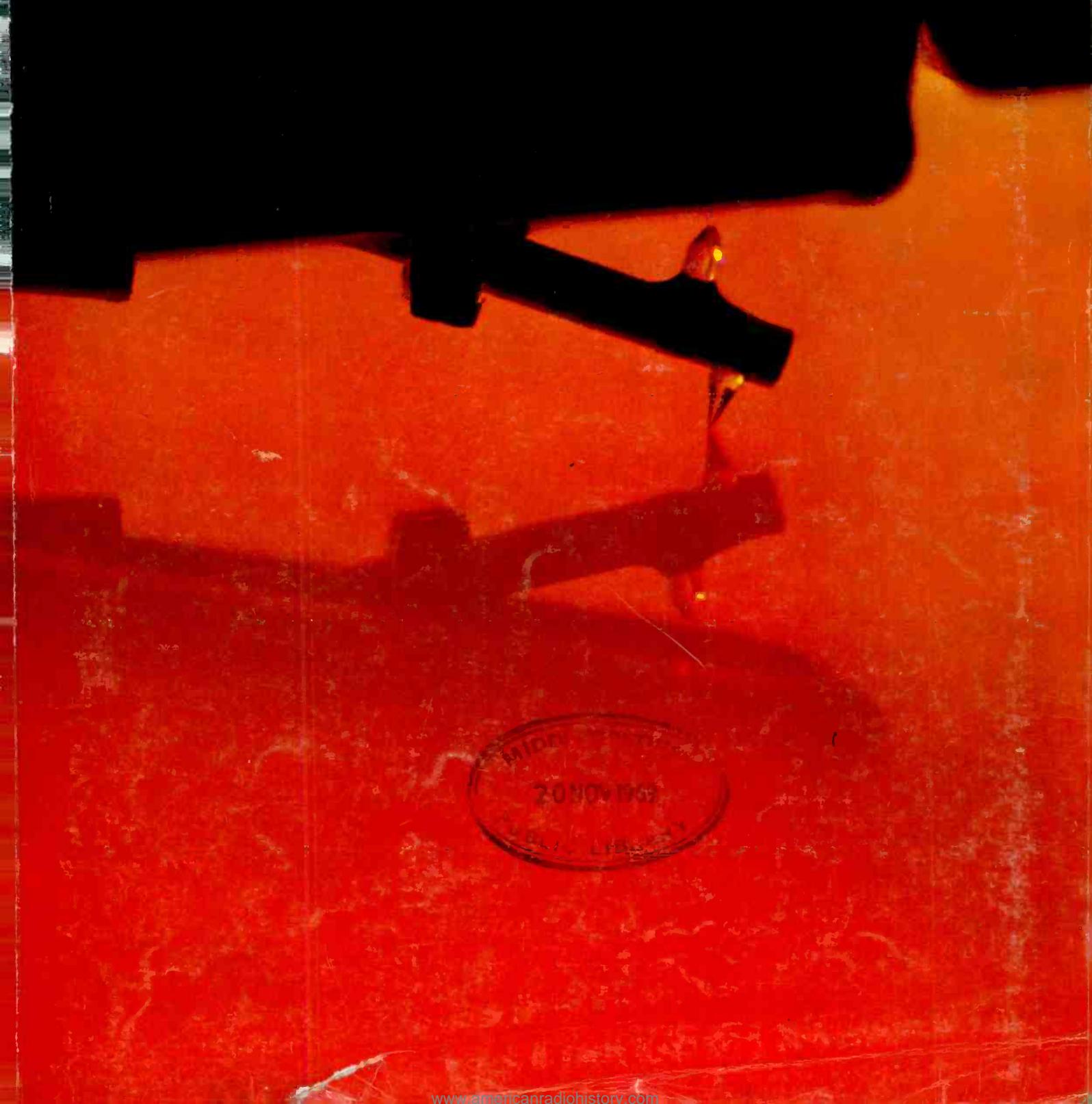


# Wireless World

December 1969 Three Shillings

Gramophone pickup review  
Thermistor hygrometer design



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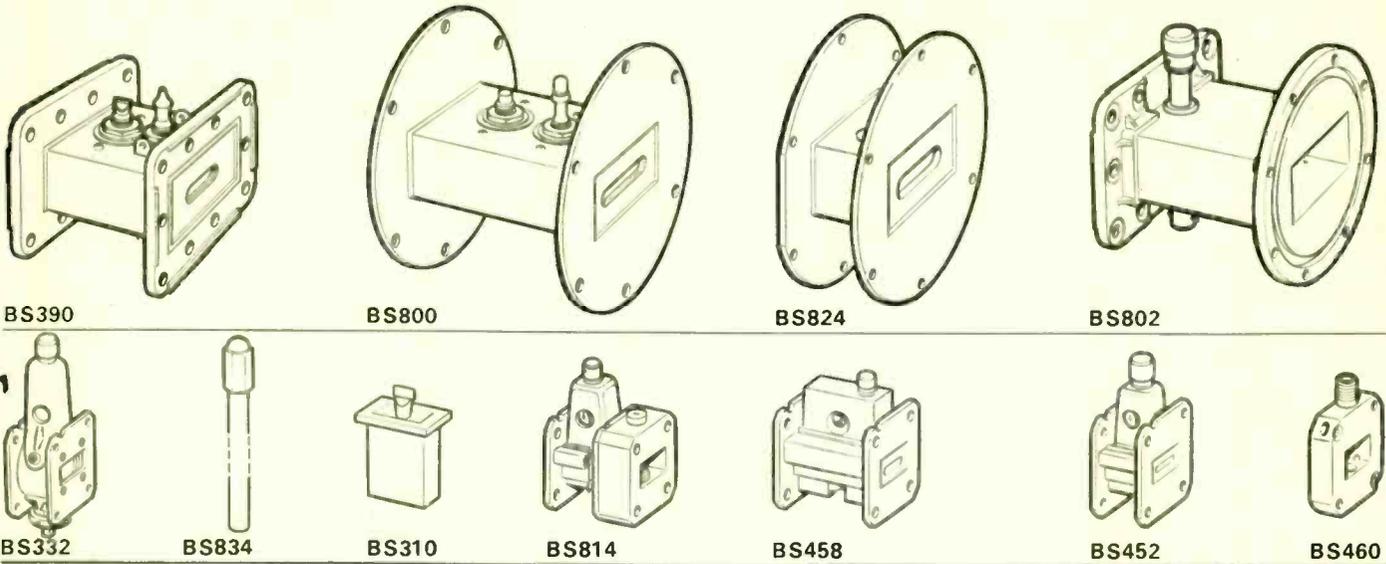
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|                                | BS452   | X    | 9310-9510             | 100             |
|                                | BS810   | X    | 9250-9550             | 75              |
| TB cells                       | BS850   | X    | 9300-9500             | 50              |
|                                | BS310   | X    | 9375                  | 5-200           |
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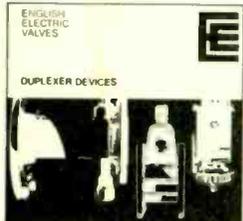
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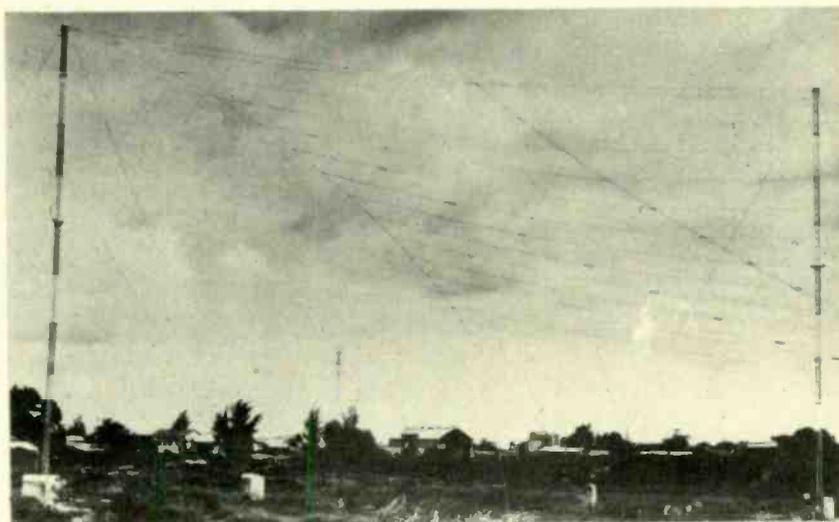
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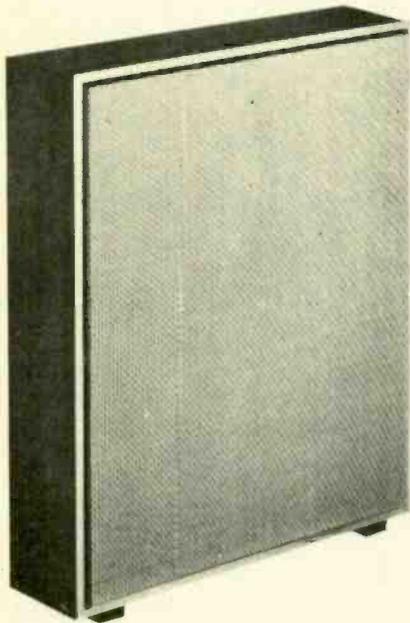
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# Stentorian

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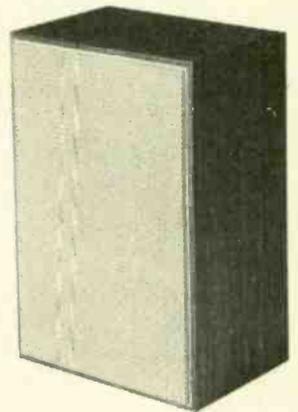
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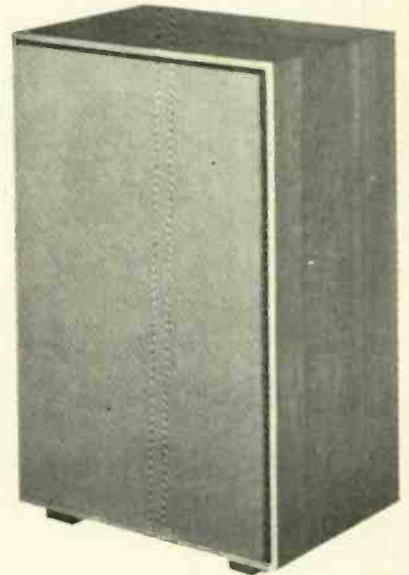


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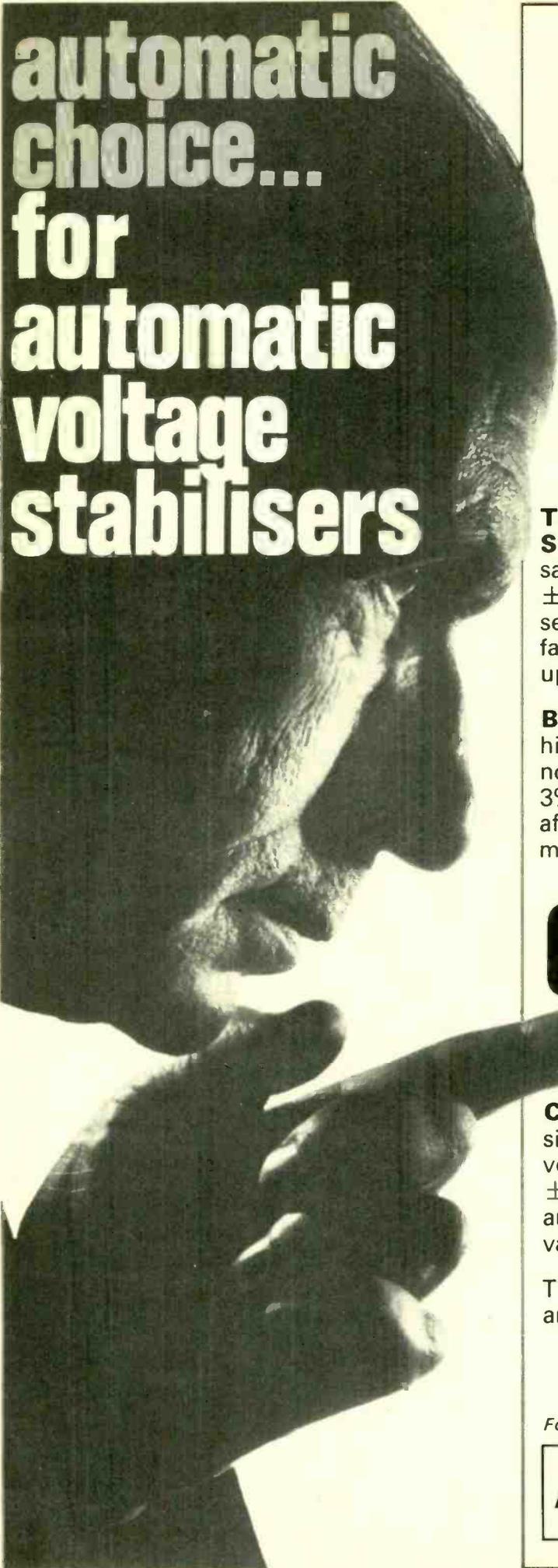
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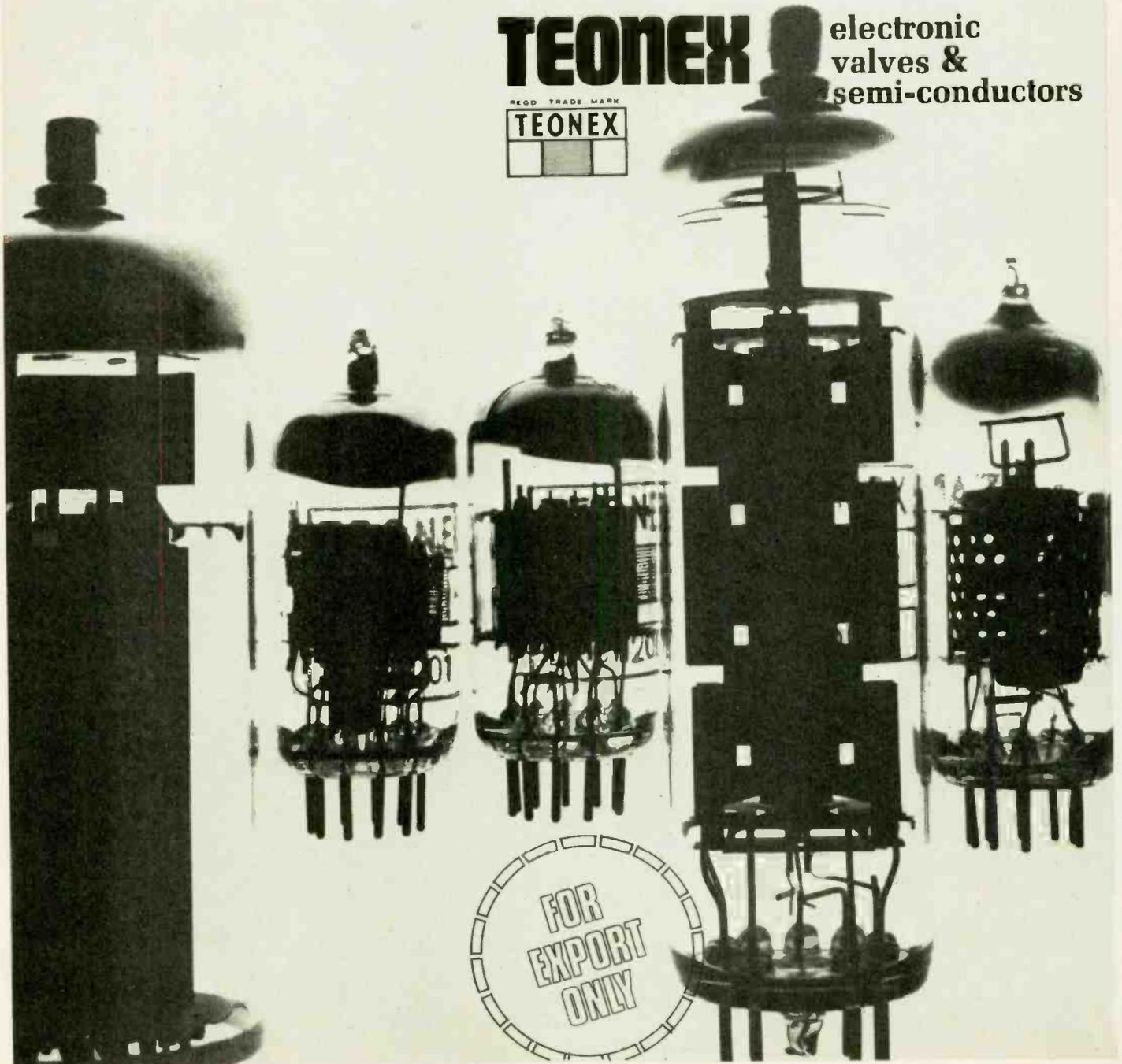
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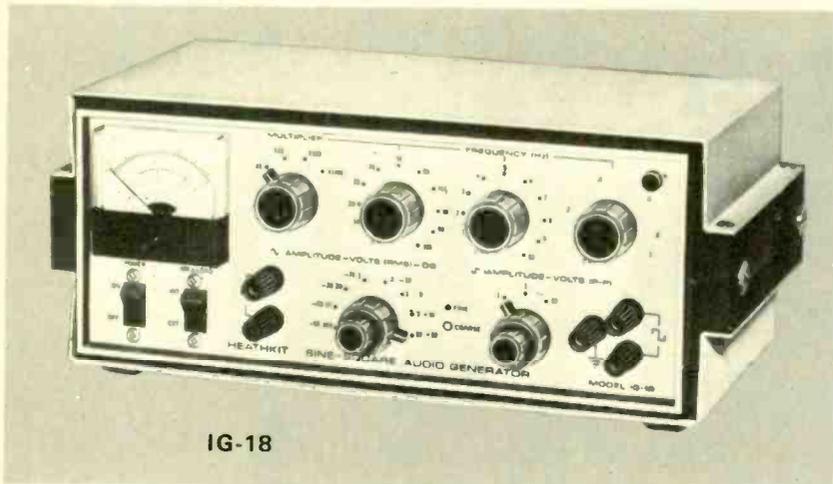


