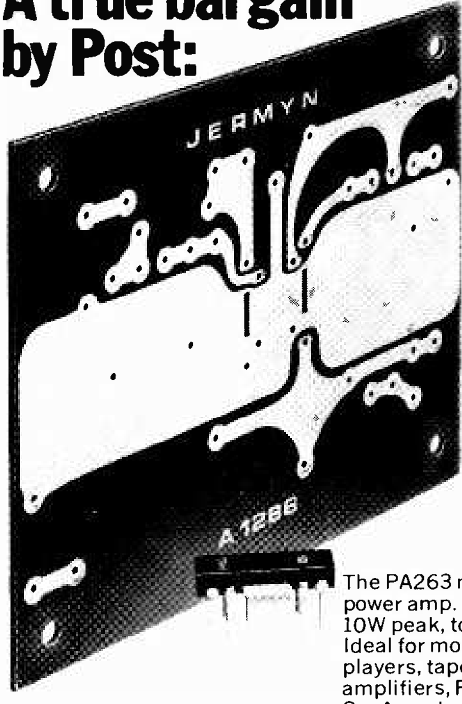

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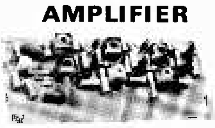

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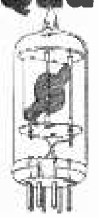

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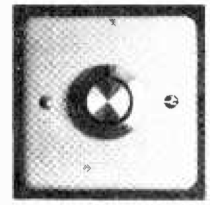

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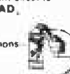

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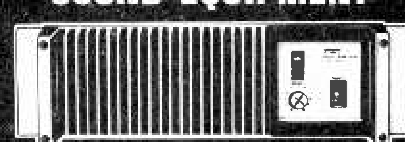

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