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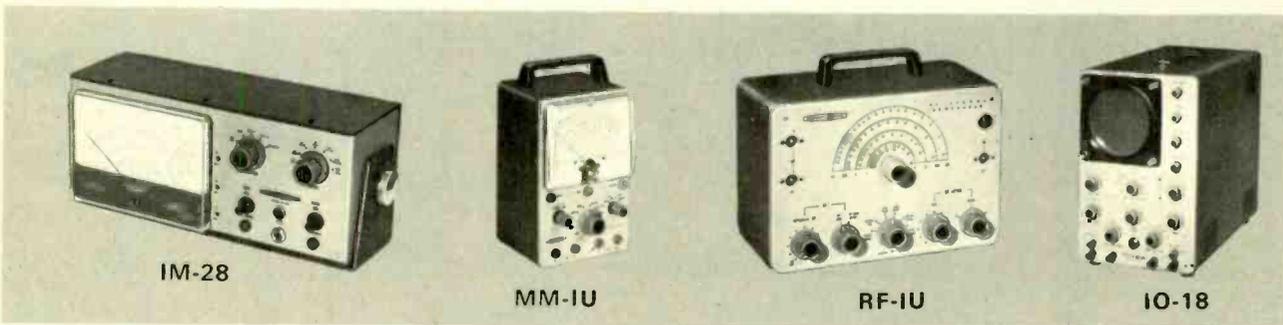
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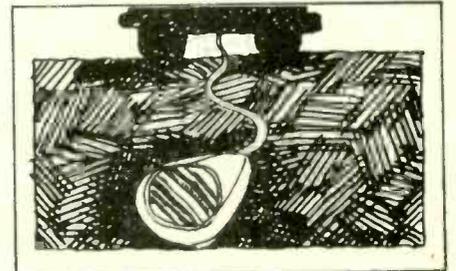
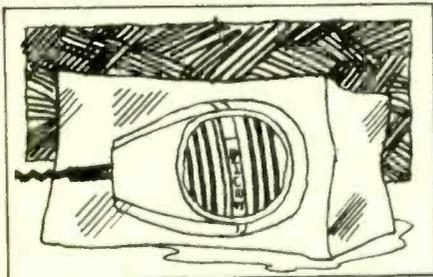
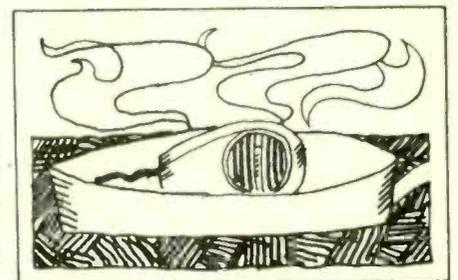
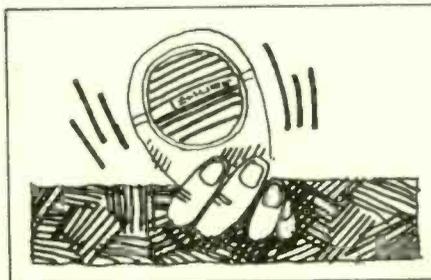
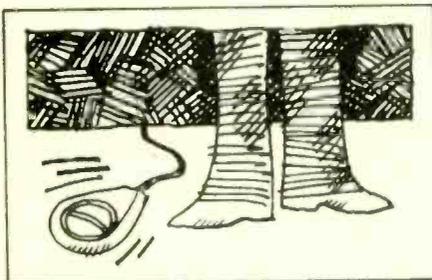
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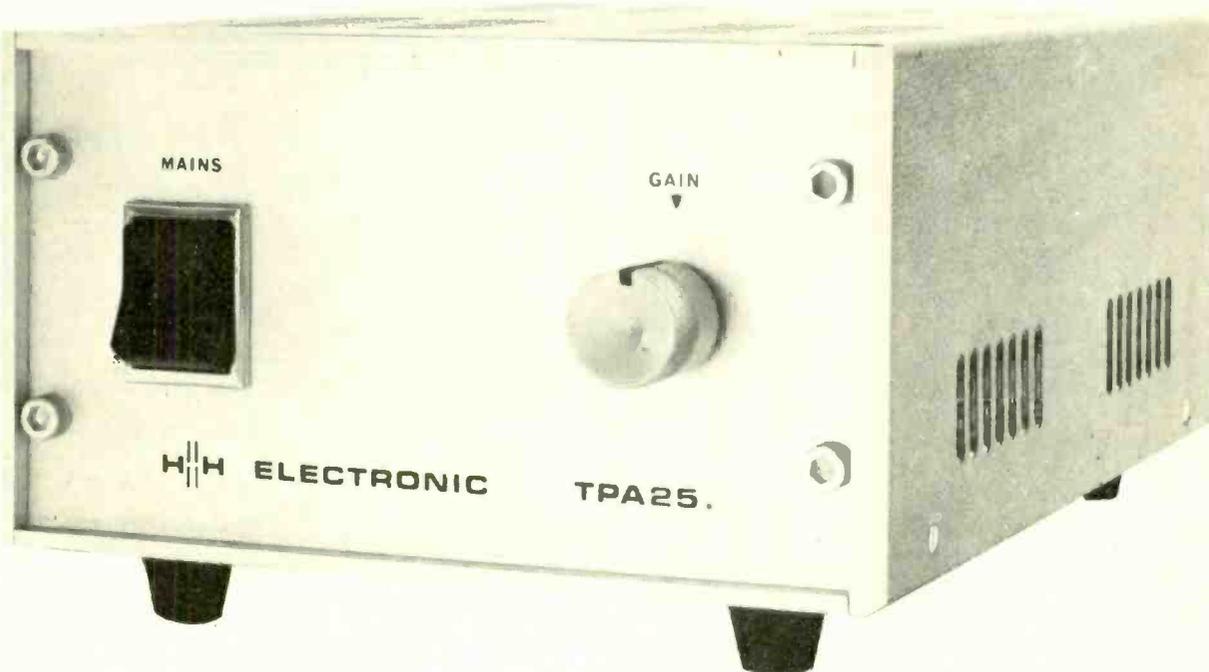
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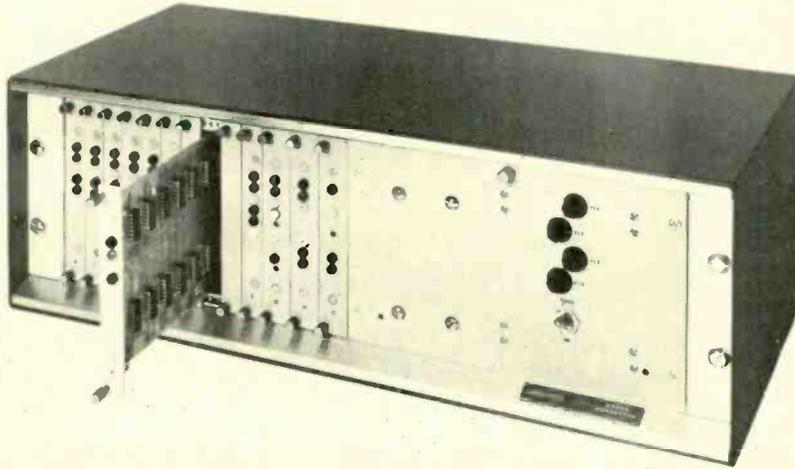
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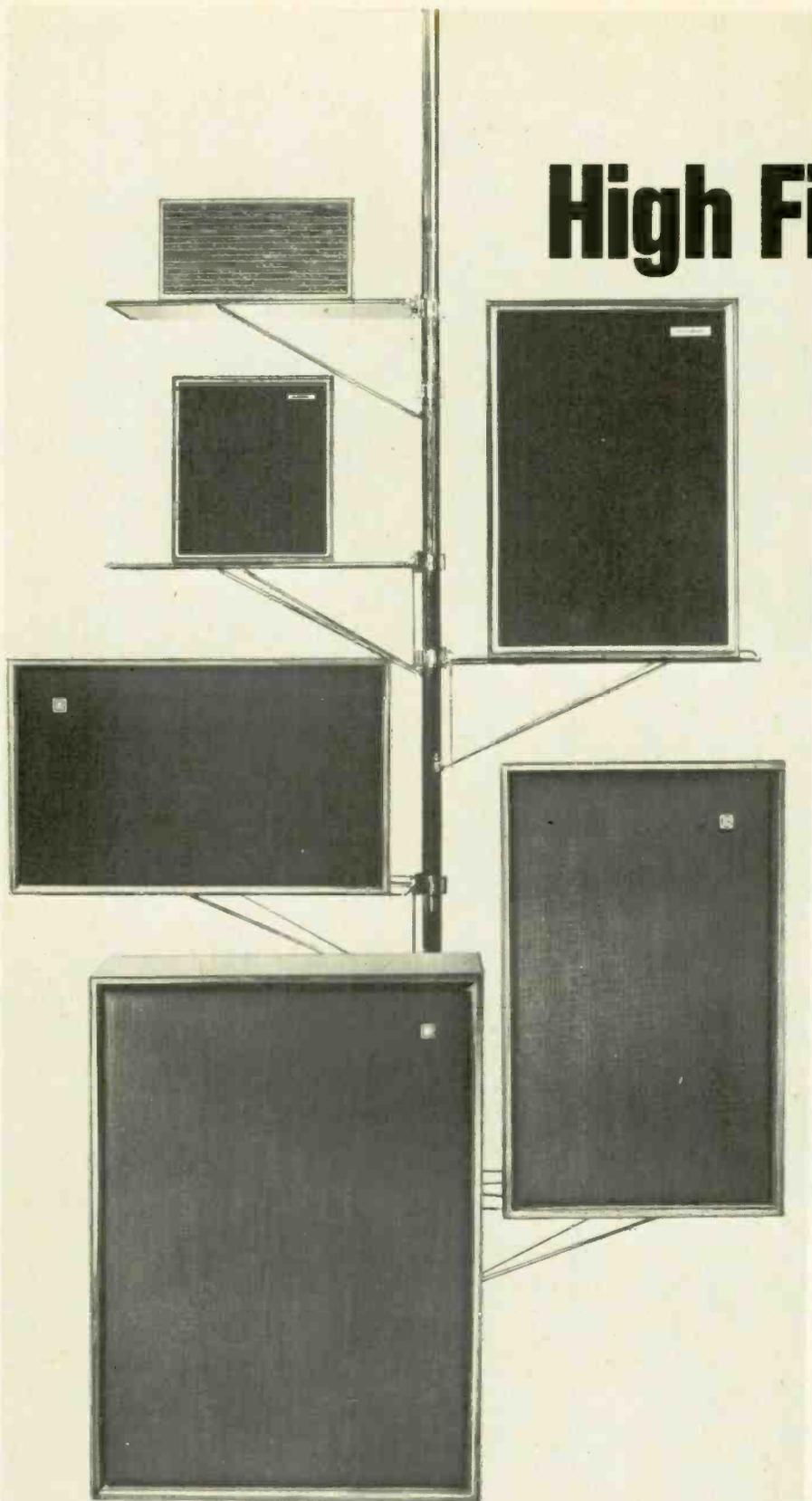
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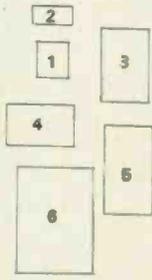
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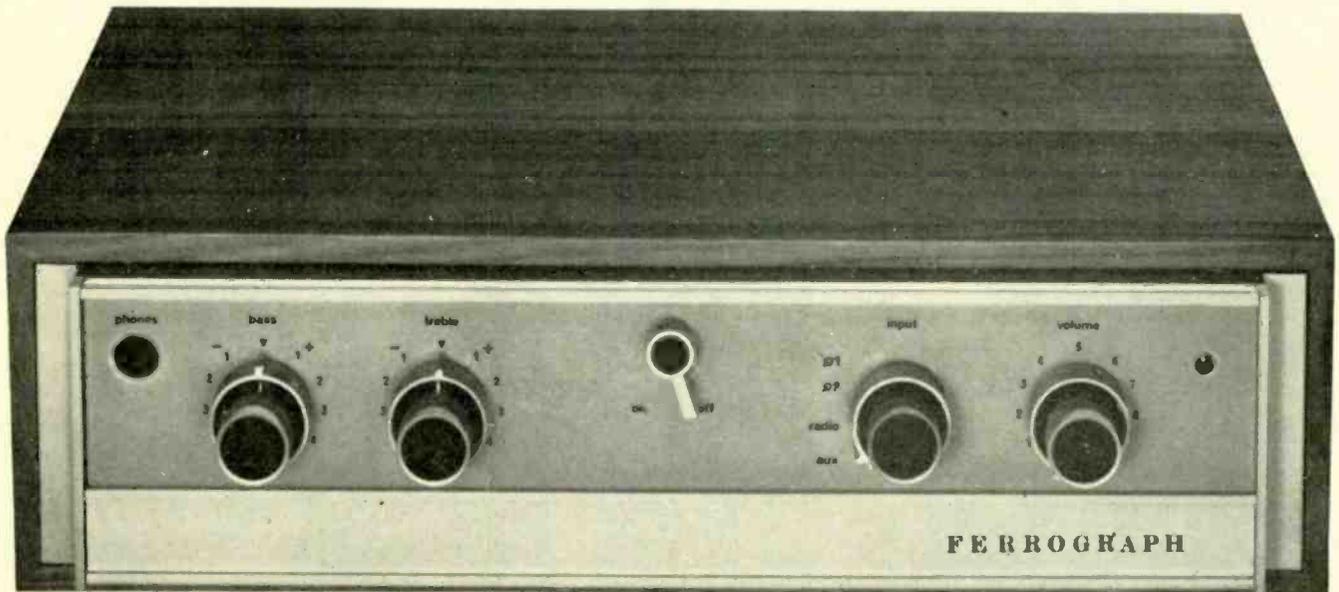
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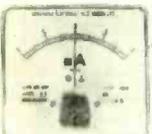
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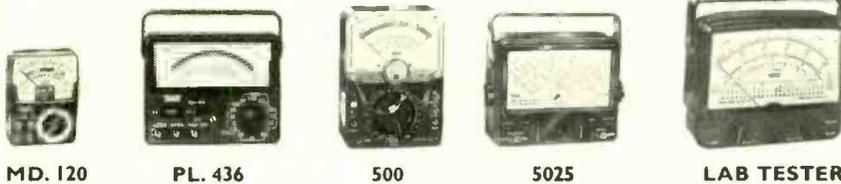
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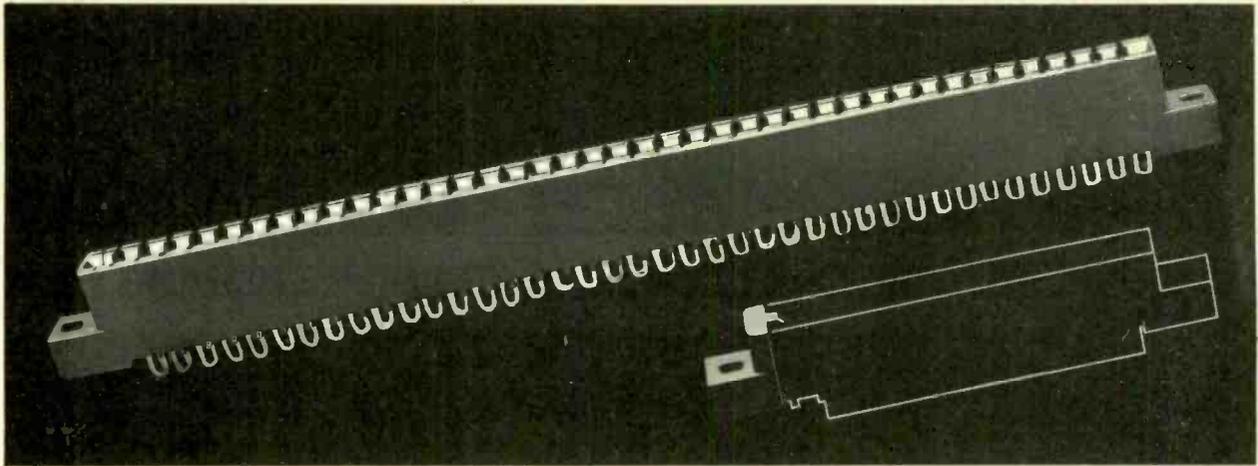
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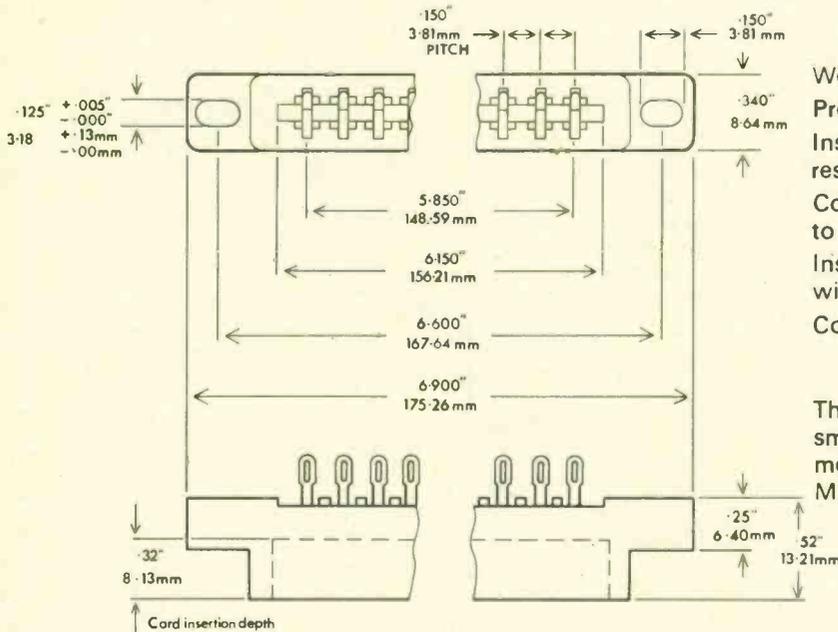


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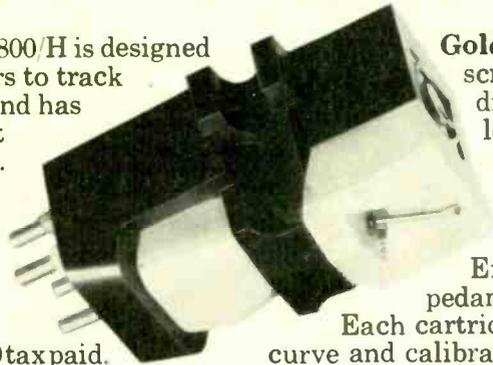
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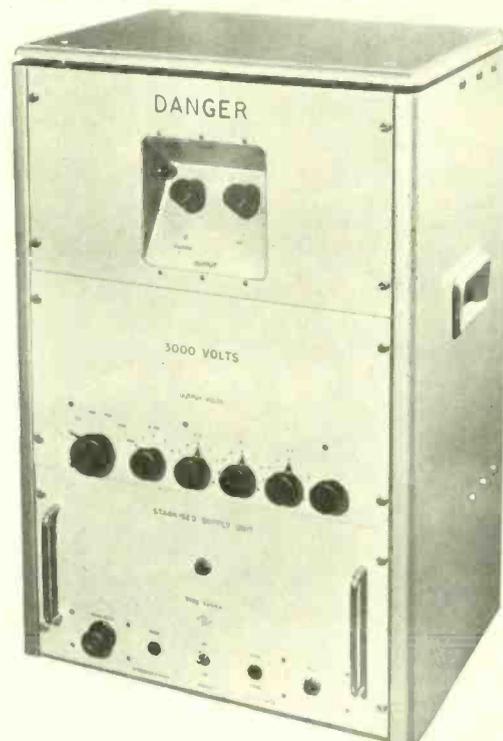
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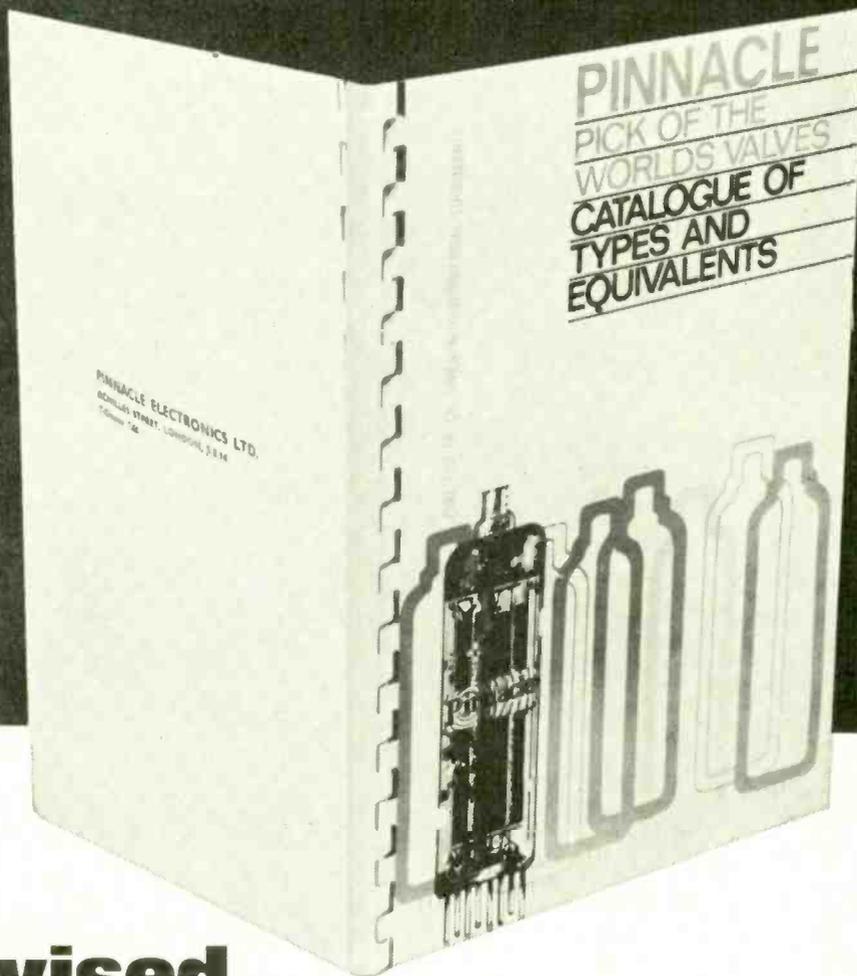


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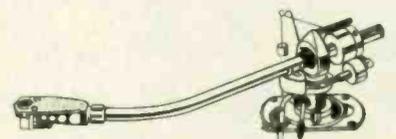
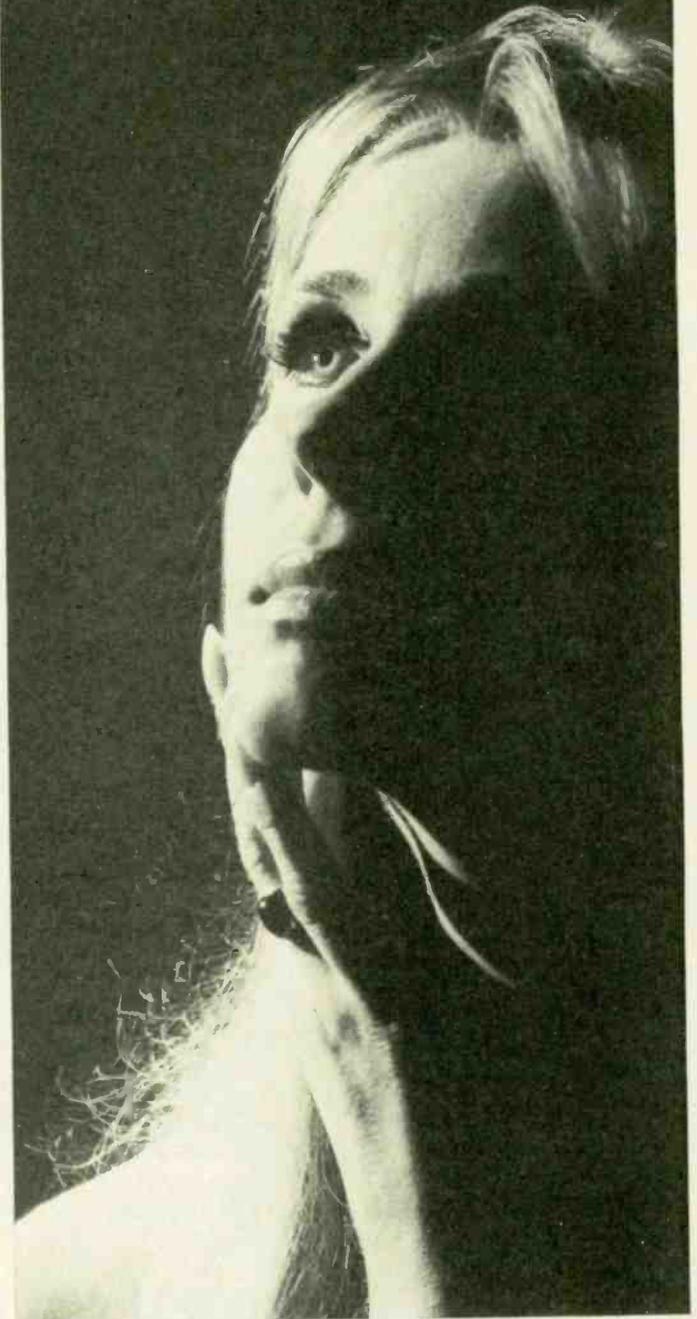
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6v, 6 watts.

**ORYX**

**MODEL WG50**  
59/6

Thermostatically  
controlled miniature  
soldering iron. 50 watts.  
5 bit sizes  $\frac{1}{8}$ " -  $\frac{1}{4}$ "  
Available for 12v.  
24v, 110v and  
210/250v. operation

**ORYX**

**MODEL M1**  
35/-

A miniature  
mains voltage  
soldering iron  
10 watts. 5 bit  
sizes  $\frac{1}{8}$ " -  $\frac{1}{4}$ "  
210/250v  
operation

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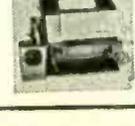
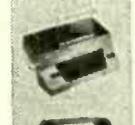
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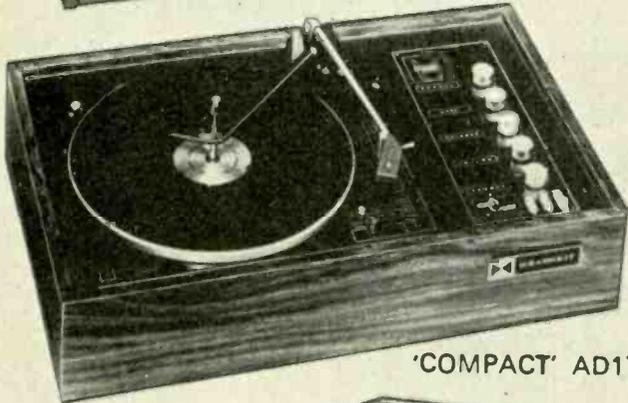
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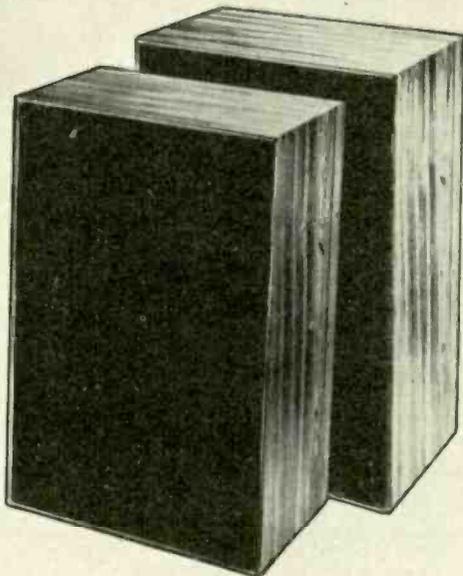
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AMBASSADOR SPEAKERS

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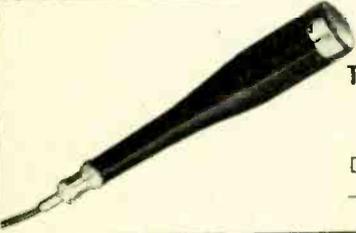
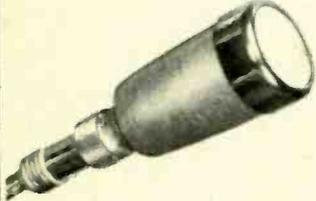
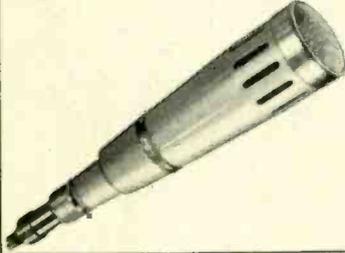
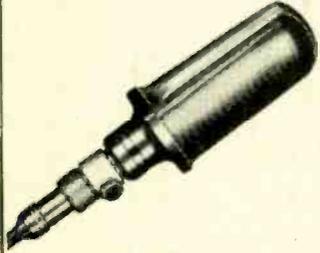
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WWW.12A

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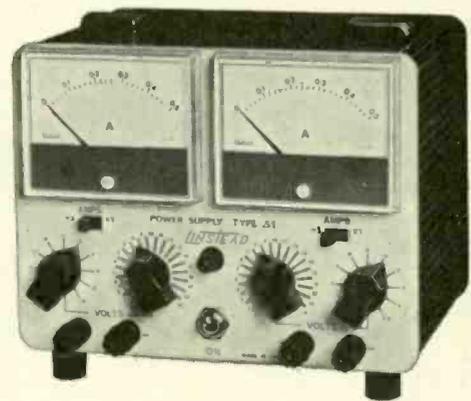
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JACW/K/26

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**S1 TWIN STABILISED  
POWER SUPPLY £45.**

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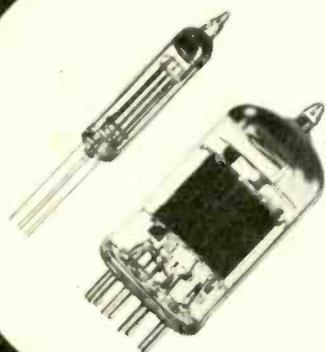
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# audix PORTABLE D.J. CONSOLE



**Specification**

Power Output: 25-30 watts at 100V line.  
 Inputs: Two microphones 30-50  $\Omega$  balanced.  
 Auxiliary switched gram, tape, or medium impedance microphone.  
 Master Gain Control, Tape Record Socket,  
 Bass Tone Control: + 10 db - 12 db @ 100 cps.  
 Treble Tone Control: + 8.5 db - 10 db @ 10 Kc/s.  
 Frequency Response:  $\pm$  .5 db 25 c/s - 12 Kc/s.  
 Dimensions: Length: 3' 4", Depth: 1' 6", Height: 2' 6".  
 Height less legs: 1' 0".

Meets the ever growing demand for well presented music and speech at private and public functions—dances, receptions, parties etc. where there is no permanent sound installation. The Audio Portable D.J. Console incorporates the A.25 silicon transistorised power amplifier with three input channels each with separate volume control. The two Garrard SP.25 single play turntable units each have continuously variable fader controls. Monitor loudspeaker, socket for headset and dynamic cardioid microphone completes the equipment which is attractively housed in solid afromosia cabinet with detachable legs.

- HIGH QUALITY REPRODUCTION
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- ★ Output 240V
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  - ★ Capacity 250 watts
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Buttons in Red, Green, White & Black  
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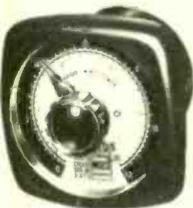


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- ★ Light force wire operated Micro-switch
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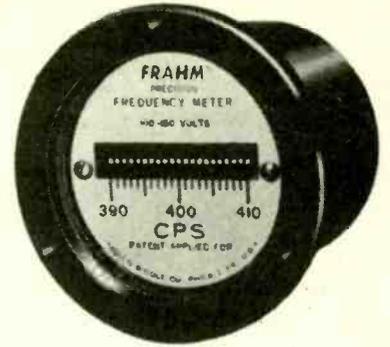
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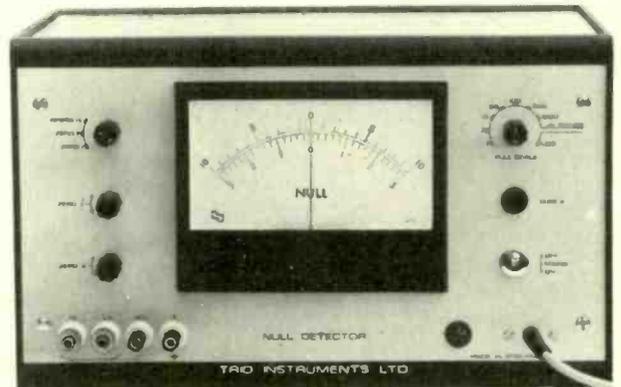
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The SL95B features the constant-speed Garrard Synchro-LAB motor and incorporates:

- Cue and pause facility
- Low resonance wood end aluminium pick-up arm
- Gimbal-type pick-up arm pivots
- Slide-in cartridge carrier
- Calibrated pick-up arm bias compensation
- Calibrated fine stylus-force adjustment
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And this is what independent opinion said about the SL95, the immediate predecessor of the SL95B:

"I have tested it for wow, flutter and rumble and found them too low to be measured with any confidence. In every way I have tried to impede its working, I have failed!"

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Audio Record Review, August '68



**Garrard**

a PLESSEY quality product



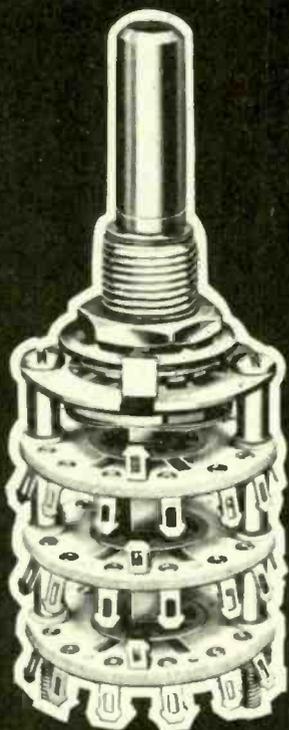
Garrard Engineering Limited, Newcastle Street, Swindon, Wiltshire, England.

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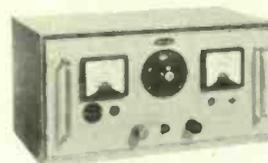


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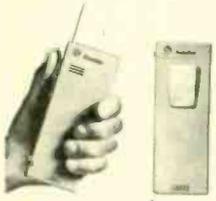
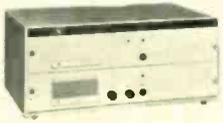
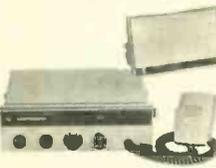
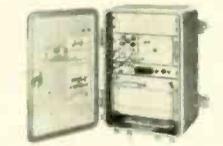
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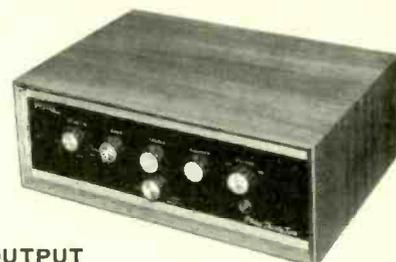
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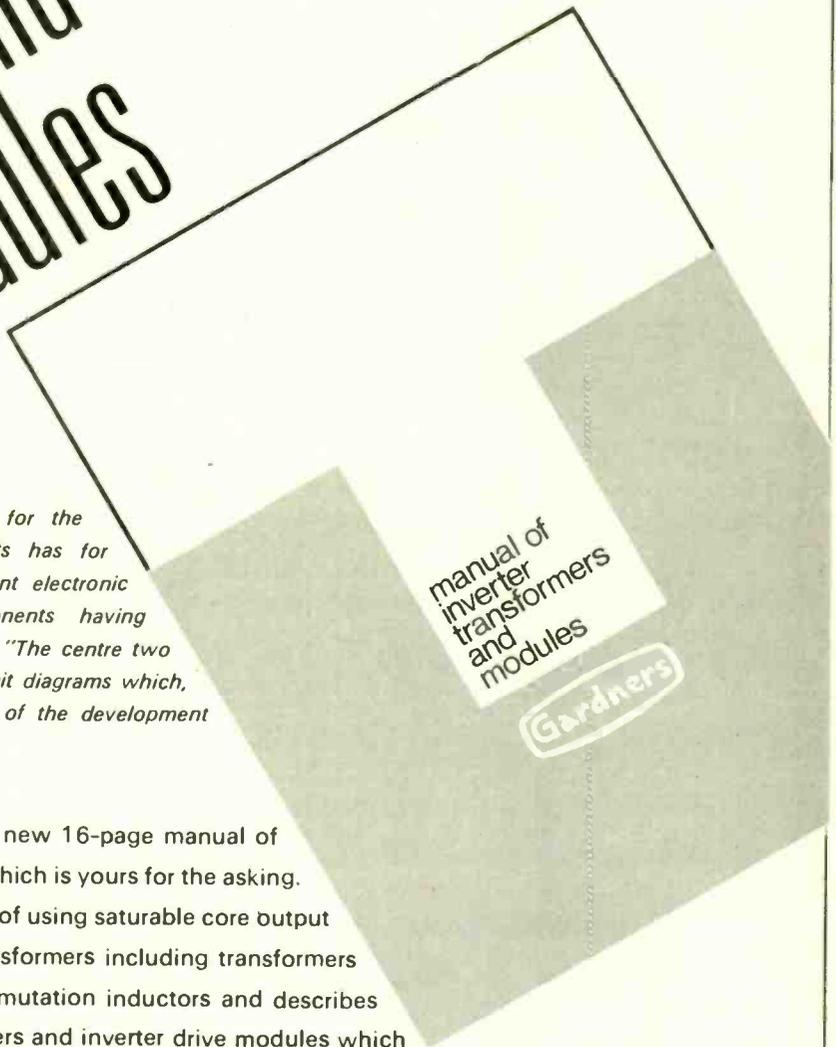
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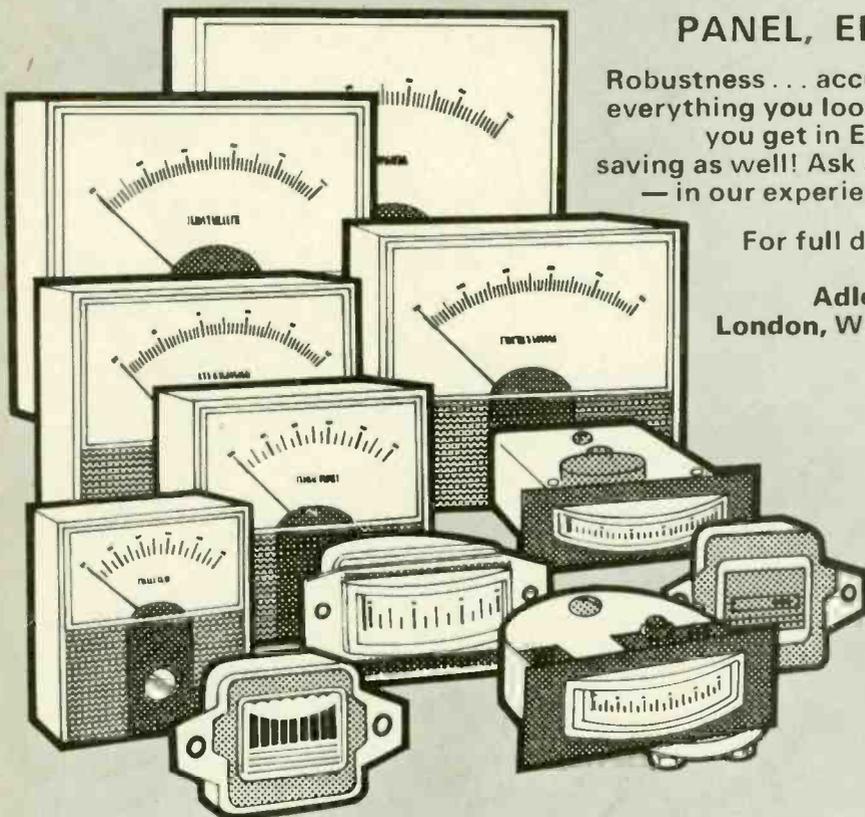
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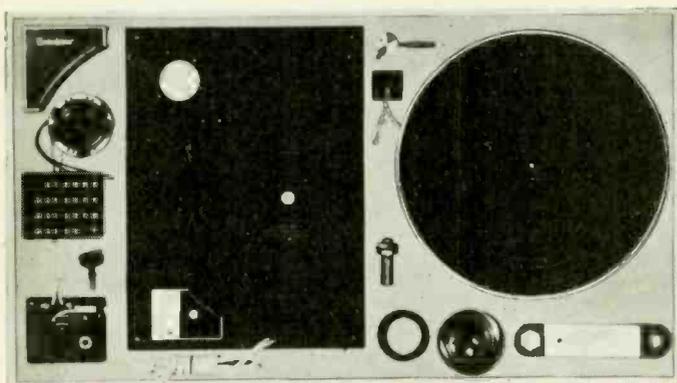
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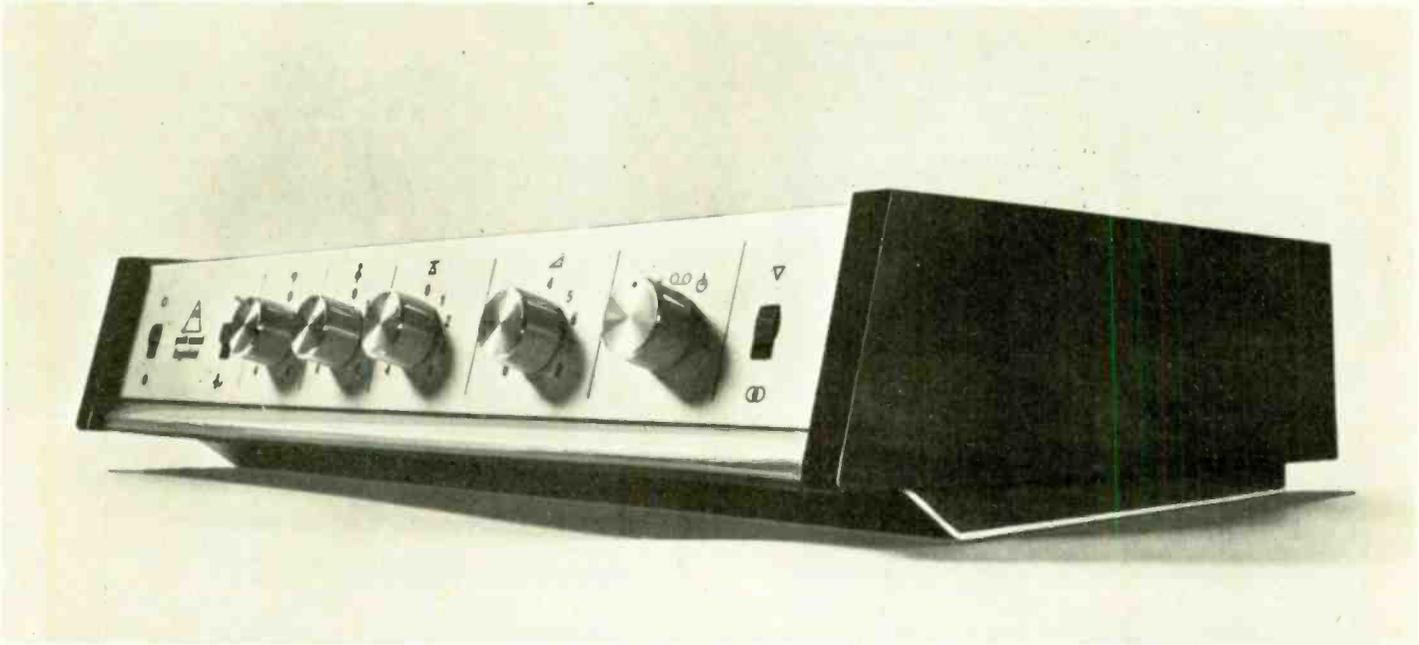
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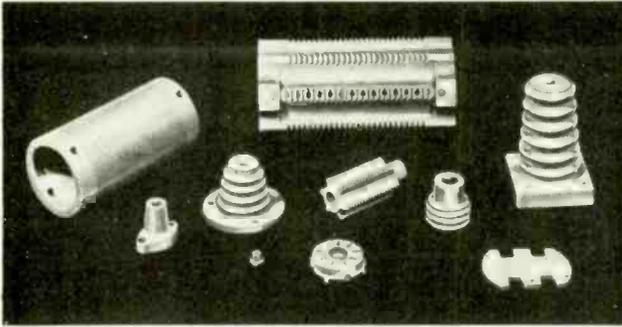
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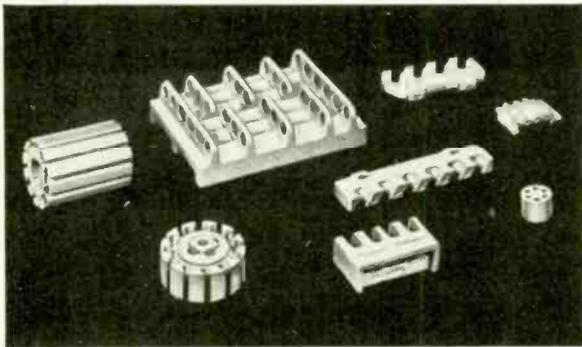
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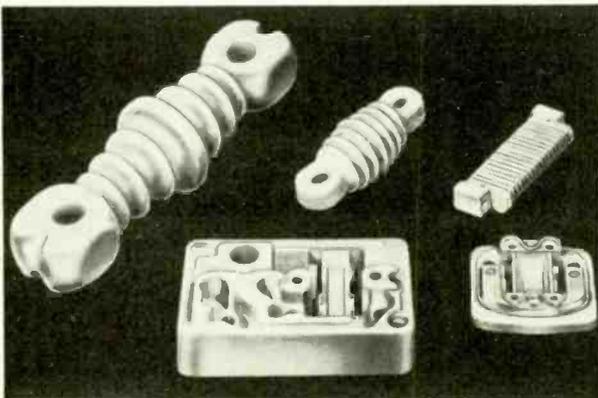
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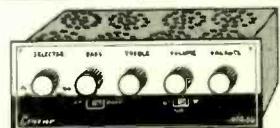
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WW-068 FOR FURTHER DETAILS

# Some notes on Bridge Measurement by WAYNE KERR

## Number 5

### Self-Balancing Bridges

In this series of notes we have examined some of the advantages of the Transformer Ratio-Arm Bridge and the facilities which are available when this type of bridge is used. However, only manually balanced networks have been considered, but there are many times when it is desirable to have an analogue output voltage in proportion to the value of the component being measured. Such a voltage may be used to operate remote indicators, chart recorders or alarm circuits, apart from providing a convenient form of local display which may consist of either a moving coil meter or a digital voltmeter.

Figure 1 shows a basic transformer ratio-arm bridge circuit.

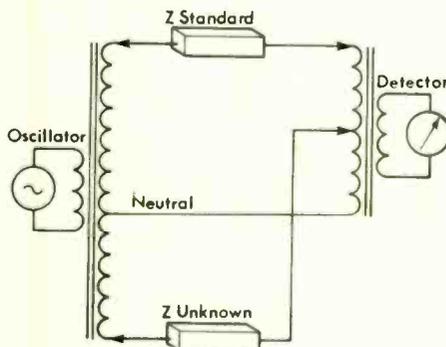


Fig. 1

Normally, the network is manually balanced so that the currents flowing in the right hand transformer give zero flux, and it is clear that any variation in either the a.c. voltage produced by the oscillator or the gain of an amplifier forming part of the detector will not affect the balance point. However, if an attempt is made to connect a voltmeter to the output of the detector and calibrate the output voltage against the value of the unknown impedance, the following difficulties arise:

(a) Variations in oscillator output level and amplifier gain directly affect the indicated voltage.

(b) The voltmeter will indicate the modulus of the impedance, and variations in both the resistive and the reactive terms will affect the indicated value.

(c) When the network is substantially off balance, the ability of the neutral connection to control an electric field is impaired. The last issue of these notes showed that this control facility was due to balanced currents flowing in the transformer.

Figure 2 shows a block-schematic circuit which removes these difficulties by forming a self-balancing network.

A stable oscillator provides the signal for the bridge and also a phase reference voltage which is fed to two phase-sensitive detectors.

The output of the amplifier provides a bridge balancing voltage which is applied through a resistor to a winding on the right hand transformer. The initial current flowing in the transformer is therefore opposed by this 'feedback' current which can be made very nearly equal

to the initial current. The approach to the ideal condition of equality is limited only by the gain of the amplifier, which can be made as large as necessary.

The amplifier output is also connected to the phase-sensitive detectors, one of which incorporates a unity gain,  $90^\circ$  phase shift network. Analogue voltage outputs are therefore formed which independently show the amount of variation of the resistive and reactive terms from the value set by the standard impedance.

The use of this circuit now extends the usefulness of the transformer ratio-arm bridge to include many process control and monitoring applications. The precision of measurement and the facility for measuring high impedances accurately at the end of long lengths of cable, together with the self-balancing network, offer unique advantages for the measurement of transducer parameters.

The basic circuit shown in Figure 2 can be adapted to give many different varieties of transformer ratio-arm bridge. These bridges can be designed for use in industrial measurement with suitable transducers as well as forming valuable tools for research.

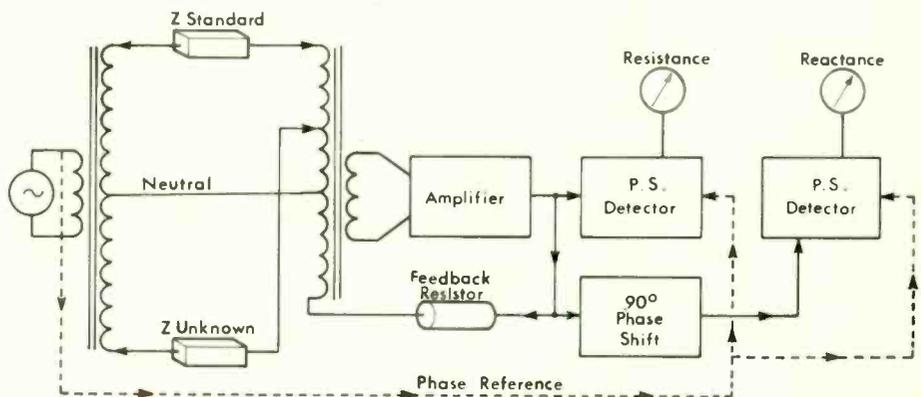


Fig. 2

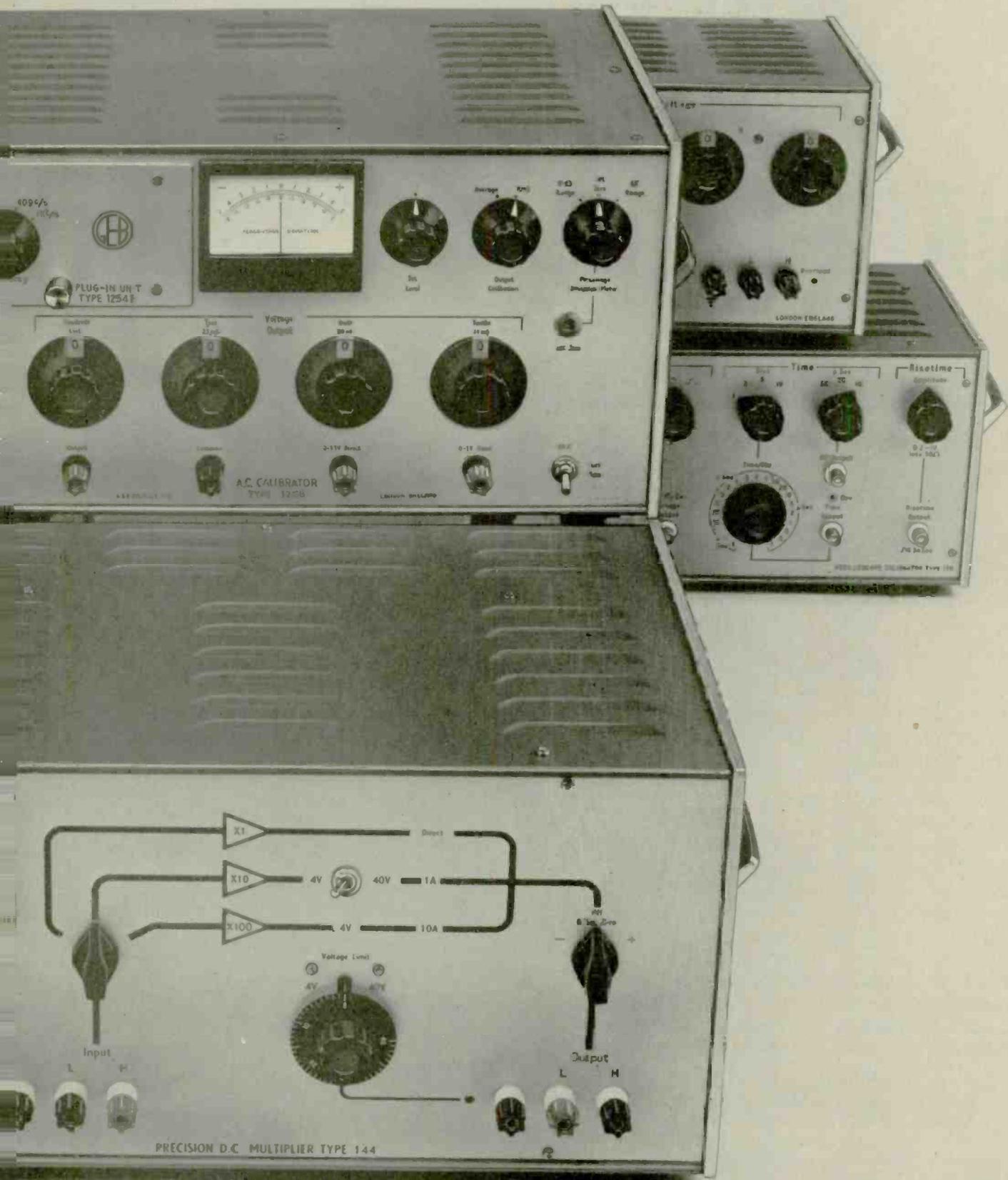
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Feb. 1969

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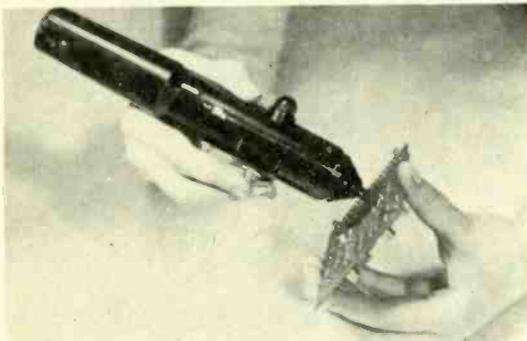
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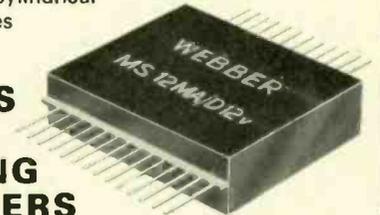
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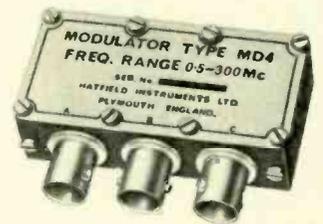


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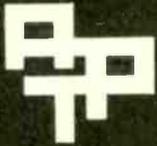
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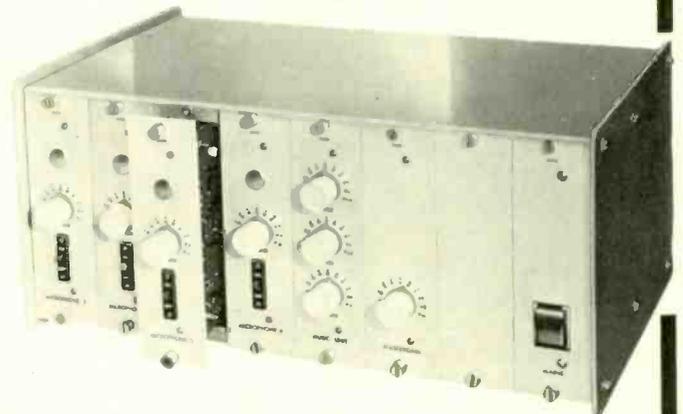
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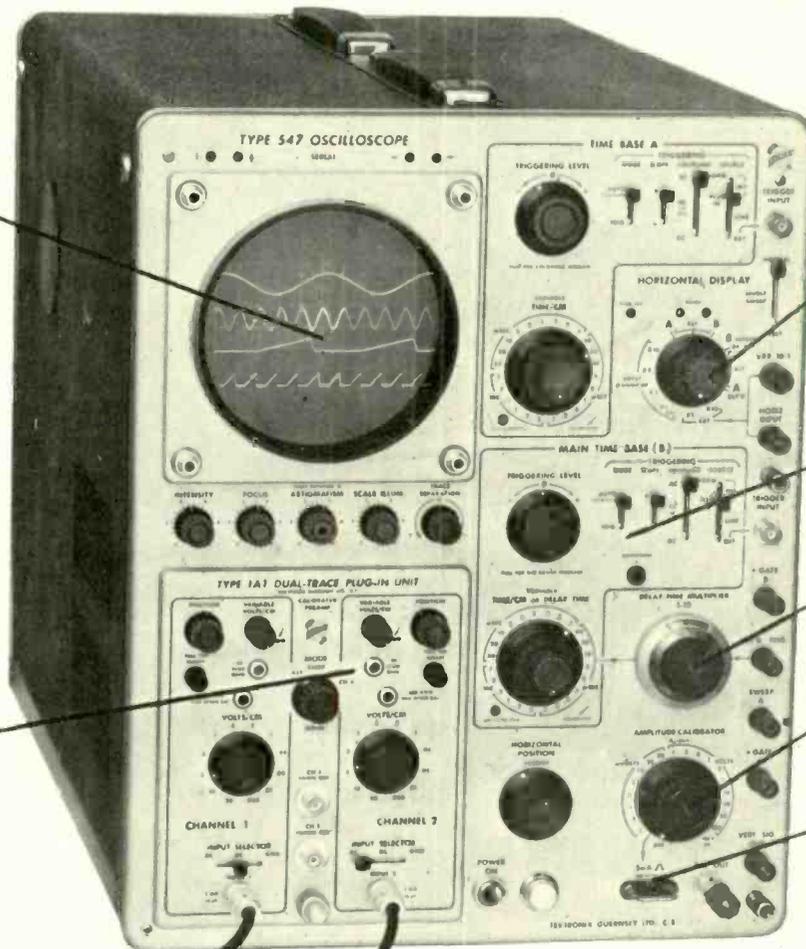
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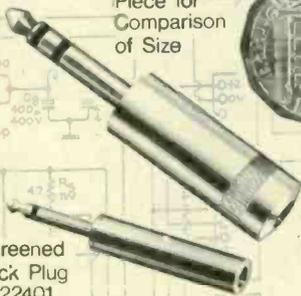
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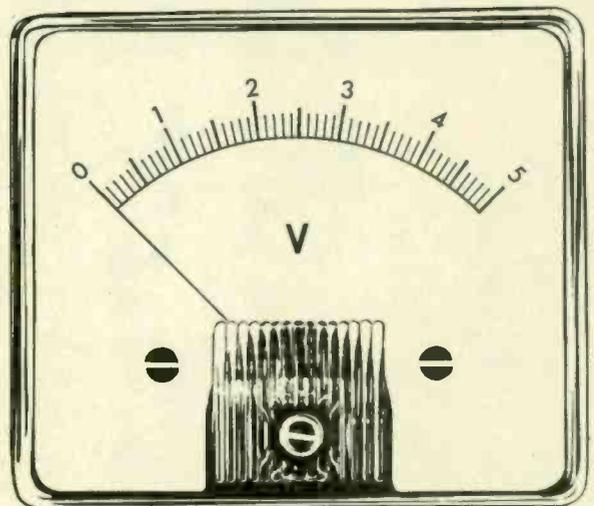


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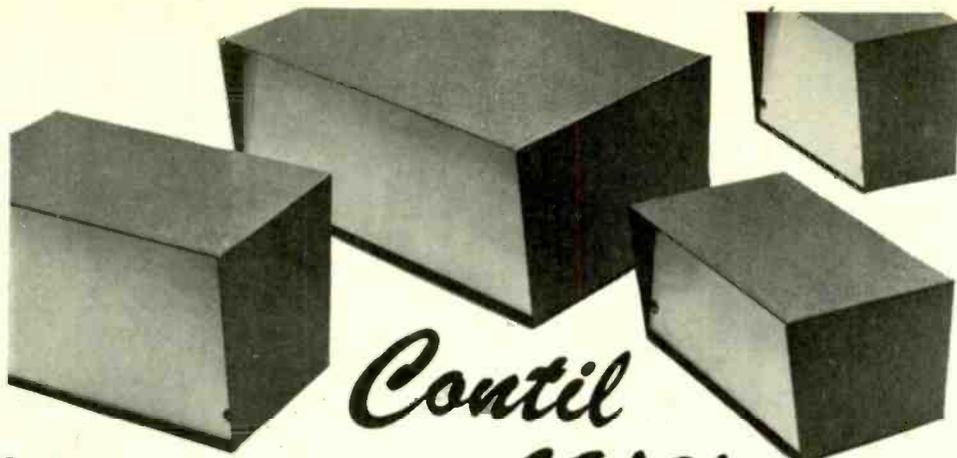
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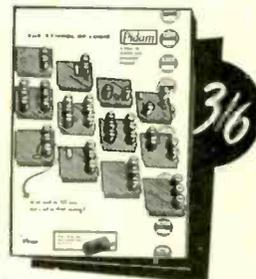
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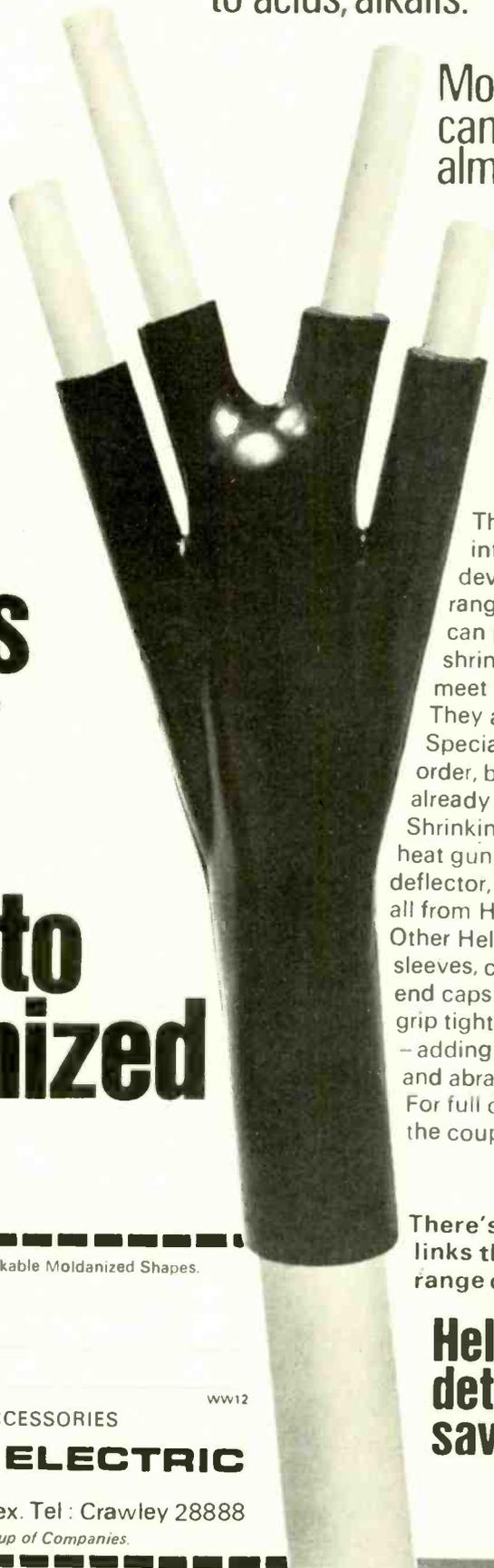
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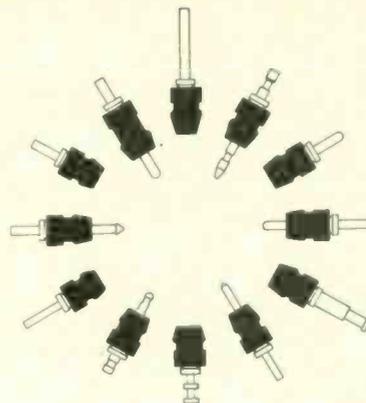
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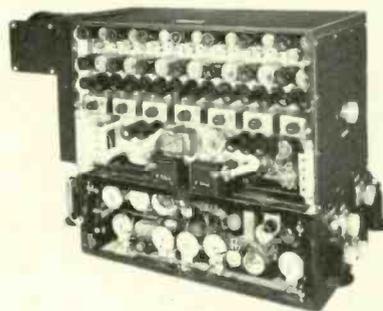
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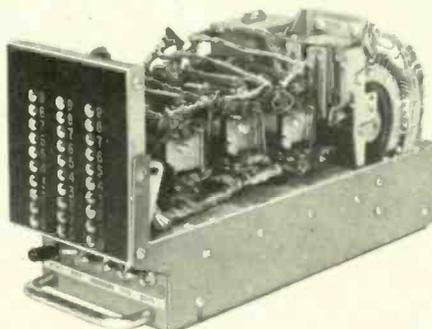
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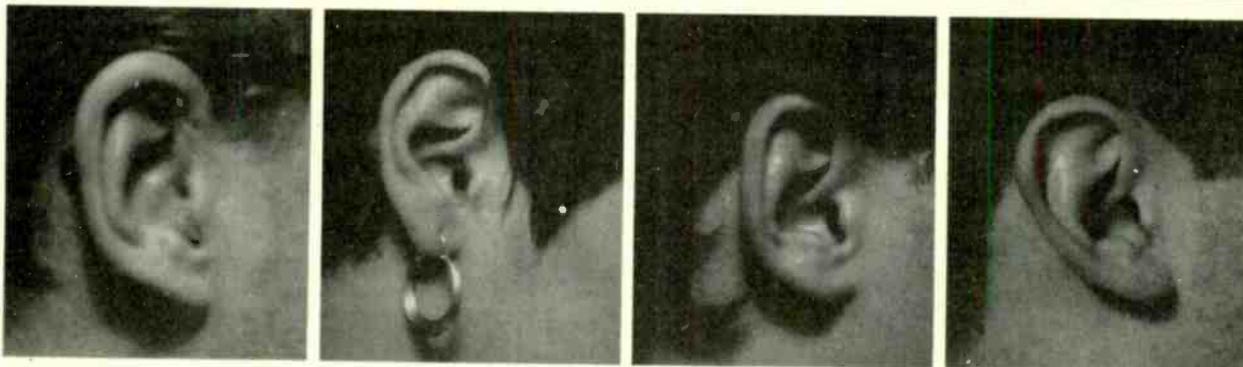
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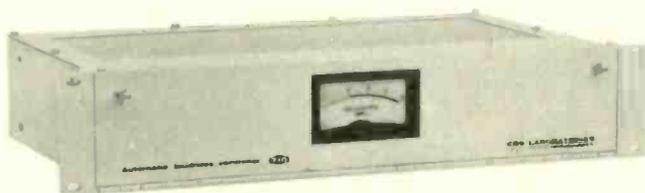
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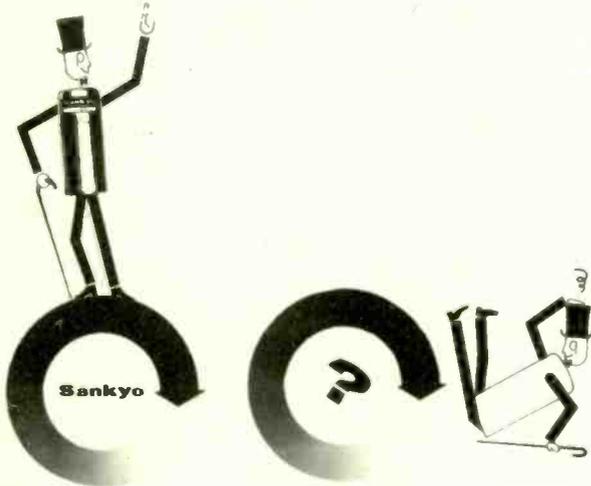
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|-----------|--------------|-------------|-------------------|----------------------|---------------------|-------------------|-------------------|------------------------|-----------|-------------------------|
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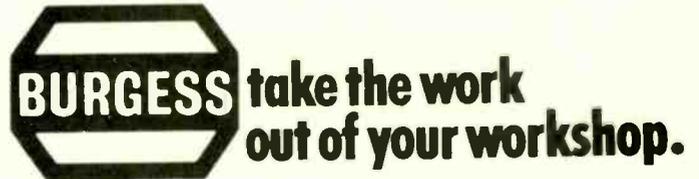
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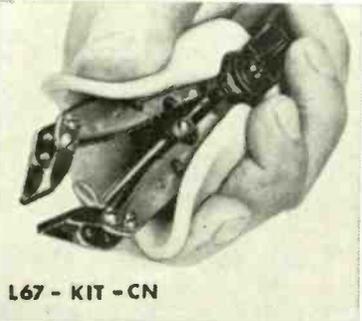
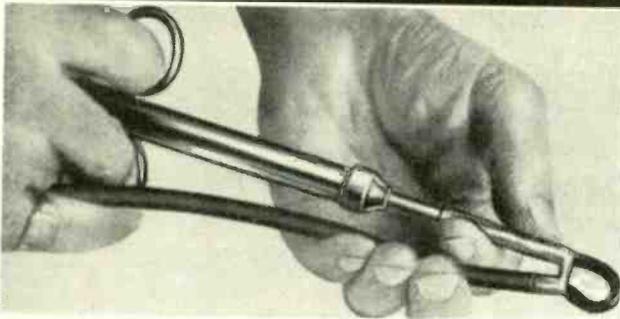
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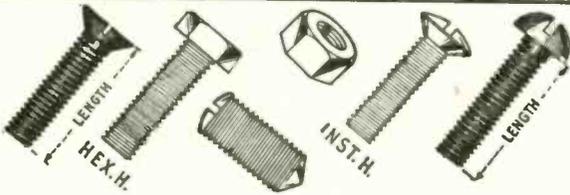
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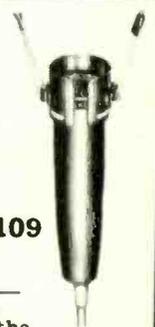
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# Wireless World

Electronics, Television, Radio, Audio

Fifty-ninth year of publication

December 1969

Volume 76 Number 1410



The review of gramophone pickups in this issue is typified by the cover illustration of a close-up of an Acos cartridge.

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## OUR NEXT ISSUE

**Capacitor-discharge Ignition System** which provides improved car engine performance.

**Linear Integrated Circuits:** a plea for some degree of standardization.

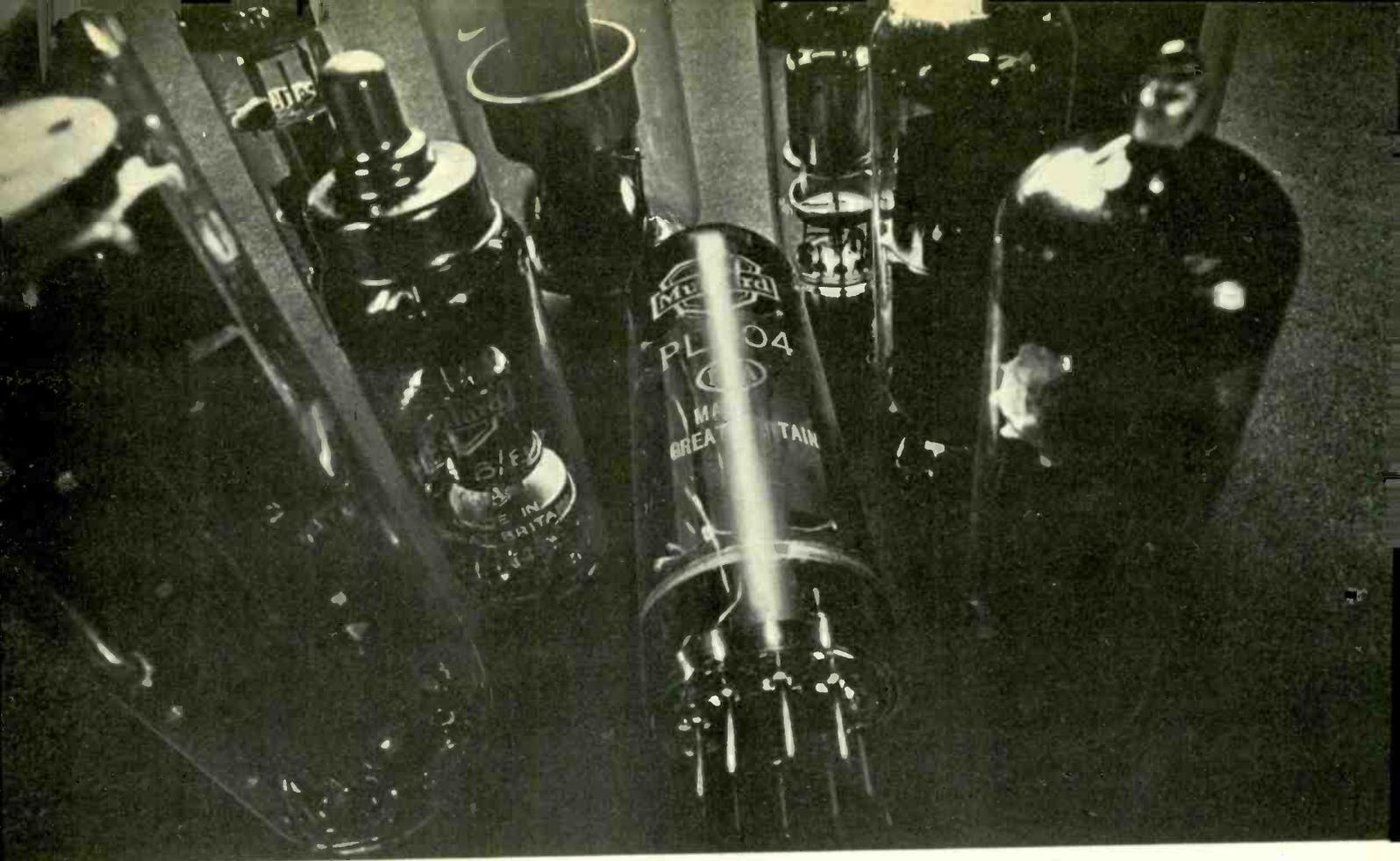
**Industrial Telemetry:** a review of recent developments.



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# Wireless World

## The Engineer in State and Private Enterprise

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This was the title of Harvey Schwarz's presidential address on October 22nd to members of the Institution of Electronic and Radio Engineers. While not denigrating the need for Government co-operation and assistance in certain circumstances he came down heavily on the side of private enterprise—as managing director of Decca Navigator Company this is not surprising. As he rightly pointed out, there are, of course, many projects which no company, unaided, could possibly implement without Government help. But Government and industry must together hammer out some means whereby the delays, which seem inherent in obtaining such effort, can be cut drastically.

Because of the different approaches of Government and commercial enterprises there is an incompatibility which can be, and often is, detrimental to the advancement of a project. However sympathetic towards or enthusiastic for a project a Government Department may be, it is less concerned with the time factor than private enterprise. Mr. Schwarz pointed out that this is because the very structure of the civil service business quite rightly starts by ensuring that public funds are properly spent and used to the best advantage. "All too frequently, this prerequisite breeds a caution which often becomes so exaggerated that by the time the project has been surveyed from every possible aspect by a series of committees, the chance may well have been lost. . . . The cushioning effect of reliance on governmental support can—human nature being what it is—stultify initiative and enterprise."

There is, however, an aspect of commercial enterprise which can be just as stultifying, and is likely to hamstring the enthusiastic engineer. Mr. Schwarz described this as "Gadarene swine-manship" which manifests itself in "a seemingly almost frenetic compulsion—not to dash over a cliff as did those unfortunate animals—but to huddle together in larger and larger conglomerates in a positive fury of gregariousness, and by a curious paradox the more entities such conglomerates absorb, the more amorphous they become". Few will not share Mr. Schwarz's regret at the growing wave of mergers with the resultant loss of famous household names and inherent danger of stifling initiative and enthusiasm.

The position of the engineer in industrial mergers and take-overs was also voiced at the meeting announcing the formation of the U.K. Association of Professional Engineers (see p. 562), membership of which is open to members of all the 14 institutions constituting the Council of Engineering Institutions. The president of UKAPE (G. B. M. Oliver) said that industrial mergers "too often produced the result that professional men . . . were lost in a vast impersonal machine where they were unable to make their voices heard".

Whereas Mr. Schwarz was concerned with the position of the individual engineer, the trade union (UKAPE) is concerned with collective bargaining on behalf of professional engineers as a body. While we are in full sympathy with any legitimate movement to improve the status, image and emoluments of the engineer—whether professional or technician—we cannot help but question what there is in common between, say, a gas or marine engineer and one in electronics. One could go still further and try to find a common denominator for the electronics engineer in, say, the guided weapons division of one of the major groups and his counterpart in the television development laboratory of a receiver manufacturer.

*Wireless World* is written for the individual engineer, both in his professional capacity and as a hobbyist, and we would therefore reiterate Mr. Schwarz's dictum that the engineer must be given freedom in which to exploit his natural talents: "Discovery cannot be made by order or regulation, nor can the engineer's ingenuity be trammelled by limitation of opportunity."

# Stereo Gramophone Pickups

## A review of the various types of transducer available

by Stanley Kelly

By definition a gramophone pickup should translate the information stored mechanically in the groove of a gramophone record into an exactly corresponding electrical signal. As is well known, it accomplishes this feat by the application of motion from a modulated Vee-shaped groove in the gramophone record via a hemispherical stylus coupled to the actual transducer element. In the case of two-channel "stereo" records the two groove walls are independently modulated. Therefore, the parameters of the record groove and the record material are major factors affecting the performance of the pickup.

Present-day styli are either sapphire or diamond, and are several orders of magnitude harder than the record material. Therefore upon the application of pressure between the stylus and the record it is the record rather than the stylus that deforms. The contact area of the stylus tip and the record groove will be a function of the effective force between the two surfaces and the mechanical constants of the record, and the attrition of the stylus will be strictly a function of this contact area and the length of travel of the stylus. This latter factor is usually equated in terms of playing time. It has been determined experimentally that at playing weights greater than about 0.5 gramme the record material is stressed beyond its elastic limit<sup>3,4</sup> and it is the aim of cartridge designers to produce pickups which will satisfactorily track heavily modulated records at playing weights below this figure. Therefore in the interests of reduced record wear and concomitantly stylus wear, the ideal limit would obviously be playing weights less than 0.5 gramme, and certainly 1.5 grammes can be taken as the upper limit to maintain maximum record life. Despite many extravagant advertising claims, there are probably fewer than a dozen pickup cartridges produced today which actually track all music records at playing weights less than 1.5 grammes. Stylus wear is generally expressed as the size of "flat" developed at the point of contact with the record, and is a complex function of playing weight, stylus dimensions, record material, and the dynamic mechanical constants of the pickup referred to the stylus tip.

Fig. 1 shows the life of a diamond stylus at two playing weights, 2 grammes and 5 grammes, and for different radii. It will be seen that even at only 2 grammes playing weight with an 0.5 thou\* stylus point, the life is only 500 hours for a "flat" diameter of 0.25 thou,

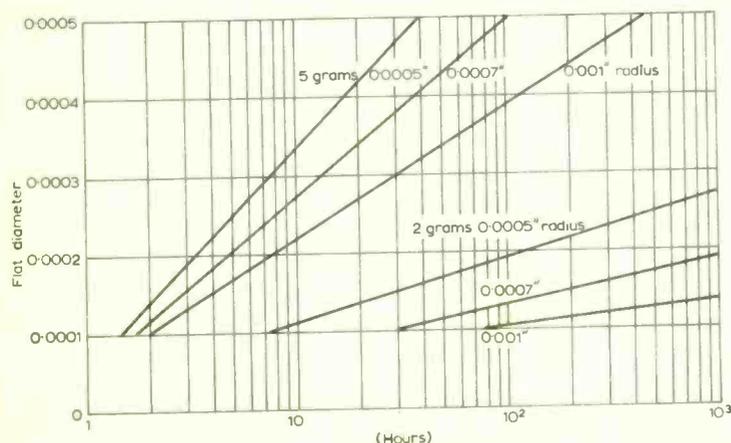


Fig. 1. Playing time for flat diameter diamond styli.

which with wide-range low-distortion equipment is currently accepted as being the maximum "flat" diameter to be tolerated. Increasing the stylus diameter to 0.7 or 1 thou considerably reduces stylus wear but at the expense of increased tracing distortion. The elimination of tracing distortion requires a stylus of minimum tip radius—ideally zero!—but apart from stylus life other factors control the minimum tip radius. The bottom of the record groove is not infinitely sharp; with commercial pressings it is of an indeterminate radius. This is maintained at minimal value by the record manufacturers but can sometimes approach 0.5 thou! Indeed, until the advent of stereo recording the groove bottom radius was not under strict manufacturing control and some of the earlier L.P. pressings are unplayable if the tip radius of the stylus is less than 1 thou.

The elliptical or biradial tip has been evolved to overcome the difficulty. The major radius—across the groove—is of the order of 0.7 thou, whilst the minor or "working" radius can be as small as 0.2 thou with consequent reduction in tracing distortion, although stylus life is reduced accordingly. The upper limit for the major axis is 0.7 thou because under conditions of maximum vertical modulation the groove width can be (and often is) instantaneously reduced to 1 thou; thus if the tip radius (either spherical or the major axis of an elliptical) is greater than 0.7 thou the stylus will ride on the interface of the groove and the record land with the possibility of groove jumping in addition to the increased distortion.

One specifies a given dimension and euphemistically hopes that this dimension will be achieved. Modern production methods work to incredibly fine tolerances and  $\pm 0.1$  thou is the norm for tip radius limits. Thus a maximum specified radius of 0.7 thou in reality means a dimension of between 0.5 and 0.7 thou although by selection close tolerances can be achieved. Even so, using optical methods of measurement the confidence limits of the measuring equipment are usually of the order of  $\pm 1$  micron (one twenty-fifth of a thou) which sets a practical limit.

[The projected use of the metric system throughout our commercial and industrial life and the introduction of SI units for all scientific work poses a number of problems at all levels of industry. This is especially exemplified in design and production of gramophone pickups where dimensions are microscopic—masses of the order of milligram length in microns or tenths of a thou—and to this author at least seems ridiculous to think of a milligram as  $10^{-6}$  kilogramme and the micron as  $10^{-6}$  metre. The magnet industry both in this country and the United States and the pickup cartridge manufacturers throughout the world all insist on specifying their products in c.g.s. units. Conversations with many commercial and technical personnel indicate an obdurate insistence on the familiar, thus c.g.s. units are used in this article.]

Before specifying the parameters of a pickup it is necessary to know the maximum modulated levels available from the record. The levels are controlled at low frequencies by the maximum groove displacement (normally 0.005 cm) and at higher frequencies by stylus tip dimensions and groove velocity. Fig. 2 shows these limits. Curve relates r.m.s. velocity to maximum displacement, and B, C, D, and G to stylus tip radius: G is the generally accepted maximum velocity for music records although these values are sometimes exceeded, especially on "gimmick" and "pop" records. From this graph it would appear that mis-tracking must occur with all styli in which the radius

\* "Thou" = 1,000th of an inch.

greater than 0.0003 inch; this assumption is modified by the fact of record deformation, but is nevertheless substantially correct for the inner grooves at high modulation levels. These limitations are reduced as the groove diameter increases and at diameters exceeding about 7 inches are negligible even for 0.0007 inch tip radius.

The basic design requirements for a pickup are fundamentally mechanical and relate to the dynamics of the moving system and one must design to track the maximum velocities shown in Fig. 2. It is convenient to divide the frequency spectrum into three sections: (a) below about 500 Hz; (b) 500 to 5000 Hz; and (c) above 5kHz. One can relate Fig. 2 to maximum "needle tip impedance" that is, the mechanical impedance at the stylus point when in contact with the record, for a given playing weight. Fig. 3 relates this premise for a playing weight of 1.5 grammes, using curves A and B as limits. The dotted lines refer to a compliance of  $5 \times 10^{-6}$  cm/dyne and mass of 2.25 milligrammes. These values may be modified by other considerations: (1) the record compliance-stylus mass resonance and the head mass/restoring force compliance resonance should be outside the recorded frequency range; (2) appreciable amounts of damping may be introduced. The high-frequency resonance can be evaluated assuming a record compliance of  $3 \times 10^{-8}$  cm/dyne. The low-frequency resonance is controlled by the mass moment of inertia of the arm plus cartridge related to the stylus tip and the cartridge compliance; it should be less than 22.5 Hz (the "slip" frequency of most induction motors used in turntables and a frequent source of "rumble") and above 10 Hz—at lower frequencies than this value the pickup system becomes very sensitive to external vibrations; and the motor board must be adequately decoupled to prevent shock excitation of the pickup and attendant acrobatic antics across the record surface.

It is generally assumed that compliance and stylus tip mass are the usual parameters hopefully specified by the manufacturer in relation to the mechanical constants of the pickup cartridge, but especially with highly damped systems the "loss" component achieves major importance in the mid-band frequencies, thus the evaluation of input mechanical impedance is necessary to the design engineer. Of more immediate importance to the user is the minimum playing weight for tracking music records. One method is to produce a disc with a (slow) sweep frequency covering the major frequency range (say, 80 Hz to 8 kHz) at maximum music modulation levels. In use the output from the pickup is observed on a cathode-ray oscilloscope and the playing weight is reduced until a "break" occurs on the waveform—usually at the point of maximum acceleration. A disc (7 inch  $33\frac{1}{3}$  r.p.m., 80 Hz to 8 kHz) has been produced as a tentative industry standard and the modulation levels are shown in curve G on Fig. 2. The disc has "left" channel information on one side and "right" channel on the other; because of tracing distortion, and also harmonic distortion generated by some pickups at these high levels, the interpretation is sometimes difficult but it does attempt to set an industry standard. Another practical method is to use discs with fixed modulation (say, 5 cm/sec. at frequencies above 500 Hz and 1.57 cm/sec. at lower frequencies), adjust the playing weight for the "break" and equate the results to the maximum music level at that frequency. Fig. 5 shows such a plot for a well damped moving magnet cartridge.

The mechanical impedance at mid-frequencies is determined almost wholly by damping of the moving system. Indeed, with most modern magnetic pickup cartridges the mechanical impedance over the major part of the audio frequency spectrum is controlled by this factor. In order to realize the design requirements mentioned above, only the simplest mechanical system can be used, and this would in essence consist of a stylus directly coupled to the armature suspended by some elastic medium, the mass being concentrated at the stylus tip and the restoring force being the only other constant, as shown in Fig. 5. These ideals cannot be achieved in practice but in the best examples of variable reluctance or moving-magnet type structures they are closely approximated.

**Crystal pickups**

By far the most popular pickup cartridge is the crystal type. This is sub-divided into two groups—(a) those using Rochelle salt elements, and (b) ceramic elements<sup>5</sup>. Rochelle salt has the material advantages of high sensitivity, high dielectric constant (and hence high capacitance and relatively low electrical impedance, it can be produced as torsional bimorphs with a low mass moment of inertia and high compliance, but suffers from the disadvantage of being highly temperature-sensitive for electrical capacitance and being deliquescent requires elaborate moisture proofing for an adequate service life. Ceramic elements are produced as bender units only, and in order to obtain reasonable mechanical values

are made in the form of narrow relatively thick elements with resulting low capacitance and require a load impedance in excess of 2 megohms for adequate low frequency response. They possess the very material advantages of being impervious to moisture and have an indefinite service and shelf life.

Rochelle salt pickups have their major use in the record players produced for the mass market where cost is of primary consideration. Because of their high sensitivity and the fact that the electrical output is "corrected" only the simplest of amplifiers are needed. Many millions of reproducers have been produced using only a single valve with a few resistors as electronic complement to the ubiquitous Rochelle salt pickup.

The demand for better reliability and consistency and freedom from the worst temperature effects led to the introduction of the piezo-electric ceramic elements. The original form of this material was barium titanate, but the crystal structure has been modified by various additions, and sensitivities of present day materials are between two and three times that of the original material.

Although there are individual differences between manufacturers the design of crystal cartridges is now fairly stable; a typical example uses a moulded case with a "turnover" stylus assembly—one point for L.P. and stereo and the other for 78 mono. In the absence of any modern 78 records being pressed this seems a needless extravagance, but then many millions of record changers have been produced with a  $16\frac{2}{3}$  r.p.m. position on the speed control, and to the author's best knowledge only a handful of  $16\frac{2}{3}$  records were ever produced and that was ten years ago—doubtless the marketing pundits have sound reasons for these anomalies. But to the pickup proper: an aluminium alloy cantilever and sapphire or diamond stylus is used, the rear suspension is approximately equally compliant in all directions, and it then drives two crystal elements through individual arms mutually perpendicular and at 45° to the record surface. The mechanical crosstalk between the two units should be a function only of the ratio of the compressional compliance to the flex-

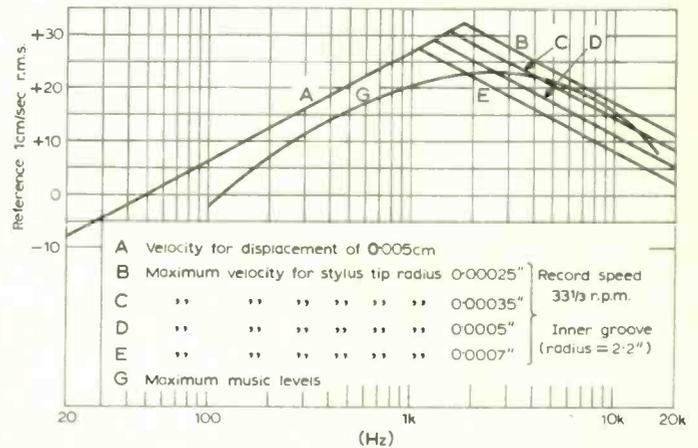


Fig. 2. Maximum velocities on music records.

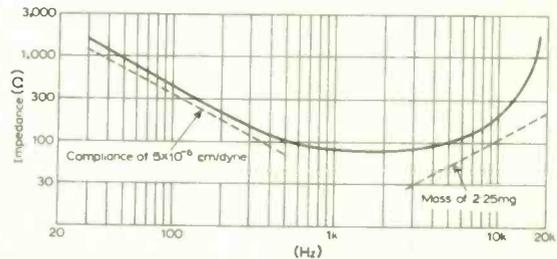


Fig. 3. Maximum mechanical impedance required to track music records with maximum modulation, at a playing weight of 1.5g.

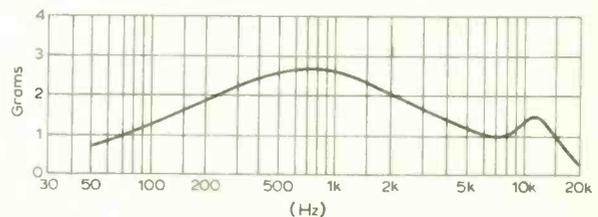


Fig. 4. Minimum playing weight for music levels with maximum modulation.

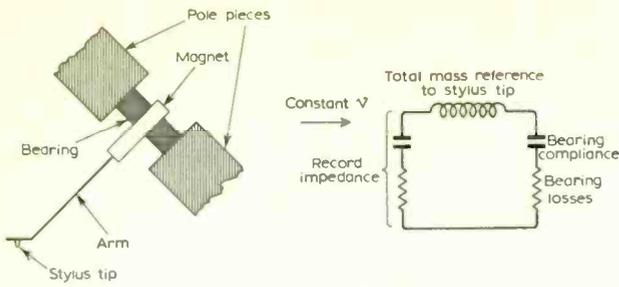


Fig. 5. Analogue of a simple armature system.

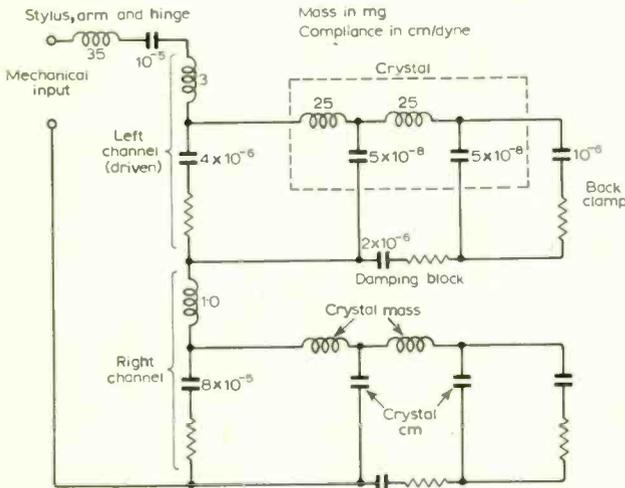


Fig. 6. Analogue of a crystal stereo pickup.

ing compliance. Now, assuming that the material is isotropic, the flexing compliance is proportional to the cube of the length and inversely proportional to the cube of the thickness times the width, whilst the compressional compliance is proportional to length and inversely proportional to the cross-sectional area. Thus for a given cross section any degree of isolation can be obtained by increasing the ratio of length to width, and for a design centre of, say, 26dB, the ratio of length to width need only be 4:1.

The lead zirconate crystals operating in flexure are supported at the rear end by a stiff block of plastic and an additional damping member is placed amidships, this also acts as the stylus cantilever support. The sections of the crystals are mutually perpendicular and 45° to the horizontal.

The analogue is shown in Fig. 6. The cantilever stylus is driven from the record, and the mass  $M_1$  and compliance  $C_m$  are respectively the dynamic mass and the restoring force of the stylus itself. Normally the compliance between the stylus point and the compliant members driving the crystals is zero, therefore any shunt effect of motion to ground can be neglected. At the driving point the motion splits into two, and drives two identical crystal elements. Because the back support of the crystal is soft compared with the stiffness of the crystal as a whole there is appreciable motion over the whole of the crystal, and it is therefore more amenable to analysis if we split the crystal mass and put clamping impedances at the centre and rear end of the crystal. The compliance and loss resistance at the crystal driving point is the compressional compliance of the coupling member between the stylus and the crystal, whilst the compliance and resistance at the remote end of the crystal is the clamping member. It will be seen that the series masses of coupling members will form resonant circuits which modify considerably the high-frequency crosstalk—indeed because of the multiplicity of resonances analysis is approximate only.

Resistances represent the losses deliberately introduced into the system in order to make the steady state response of the cartridge as smooth as possible.

The force developed across the compliances of the crystal itself is converted into electrical energy by means of the transducer action, the e.m.f. being generated in series with the electrical capacitance of the crystal. It is the finite value of this capacitance which limits the output voltage at low frequencies when the pickup is terminated in a practical value of resistance. The series mass between the cantilever and the crystal is the total mass of the coupling member. The other half of the circuit represents the load imposed at the driving point from the other

crystal. Here, the reflected dynamic mass of the other channel coupling member is reduced because it is operated in flexure rather than in compression, whilst the compliance is very materially increased.

The low-frequency crosstalk separation is, to all intents and purposes, the ratio of these two compliances. Connected in parallel with this latter compliance is the complex impedance presented by the other crystal and its supports; it forms various resonant circuits at different frequencies, and if the impedance at this point rises unduly it will be reflected in increased crosstalk.

During this analysis it is assumed that one channel only is being driven, but as both channels are symmetrical and identical, the analysis can be considered to be fairly rigorous. Because the pickups are high impedance devices, a common ground connection can be used without introducing any substantial increase of crosstalk due to common ground impedance.

It will be appreciated from the foregoing that a rigorous analysis of this type of cartridge is very difficult, and it is usual to rely on "know-how" and empirical trial and error rather than to design the cartridge from basic piezo-electric and mechanical constants.

Compared with a single channel cartridge, it will be appreciated that the effective dynamic mass referred to the stylus must be greater than that of a single channel unit of the same crystal and stylus dimensions by virtue of the reflected impedances of the unwanted channel. Because the impedance is complex, the impedance changes rapidly with frequency, and is responsible for the wide variations in crosstalk, especially in the upper frequencies. Whilst, theoretically, the mechanical impedance of the twin channel cartridge should not be appreciably greater than that of the single channel (because of the de-coupling effect of the transmission members) in point of fact for a given sensitivity it is usually found that the mechanical impedance is about 50% greater than that of an equivalent single channel cartridge.

The external mechanical constants of this cartridge are compliance at 30 Hz,  $5 \times 10^{-6}$  cm/dyne. Effective tip mass at 10 kHz, 7.5 milligrammes, playing weight 3 to 4 grammes. Fig. 7 shows the response of this pickup. It is not claimed to be high fidelity but gives an acceptable performance with domestic equipment.

As can be expected, the mechanical input impedance varies with frequency, as shown in Fig. 8. The rise at low frequencies is due almost entirely to the stiffness of the mounting and damping parts. The various drive members and supports are usually moulded from plasticized copolymers of vinyl chloride and acetate or other thermo-plastic material. The elastic constants of these plastics vary rather widely with temperature and both the output and compliance decrease with increasing temperature, as shown in Fig. 9. Be this as it may, about 90% of all twin channel cartridges presented to the public today are crystal or ceramic.

To summarize: A crystal cartridge has the prime advantages of low cost, ease of manufacture, and a high output voltage, which are precisely the requirements for transducers in the domestic reproducing field. To date, all crystal pickups are of the 45-45 sensing variety, that is, the two elements are sensitive only to forces in the direction of their required plane, and no "sum and difference" crystal cartridges have yet appeared on the market.

### Magnetic cartridges

Magnetic pickup cartridges are fundamentally different from crystal in that the output voltage is proportional to the velocity of the armature and by inference to the velocity of the record groove modulation whereas crystal devices produce a voltage which is proportional to the force applied to the crystal and, to a first approximation, to the amplitude of the modulated groove.

In order to achieve wide frequency response and low playing weight the dynamic mass and the restoring force of the moving system must be minimal. At high frequencies of the order of 10kHz, accelerations in excess of 1000 g are experienced at high modulation levels, thus for playing weights of the order of 1.5 grammes the maximum dynamic mass referred to the stylus point should be of the order of 1 milligramme.

The majority of magnetic cartridges are of the moving magnet variety although because of patent restrictions variable reluctance systems use the same mechanical configuration as that of the moving magnet (but using an external polarizing magnet) are now appearing on the market in increasing numbers. The overall design considerations and performance are approximately similar to those in the moving magnet design although it is possible in theory at least to reduce the mass moment of inertia (and hence the mechanical impedance at high frequencies) by substituting a thin walled tube in place of the solid rod used in moving

magnet systems. The point of no return is quickly reached because of magnetic saturation of the subsequent very small cross-sectional area of the armature.

The magnetic circuit consists essentially of two pairs of pole pieces arranged symmetrically around the centre line of the armature with pickup coils wound over the yokes connecting opposite pairs of poles. The armature is usually a small cylindrical magnet about 0.030 inch diameter by 0.1 inch long cemented to a thin walled aluminium or duraluminium tube approximately 0.3 inch long and carrying a miniature diamond tip at the front end. The assembly is supported by a compliant hinge at its centre of gravity and in some models a tie bar, usually 0.002 inch diameter stainless steel, is connected to prevent longitudinal motion. By suitable proportioning the dimensions of the tie bar it can also be used as the major restoring force, the plastic collar then providing central support and damping. The hinge can be one of a variety of elastomers, either copolymers of polyvinyl chloride or polyvinyl acetate; butyl plus neoprene rubber is sometimes used, as have been some of the polyurethanes. Silicone elastomers have not been very successful because of their low internal damping. The success (or failure) of the pickup is intimately bound up with this bearing design. The bearing is highly stressed in one direction due to the force developed by the playing weight—it is well known that most types of elastomers have a non-linear relation between stress and strain under these conditions. Additionally, hysteresis shows itself as distortion in the middle to high frequencies. At low frequencies the armature system vibrates about the centre of the plastic bearing but it is very rare for the inertial centre of gravity to coincide; the result of this is that with increasing frequency the effective mass increases, thus reducing tracking capabilities at high frequencies.

The static mass of this system is between 8 and 20 milligrammes depending on the particular design and the dynamic mass at 10 kHz in the best designs can approach 1.2 to 2 milligrammes. The static compliance varies between  $5 \times 10^{-6}$  cm/dyne and, in extreme cases,  $40 \times 10^{-6}$  cm/dyne, but because of the deliberately introduced mechanical damping (due to losses in the plastic hinge and sometimes by the addition of silicone or other grease) the mechanical impedance can be made almost wholly resistive between limits of 100Hz and 10kHz.

Clearance between the magnet and the poles is about 0.15 thou and because of the efficient magnetic circuit, generally using Mumetal or other high permeability materials, leakage flux is extremely low and from a magnetic point of view the system is extremely efficient. The sensitivity is generally of the order of 1 to 2 millivolts/cm/sec., although some recent Japanese cartridges have been produced with five times this output. The development of this elegant type of cartridge is due to Schmidt of Elac, Kiel, Germany, and has been extensively copied throughout the world.

Because of the magnetic symmetry, mutual induction between the coils is small and crosstalk arising from this factor is usually less than -40dB whilst overall crosstalk varies between about -10dB or -15dB at the extremes of the frequency band (20 Hz and 20 kHz) improving to a maximum of about -30dB in the mid frequencies, say, 500 Hz to 1 kHz. This crosstalk is due almost entirely to unwanted modes of vibration of the armature system. As an example, increasing the stylus length by only 0.01 inch can increase crosstalk caused by torsional vibrational modes by 15dB in the mid-upper frequency range. Notwithstanding the technical criticisms, the performance of the best examples of moving magnet type cartridges are impressive.

The field strength (and hence sensitivity) of the variable magnetic field transducer, whether variable reluctance or moving magnet, is limited by saturation of the armature or the pole pieces and by the "negative compliance" due to the pull of the steady magnetic field on the armature. If the field exceeds a critical value determined by the static compliance of the armature restoring force it will result in the armature being attracted to one of the pole faces and hence no music! It is this negative compliance which generally limits the sensitivity of the pickup, requiring coils of several thousand turns of fine gauge wire to produce usable output.

**Moving-coil pickup**

The moving-coil pickup suffers none of the disadvantages listed above. If the magnetic field is linear and this condition is not difficult to achieve, the output will be strictly a function of coil velocity with no inherent generated distortion. Because of the absence of negative compliance the magnetic field can be increased to the limit and field strengths of the order of 15 kilogauss instead of a few tens or hundreds

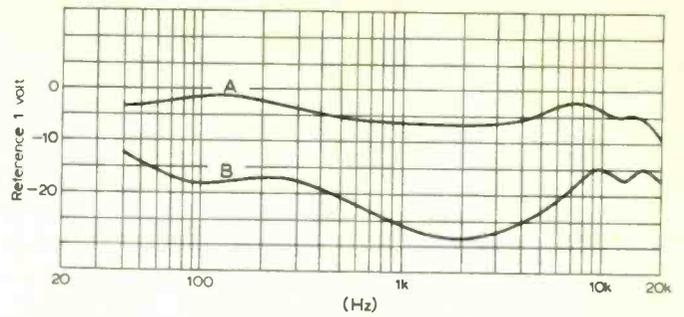


Fig 7. Curves A and B show, respectively, the wanted signal and the crosstalk into the second channel, from a ceramic cartridge loaded by 2M  $\Omega$  and of 5g playing weight. The temperature is 21°C and the test record TC5702.

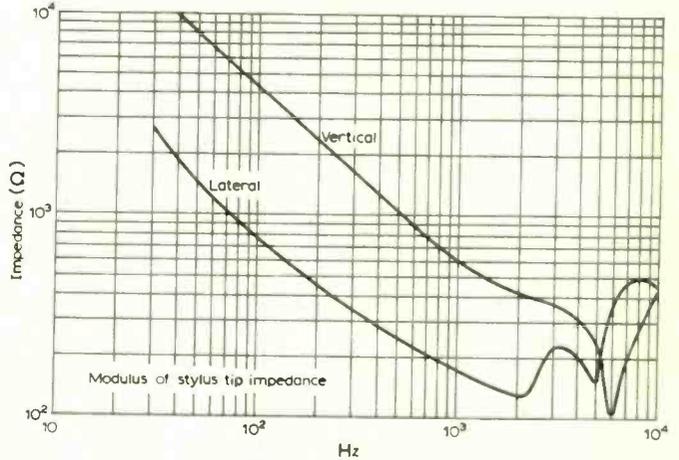


Fig. 8. A graph showing the stylus-tip impedance changes (lateral and vertical) with changing signal frequency.

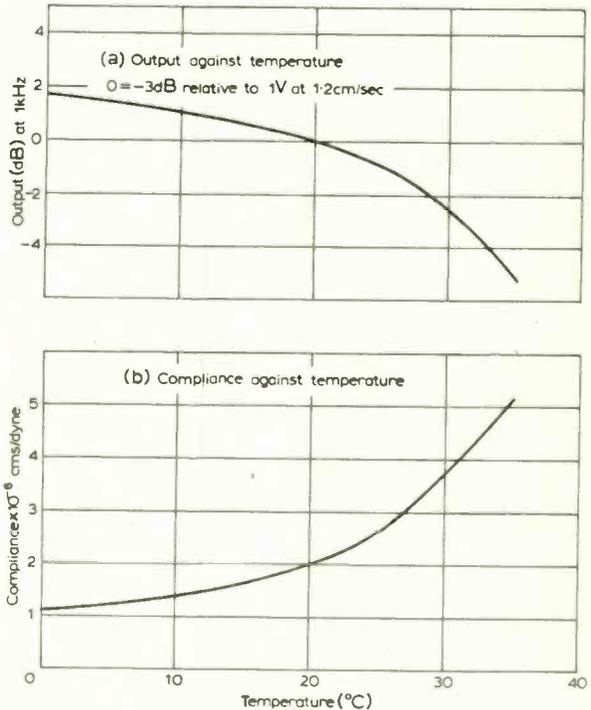


Fig. 9. Variations with temperature in a crystal pickup cartridge.

of gauss are possible. In addition to increasing the output the signal to noise ratio is improved proportionately. The secret of success is in the design of the coil and the support system.

The most popular moving-coil cartridge uses a coil former in the form of a rectangular plate 2 mm square x 0.5 mm thick wound with four coils each with ten turns symmetrically placed about the centre line. Thus each generator consists of two coils in series, rising perpendicularly from the centre plate is an aluminium tube cantilever about 7 mm long

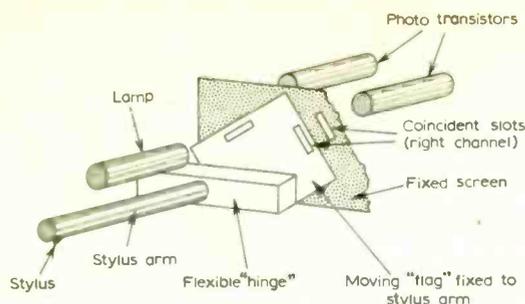


Fig. 10. Diagrammatic representation of Toshiba C100P pickup cartridge.

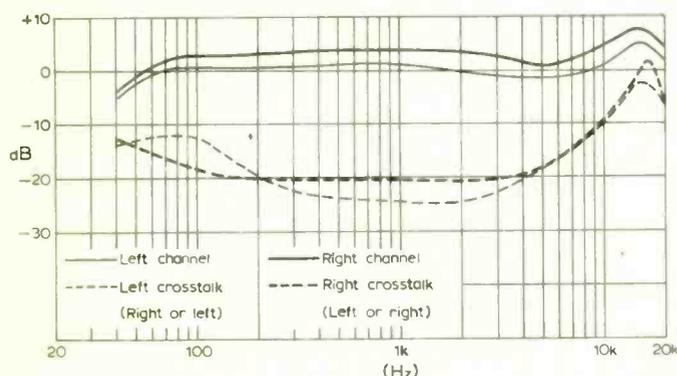


Fig. 11. Frequency response curves for photo-electric cartridge.

carrying the stylus at its free end. The rear end of the coil is flexibly mounted on to a steel tube which forms one pole of the magnet. The other pole in front of the coil is bored to take the cantilever and its protecting tube. The flexible mounting carries a damping block and is arranged to prevent fore and aft movement. There is, however, some torsional movement which shows as a minor resonance in the 7 kHz to 9 kHz region. The ratio of cantilever length to coil dimension is 7:1, giving a mechanical ratio of 50:1, and this results in an extremely low mechanical impedance at the stylus tip. Static compliance is of the order of  $20 \times 10^{-6}$  cm/dyne, but because of mechanical damping the resistive component becomes predominant between 100 Hz and 3 kHz, and approximates 40 mechanical ohms. Stylus resonance is at 26 kHz giving a calculated mass of 1.24 milligrammes. The coils are low impedance, about 2 ohms, and a matching transformer is used to raise the voltage sensitivity to about 2 millivolts/cm/sec.

The best examples of the magnetic cartridges (both variable field and moving coil) described above can generally be produced to give a flat frequency response with velocity from 20 Hz to 10 kHz  $\pm 1$ dB and 10 kHz to 20 kHz within  $\pm 2$ dB. Crosstalk will generally approximate 25dB between 400 Hz and 5000 Hz, gradually deteriorating to 10dB or 15dB at the extremes of the frequency range. With lower priced units the frequency response is somewhat more variable, generally being characterized by a "suck out" of a few dB between 5 kHz and 15 kHz, the extreme high frequencies being restored by the stylus/record resonance.

### "Strain Gauge" pickup

Recently a number of novel types of transducers have made their appearance, the first using a "strain gauge" transducer which unlike magnetic and piezo-electric pickups is not a generator but operates by modulating a d.c. current supplied from an external source in sympathy with the mechanical information. The transducer proper is a tiny doped silicon element,  $0.020 \times 0.008 \times 0.004$  inch, similar to the base material of modern transistors. It is cemented to a plastic beam which in turn is driven through a flexible member by the stylus. For stereo use two such members are used, and the general assembly is very similar to that of the modern ceramic cartridge. The *modus operandi* of the transducer is that the resistance changes when subjected to a force across the driving points. The magnitude of the resistance change has a linear function of the applied force thus providing that the current through the element is constant the transducer is inherently distortionless. The element is fed with a constant current and the resultant voltage which is proportional to displacement is applied to the amplifier through a coupling capacitor. Thus to a first approximation the response is similar to that of a crystal or ceramic cartridge.

The art in designing this type of pickup is to so proportion the dimensions and the material of the drive back clamp and damping members as to give a mechanical transfer that is the inverse of the record amplitude characteristic, at the same time taking into account the fact that the mechanical impedance of the transducing element is several hundred times greater than the permissible stylus tip impedance. The semiconductor transducer by virtue of its small size has a major advantage over the ceramic element in that resonances associated with it are outside the audio frequency spectrum (the average ceramic transducer has at least one major resonance in the mid-upper frequency range) although resonances can and are introduced by other parts of the mechanical system.

The virtue of this type of pickup is that because the transducer is a modulating element the electrical output power can be considerably greater than with "generating" types of transducer. Comparison between the high quality moving coil and this type of pickup may be instructive. The moving coil cartridge requires a playing weight of 1.9 grammes at a velocity of 20 cm/sec. at 1 kHz and produces an output of 800 millivolts from a source impedance of 2 ohms. Thus the input power is 2.7 milliwatts and the output power 0.32 milliwatts giving a conversion efficiency of 0.012 per cent. A representative strain gauge pickup requires a playing weight of 3 grammes at a velocity of 20 cm/sec. at 1 kHz and gives an output of 120 millivolts from a source impedance of 400 ohms. Thus the input power is 4.2 milliwatts and the output power is 36 milliwatts and the overall efficiency is 1.16 per cent. Neglecting the electrical input power, the overall efficiency of this type of cartridge is approximately one hundred times as great as its ceramic counterpart! Distortion is commendably low, and signal to noise ratio more than adequate, but frequency response and crosstalk are inferior to the better magnetic units and because the response of the system is flat to d.c., motor rumble and low frequency feedback can be troublesome unless a rumble filter is fitted to the amplifier.

### Photo-electric pickup

During 1968 a new type of pickup (or more correctly a new version of a pre-war type of pickup) made its appearance, namely the photo-electronic pickup. Fig. 10 shows a sketch of the system. The diamond stylus is placed at one end of an aluminium alloy tube 0.02 inch diameter  $\times$  0.25 inch long. The remote end of the tube supports a small flag approximately 0.1 inch square  $\times$  0.002 inch thick. Pierced in this flag are two slots,  $0.062 \times 0.008$  inch. The slots are mutually perpendicular and  $45^\circ$  to the horizontal. Behind the flag is a fixed screen with two similar slots and behind the screen are two photo transistors complete with miniature focusing lens each approximately 0.62 inch diameter. The moving assembly is supported by a compliant hinge approximately 0.040 inch in front of the flag. Under operating conditions the two pairs of slots overlap by 50%, displacing the stylus tip around this mean position will vary the amount of overlap and hence the total quantity of light received by the photo transistor and finally the output voltage developed by it. The lamp is fed from a stabilized d.c. power supply and the outputs from the photo transistors are taken through a correcting amplifier to the normal hi-fi amplifier.

Like the strain gauge and ceramic cartridges, this is a displacement type of pickup in which the output is proportional to amplitude rather than to velocity. The frequency response is shown in Fig. 11, and it will be seen that the main resonance occurs at approximately 15 kHz, whilst at frequencies above 20 kHz the pickup exhibits two resonant modes, one at 28 kHz in which the output drops to practically zero, and the other with a sharp peak at 35 kHz. These two resonances are probably connected with the dynamics of the light valve system. Distortion at middle and low frequencies is quite low, being less than 1% at 2 kHz but increasing to 6% at 5 cm/sec. at 10 kHz.

This brief survey of currently available pickups of necessity only skims the surface of technical development; considerable engineering skill is being constantly applied to the problems outlined above, and although the possibility of novel forms of transducer are remote, detailed improvements of established designs are continually appearing, thus automatically outdating any survey.

### References

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|   |  | E.R.C.   |           |          |        |         |        |        |         |         |             | EAGLE   |         |
|---|--|----------|-----------|----------|--------|---------|--------|--------|---------|---------|-------------|---------|---------|
| <b>Model Type 1</b>                     |  | Compax X | Compax X2 | Compax C | 2SB    | 2SX     | 5MX    | 7MX    | 5MB     | ERC1    | Power Point | LC05    | LC07    |
| Frequency response (Hz)                 |  | 40-12k   | 40-12k    | 30-12k   | 30-12k | 40-12k  | 40-12k | 40-10k | 30-12k  | 60-10k  | 40-12k      | 30-18k  | 20-21k  |
| Channel separation (dB)                 |  | 925      | 2150      | 700      | 420    | 800     | 1450   | 2300   | 875     | 625     | 1670        | 6       | 7       |
| Output voltage <sup>2</sup> (mV)        |  | 1M       | 1M        | 1M       | 1M     | 1M      | 1M     | 1M     | 1M      | 1M      | 1M          | 47k     | 47k     |
| Load impedance (Ω)                      |  | S-D      | S-D       | S-D      | S-D    | S-D     | S-D    | S-D    | S-D     | S-D     | S-D         | D       | D       |
| Stylus <sup>3</sup>                     |  | 3        | 2.5       | 2.5      | 5      | 4       | 2      | 1.2    | 0.6/0.7 | 0.6/0.7 | 0.6/0.7     | 9       | 12      |
| Stylus dimensions (10 <sup>-3</sup> in) |  | —        | —         | —        | —      | —       | —      | —      | —       | —       | —           | —       | —       |
| Compliance (10 <sup>-6</sup> cm/dyne)   |  | —        | —         | —        | —      | —       | —      | —      | —       | —       | —           | —       | —       |
| Dynamic mass (mg)                       |  | —        | —         | —        | —      | —       | —      | —      | —       | —       | —           | —       | —       |
| Playing weight (g)                      |  | 700pF    | 700pF     | 600pF    | 850pF  | 700pF   | 700pF  | 700pF  | 700pF   | 600pF   | 600pF       | —       | —       |
| Inductance/capacitance                  |  | 3.2      | 3.2       | 3.2      | 3.5    | 3.5     | 3.2    | 3.2    | 3.2     | 2       | 0.3         | —       | —       |
| D.C. resistance (Ω)                     |  | —        | —         | —        | —      | —       | —      | —      | —       | —       | —           | —       | —       |
| Weight (g)                              |  | —        | —         | —        | —      | —       | —      | —      | —       | —       | —           | —       | —       |
| Mounting                                |  | —        | —         | —        | —      | —       | —      | —      | —       | —       | —           | —       | —       |
| Retail price Inc. P.T.                  |  | £1.6.0   | £1.6.0    | £1.11.0  | £2.3.4 | £1.17.2 | £1.6.0 | £1.6.0 | £1.11.0 | —       | 17.4        | £4.19.9 | £6.19.6 |

|   |  | ELAC    |         |         |         |         |         |        |          |          |         | EMPIRE   |         |         |
|---|--|---------|---------|---------|---------|---------|---------|--------|----------|----------|---------|----------|---------|---------|
| <b>Model Type 1</b>                     |  | 244-17  | 244-C   | 244-65  | 344-17  | 444-12  | 444-E   | 808    | 808E     | 888      | 888E    | 888TE    | 888VE   | 999VE   |
| Frequency response (Hz)                 |  | 20-20k  | 20-20k  | 20-20k  | 20-22k  | 10-24k  | 10-24k  | 15-20k | 10-25k   | 10-24k   | 10-30k  | 8-32k    | 6-32k   | 6-35k   |
| Channel separation (dB)                 |  | <2      | <2      | <1.5    | <1.5    | <1.5    | <1.5    | 8      | 8        | 8        | 8       | 8        | 8       | 8       |
| Output voltage <sup>2</sup> (mV)        |  | 7.5     | 7.5     | 7.5     | 5       | 5       | 5       | 8      | 8        | 8        | 8       | 8        | 8       | 8       |
| Load impedance (Ω)                      |  | D       | D       | S       | D       | D       | D       | D      | D        | D        | D       | D        | D       | D       |
| Stylus <sup>3</sup>                     |  | 18      | 10      | —       | 25      | 33      | 33      | 8      | 12       | 10       | 12      | 25       | 30      | 30      |
| Stylus dimensions (10 <sup>-3</sup> in) |  | —       | —       | —       | —       | —       | —       | —      | —        | —        | —       | —        | —       | —       |
| Compliance (10 <sup>-6</sup> cm/dyne)   |  | —       | —       | —       | —       | —       | —       | —      | —        | —        | —       | —        | —       | —       |
| Dynamic mass (mg)                       |  | —       | —       | —       | —       | —       | —       | —      | —        | —        | —       | —        | —       | —       |
| Playing weight (g)                      |  | 320mH   | 320mH   | 320mH   | 320mH   | 320mH   | 320mH   | —      | —        | —        | —       | —        | —       | —       |
| Inductance/capacitance                  |  | —       | —       | —       | —       | —       | —       | —      | —        | —        | —       | —        | —       | —       |
| D.C. resistance (Ω)                     |  | —       | —       | —       | —       | —       | —       | —      | —        | —        | —       | —        | —       | —       |
| Weight (g)                              |  | —       | —       | —       | —       | —       | —       | —      | —        | —        | —       | —        | —       | —       |
| Mounting                                |  | —       | —       | —       | —       | —       | —       | —      | —        | —        | —       | —        | —       | —       |
| Retail price Inc. P.T.                  |  | £7.17.6 | £7.17.6 | £7.17.6 | £16.5.6 | £16.5.6 | £22.0.0 | £9.9.6 | £13.14.5 | £12.11.1 | £17.4.8 | £24.17.6 | £29.5.7 | £36.6.6 |

|   |  | GARRARD |         |         |          |         |          |         |        |         |           | GOLDRING  |           |         |          |          |  |  |  |  |  | ORTOFON |  |  |  |  |  |  |  |  |  |
|---|--|---------|---------|---------|----------|---------|----------|---------|--------|---------|-----------|-----------|-----------|---------|----------|----------|--|--|--|--|--|---------|--|--|--|--|--|--|--|--|--|
| <b>Model Type 1</b>                     |  | GCM31   | GCS35   | KS40A   | 800H     | 800     | 800E     | 800SE   | CS90   | CS90E   | SL15      | SL15E     | M15G      | M15B    | MFT5G    | MFT5B    |  |  |  |  |  |         |  |  |  |  |  |  |  |  |  |
| Frequency response (Hz)                 |  | 100-8k  | 100-8k  | 50-10k  | 20-20k   | 20-20k  | 10-23k   | 10-23k  | 30-20k | 30-20k  | 10-40k    | 10-40k    | 20-20k    | 20-20k  | 20-20k   | 20-20k   |  |  |  |  |  |         |  |  |  |  |  |  |  |  |  |
| Channel separation (dB)                 |  | —       | —       | —       | —        | —       | —        | —       | —      | —       | —         | —         | —         | —       | —        | —        |  |  |  |  |  |         |  |  |  |  |  |  |  |  |  |
| Output voltage <sup>2</sup> (mV)        |  | 3.5     | 1.9     | 0.5     | 8        | 20      | 20       | 25      | 20     | 20      | 30        | 30        | 30        | 30      | 30       | 30       |  |  |  |  |  |         |  |  |  |  |  |  |  |  |  |
| Load impedance (Ω)                      |  | 2M      | 2M      | 2M      | 50-100k  | 50-100k | 50-100k  | 50-100k | 2M     | 2M      | 47k       | 47k       | 47k       | 47k     | 47k      | 47k      |  |  |  |  |  |         |  |  |  |  |  |  |  |  |  |
| Stylus <sup>3</sup>                     |  | 2.5/0.7 | 2.5/0.7 | 2.5/0.7 | D/S      | D       | D        | D       | D      | D       | D         | D         | D         | D       | D        | D        |  |  |  |  |  |         |  |  |  |  |  |  |  |  |  |
| Stylus dimensions (10 <sup>-3</sup> in) |  | 1.5     | 0.6     | 2       | 18       | 20      | 30       | 35      | 8      | 8       | 25        | 25        | 25        | 25      | 25       | 25       |  |  |  |  |  |         |  |  |  |  |  |  |  |  |  |
| Compliance (10 <sup>-6</sup> cm/dyne)   |  | —       | —       | —       | —        | —       | —        | —       | —      | —       | —         | —         | —         | —       | —        | —        |  |  |  |  |  |         |  |  |  |  |  |  |  |  |  |
| Dynamic mass (mg)                       |  | —       | —       | —       | —        | —       | —        | —       | —      | —       | —         | —         | —         | —       | —        | —        |  |  |  |  |  |         |  |  |  |  |  |  |  |  |  |
| Playing weight (g)                      |  | 1000pF  | 1000pF  | 600pF   | 450pF    | 450pF   | 450pF    | 450pF   | 900pF  | 900pF   | 1.1k      | 1.1k      | 1.1k      | 1.1k    | 1.1k     | 1.1k     |  |  |  |  |  |         |  |  |  |  |  |  |  |  |  |
| Inductance/capacitance                  |  | —       | —       | —       | —        | —       | —        | —       | —      | —       | —         | —         | —         | —       | —        | —        |  |  |  |  |  |         |  |  |  |  |  |  |  |  |  |
| D.C. resistance (Ω)                     |  | —       | —       | —       | —        | —       | —        | —       | —      | —       | —         | —         | —         | —       | —        | —        |  |  |  |  |  |         |  |  |  |  |  |  |  |  |  |
| Weight (g)                              |  | —       | —       | —       | —        | —       | —        | —       | —      | —       | —         | —         | —         | —       | —        | —        |  |  |  |  |  |         |  |  |  |  |  |  |  |  |  |
| Mounting                                |  | —       | —       | —       | —        | —       | —        | —       | —      | —       | —         | —         | —         | —       | —        | —        |  |  |  |  |  |         |  |  |  |  |  |  |  |  |  |
| Retail price Inc. P.T.                  |  | —       | —       | —       | £10.13.9 | £13.0.0 | £18.17.1 | £26.0.0 | £5.4.0 | £7.16.0 | £36.12.11 | £29.10.11 | £29.12.11 | £23.9.5 | £24.14.1 | £18.10.7 |  |  |  |  |  |         |  |  |  |  |  |  |  |  |  |

(2) First letter: S = sapphire, M = mono, second letter: M = moving magnet, V = variable reluctance, D = moving coil, C = ceramic, R = induced magnet, F = free field

|  | ORBIT  |           | PHILIPS  |         | PICKERING |         | SHURE    |         |          |           |        |           |           |           |         |
|--|--------|-----------|----------|---------|-----------|---------|----------|---------|----------|-----------|--------|-----------|-----------|-----------|---------|
| <b>Model</b>                                 | NM22   | GP412     | GP411    | GP410   | GP200     | GP300   | AC2      | AT2     | AM2      | AME2      | M3D    | M31E      | M32E      | M32-3     | M44-5   |
| <b>Type<sup>1</sup></b>                      | 20-20k | 20-20k    | 30-18k   | 30-18k  | 50-16k    | 50-17k  | 20-20k   | 20-20k  | 20-20k   | 20-20k    | 20-15k | 20-18.5k  | 20-17.5k  | 20-17.5k  | 20-20k  |
| <b>Frequency response (Hz)</b>               | >25    | >5        | >5       | >5      | >300      | >500    | 35       | 35      | 35       | 35        | >20    | >20       | >20       | >20       | >25     |
| <b>Channel separation (dB)</b>               | 50k    | 47k       | 68k      | 68k     | 1M        | 1M      | 7.5      | 47k     | 47k      | 47k       | 47k    | 47k       | 47k       | 47k       | 47k     |
| <b>Output voltage<sup>2</sup> (mV)</b>       | D      | D         | D        | D       | S         | S       | D        | D       | D        | D         | D      | D         | D         | D         | D       |
| <b>Load impedance (Ω)</b>                    | 5      | 0.7 x 0.3 | 0.6      | 0.6     | 0.7       | 0.7     | 0.7      | 0.7     | 0.7      | 0.4 x 0.9 | 0.7    | 0.7 x 0.2 | 0.7 x 0.4 | 0.7 x 0.4 | 0.5     |
| <b>Stylus dimensions (10<sup>-3</sup>in)</b> | 5      | <0.75     | 10       | 10      | 2.5       | 2.5     | 0.7      | 0.7     | 0.7      | —         | 4      | 15        | 10        | 2.5       |         |
| <b>Compliance (10<sup>-6</sup>cm/dyne)</b>   | 2-3†   | 1         | 1        | 1       | 3-7       | 3-7     | 3-7      | 1-5     | 1-5      | 1-1†      | 3-6    | 1-2       | 21-5      | 21-5      | 1-1†    |
| <b>Dynamic mass (mg)</b>                     | —      | 11-1      | 2-4      | 2-4     | 700pF     | 1000pF  | —        | —       | —        | —         | 420mH  | 720mH     | 720mH     | 720mH     | 720mH   |
| <b>Playing weight (g)</b>                    | —      | 75mH      | 56       | 56      | 5 pin     | 5 pin   | 5        | 5       | 5        | 5         | 280    | 630       | 630       | 630       | 630     |
| <b>D.C. resistance/capacitance</b>           | 10     | 1030      | 11.5     | 11.5    | 11        | 11      | 5        | 5       | 5        | 5         | 8.5    | 6         | 6         | 6         | 6       |
| <b>Weight (g)</b>                            | 1 in   | 1 in      | 1 in     | 1 in    | 5 pin     | 5 pin   | 1 in     | 1 in    | 1 in     | 1 in      | 1 in   | 1 in      | 1 in      | 1 in      | 1 in    |
| <b>Mounting</b>                              | 1 in   | 1 in      | 1 in     | 1 in    | 5 pin     | 5 pin   | 1 in     | 1 in    | 1 in     | 1 in      | 1 in   | 1 in      | 1 in      | 1 in      | 1 in    |
| <b>Retail price inc. P.T.</b>                | £7.8.9 | £39.0.0   | £13.15.0 | £14.1.1 | £310.0    | £118.11 | £12.17.0 | £14.1.4 | £16.12.0 | £23.1.8   | £7.8.3 | £12.19.5  | £12.0.11  | £11.2.4   | £11.2.4 |

|  | SHURE (contd.) |          | STANTON   |           |          |           |           |           |          |          |          |         |          |           |
|--|----------------|----------|-----------|-----------|----------|-----------|-----------|-----------|----------|----------|----------|---------|----------|-----------|
| <b>Model</b>                                 | M44-7          | M44C     | M44E      | M45E      | M75C     | M75EJ     | M75E-D19  | M75E-959  | M75SG    | VIS-II   | VIS-II-7 | 500A    | 500AA    | 500E      |
| <b>Type<sup>1</sup></b>                      | 20-20k         | 20-20k   | 20-20k    | 20-20k    | 20-20k   | 20-20k    | 20-20k    | 20-20k    | 20-20k   | 20-20k   | 20-20k   | 20-20k  | 20-20k   | 20-20k    |
| <b>Frequency response (Hz)</b>               | >25            | >25      | >25       | >25       | >25      | >25       | >25       | >25       | >25      | >25      | >25      | >35     | >35      | >35       |
| <b>Channel separation (dB)</b>               | 11             | 9.3      | 6.6       | 9.3       | 5        | 5         | 5         | 5         | 5        | 3.5      | 3.5      | 4       | 4        | 4         |
| <b>Output voltage<sup>2</sup> (mV)</b>       | 47k            | 47k      | 47k       | 47k       | 47k      | 47k       | 47k       | 47k       | 47k      | 47k      | 47k      | 47k     | 47k      | 47k       |
| <b>Load impedance (Ω)</b>                    | D              | D        | D         | D         | D        | D         | D         | D         | D        | D        | D        | D       | D        | D         |
| <b>Stylus dimensions (10<sup>-3</sup>in)</b> | 0.7            | 0.7      | 0.7 x 0.4 | 0.7 x 0.2 | 0.6      | 0.7 x 0.4 | 0.7 x 0.2 | 0.7 x 0.2 | 0.6      | 0.7      | 0.7      | 0.7     | 0.5      | 0.9 x 0.4 |
| <b>Compliance (10<sup>-6</sup> cm/dyne)</b>  | 20             | 7.5      | 15        | 20        | T        | T         | T         | T         | T        | T        | T        | —       | —        | —         |
| <b>Dynamic mass (mg)</b>                     | 1-3            | 3-5      | 1-4       | 1-4       | 1-3      | 1-3       | 1-1       | 1-1       | 1-1      | 1-1      | 1-1      | 2-5     | 1-3      | 2-5       |
| <b>Playing weight (g)</b>                    | 720mH          | 720mH    | 720mH     | 720mH     | 720mH    | 720mH     | 720mH     | 720mH     | 720mH    | 720mH    | 720mH    | 0.4H    | 0.4H     | 0.4H      |
| <b>D.C. resistance/capacitance</b>           | 630            | 630      | 630       | 630       | 630      | 630       | 630       | 630       | 630      | 630      | 630      | 850     | 850      | 850       |
| <b>Weight (g)</b>                            | 7              | 7        | 7         | 7         | 6        | 6         | 6         | 6         | 6        | 6.8      | 6.8      | 5       | 5        | 5         |
| <b>Mounting</b>                              | 1 in           | 1 in     | 1 in      | 1 in      | 1 in     | 1 in      | 1 in      | 1 in      | 1 in     | 1 in     | 1 in     | 1 in    | 1 in     | 1 in      |
| <b>Retail price inc. P.T.</b>                | £10.3.10       | £10.3.10 | £14.16.6  | £16.13.6  | £16.13.6 | £24.1.9   | £27.15.11 | £27.15.11 | £17.12.1 | £40.15.3 | £38.18.3 | £12.7.0 | £14.15.6 | £18.10.0  |

|  | SONOTONE |        | SONY   |        | TANNOY |         |           |        |        |          |
|--|----------|--------|--------|--------|--------|---------|-----------|--------|--------|----------|
| <b>Model</b>                                 | 2T       | 8T4A   | 9TA    | 9TAHC  | 2539   | 3509    | VC-8E     | VM-10P | VM-11G | Turnover |
| <b>Type<sup>1</sup></b>                      | MC       | SC     | SC     | SC     | SR     | SC      | SD        | SI     | SI     | MV       |
| <b>Frequency response (Hz)</b>               | 30-10k   | 30-12k | 30-15k | 30-20k | 100-8k | 100-10k | 15-25k    | 20-20k | 20-25k | 40-14k   |
| <b>Channel separation (dB)</b>               | 180†     | 90†    | 80†    | 55†    | 12     | 20      | 30        | 15     | 20     | —        |
| <b>Output voltage<sup>2</sup> (mV)</b>       | 2k       | 2k     | 2k     | 2k     | 550†   | 140†    | 4         | 3      | 3      | 15       |
| <b>Load impedance (Ω)</b>                    | S/D      | S/D    | S/D    | S/D    | 2k     | 2k      | 10-10k    | 47k    | 47k    | 50k      |
| <b>Stylus dimensions (10<sup>-3</sup>in)</b> | 0.7      | 0.7    | 0.7    | 0.7    | S/D    | S/D     | D         | D      | D      | D or S   |
| <b>Compliance (10<sup>-6</sup>cm/dyne)</b>   | 1        | 1.4    | 3      | 3      | 1      | 2       | 0.2 x 0.7 | 0.7    | 0.5    | —        |
| <b>Dynamic mass (mg)</b>                     | —        | —      | 3.5    | 2.5    | 1      | 2       | —         | —      | 30     | —        |
| <b>Playing weight (g)</b>                    | 6-10     | 4-6    | 2-4    | 1-3    | 8-10   | 5-7     | 1-2       | —      | 11-3   | —        |
| <b>Inductance/capacitance</b>                | 650pF    | 650pF  | 450pF  | 800pF  | 800pF  | 800pF   | 40Ω       | —      | 5kΩ    | 280mH    |
| <b>D.C. resistance (Ω)</b>                   | >50M     | >50M   | >50M   | >50M   | >50M   | >50M    | 40        | —      | 1300   | —        |
| <b>Weight (g)</b>                            | 4        | 4.5    | 3      | 3      | <3.5   | <3.5    | 15.5      | —      | 8      | 16       |
| <b>Mounting</b>                              | 1 in     | 1 in   | 1 in   | 1 in   | 1 in   | 1 in    | EIA       | —      | —      | 1 in     |
| <b>Retail price inc. P.T.</b>                | £10.10   | £2.3.3 | £3.1.9 | £3.1.9 | £2.8.7 | £2.16.0 | £37.3.7   | —      | —      | —        |

T = Trackability figures are available

† at 1 cm/sec at 1kHz. \* or centre.

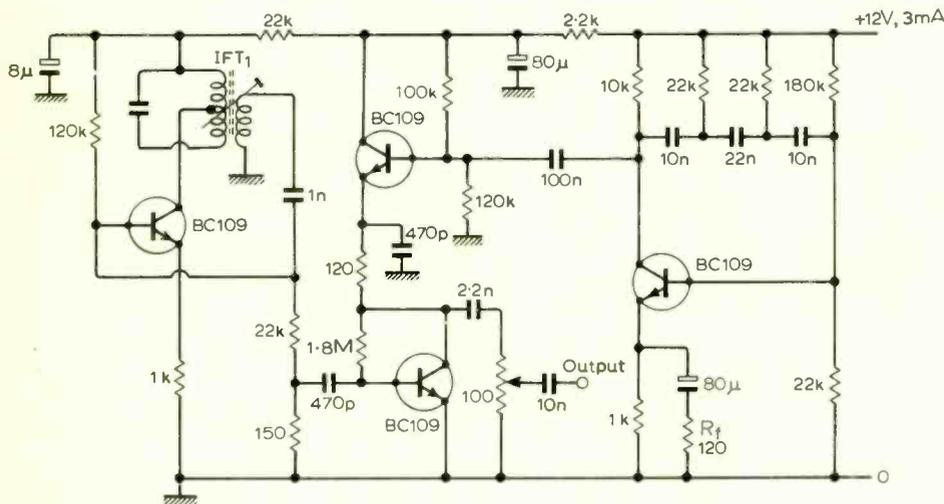
(1) First letter: S = stereo, M = mono. Second letter: M = moving magnet, V = variable reluctance, D = moving coil, C = ceramic, R = rochelle salt, I = induced magnet, F = free field.  
 (2) at 1 kHz at 5cm/sec. (3) D = diamond. S = sapphire.

# Circuit Ideas

## A.M. oscillator

The circuit shown is that of a 470kHz a.m. oscillator. The a.f. component is about 220Hz and is a pure sine wave. Modulation is fixed at about 90% but may be increased or decreased by varying the a.c. feedback resistor  $R_f$  in the a.f. oscillator. IFT<sub>1</sub> is an ordinary i.f. transformer from a transistor radio, and is tuned to give the required carrier frequency. The maximum peak-to-peak output is 60mV which is more than adequate, and the output impedance is 100Ω. The modulator section has a perfectly linear relationship between modulation depth and a.f. input.

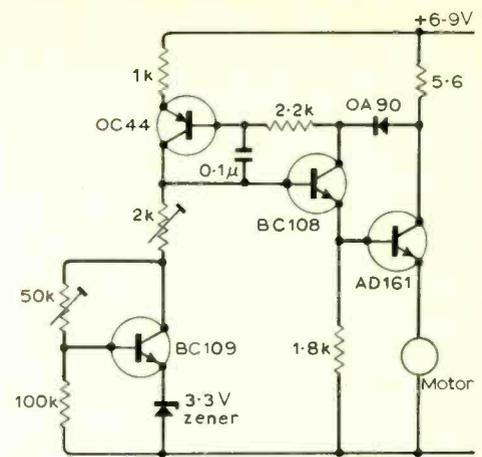
K. E. POTTER,  
Iverley,  
Worcs.



470kHz oscillator with 220Hz modulation, submitted by K. E. Potter. Modulation is at about 90%.

## Motor speed control

The circuit was devised for a battery tape recorder, in lieu of a centrifugal governor which was inclined to be erratic and produce interference in the audio. The motor required about 3V at 180mA. The circuit is virtually a fixed voltage source, with a negative output resistance that can be adjusted to be slightly less than the motor winding resistance (10Ω). This has the effect of keeping the motor's back e.m.f. constant. The AD161 supplies to the motor a voltage which is determined by the BC109 and zener diode, plus a voltage which increases in proportion to the current taken by the motor, as monitored by the 5.6Ω resistor. The OA90 is merely to offset the  $V_{be}$  of the OC44, and the 2.2kΩ, 0.1μF combin-



Electronic governor, devised by D. Williams for a battery tape recorder.

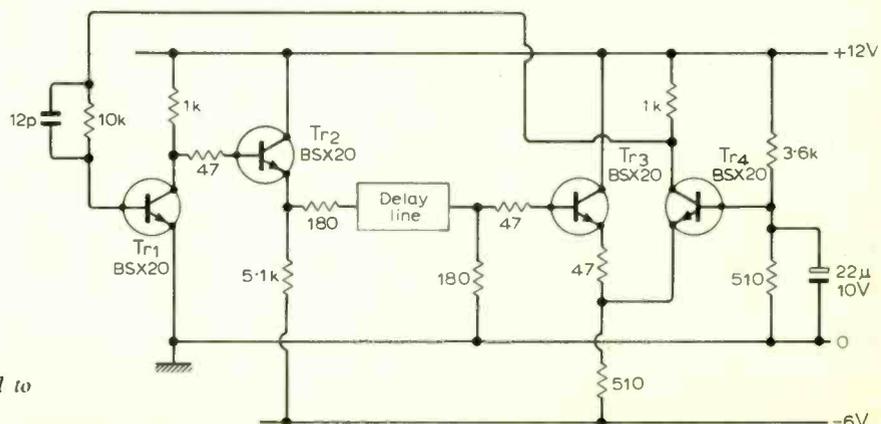
ation is to filter out fast current fluctuations from the motor's commutator. In use the 2kΩ potentiometer is set just short of 'hunting' of the system, and then the 50kΩ potentiometer is adjusted for fine speed setting. The circuit is practically independent of battery and temperature variations.

DAVID WILLIAMS,  
Sidcup,  
Kent.

## Delay-line coupled multivibrator

This astable circuit is a simple square-wave generator that has an excellent frequency stability. Unlike the conventional RC coupled multivibrator, change in collector-to-emitter saturation voltage cannot cause a frequency drift. Drifts in the base-to-emitter voltage influence the frequency slightly because the rise and fall times are finite. The signal on the base of  $Tr_3$  has comparatively slow edges that have been slowed down by the delay line. In this way turn on and off time varies with fluctuations of base-to-emitter voltage. Although this stage is more critical than  $Tr_1$  and  $Tr_2$ , it changes the length of period by only a few nanoseconds, since a voltage swing of roughly 200mV on the base of  $Tr_3$  drives  $Tr_4$  from cut-in to saturation. In a temperature range of 0 to 45°C the total frequency drift is much better than 0.1%. Selection of components was not necessary to achieve such stability.

J. HEINZL,  
St. Albans,  
Herts.



Astable multivibrator, submitted by J. Heinzl, which is said to have excellent frequency stability.

# A Thermistor Hygrometer

Instrument uses an i.c. op. amp. as a computing element

by D. Bollen

Atmospheric humidity is an important factor in many industrial processes. To give just two examples; the size and register of printing paper will vary with moisture content, and some textiles can generate dangerous amounts of static electricity in dry air. Equally important outside industry is the damaging effect of incorrect storage humidity on valuable items, such as oil paintings and antique furniture.

Hygrometry instruments which give a direct indication of relative humidity are usually far from precise because of temperature dependence or a drift of calibration with time. The popular hygroscopic hair hygrometer will only behave consistently over a restricted temperature range, and needs to be re-calibrated at frequent intervals. Successful attempts have been made to adapt the potentially more accurate wet and dry bulb hygrometer (psychrometer) to control applications, but the major difficulty here lies in converting two temperature signals into a continuous electrical output which is proportional to humidity. Also, where delicate d.c. amplifiers are employed with low output temperature sensors, the problem of drift occurs.

The thermistor hygrometer described here uses a single i.c. operational amplifier as a computing element, to convert wet and dry temperatures into a voltage which varies with humidity. The circuit is relatively insensitive to changes in air temperature, and will retain its calibration over long periods of time. Typical accuracy for humidities between 40% and 100% over a temperature range of 15°C to 40°C is  $\pm 5\%$  of full scale.

## Relative humidity

Water vapour in air can be expressed as a percentage of the amount of water vapour that would be present if the air was completely saturated, and the result is a dimensionless ratio known as relative humidity. Unlike absolute humidity, relative humidity is approximately related to evaporation and the moisture content of absorbent materials, and is therefore the most widely used humidity parameter. It is important to remember that, for a given weight of water vapour in a volume of air, relative humidity decreases as temperature is raised.

Quantities of water vapour are often measured in terms of vapour pressure, that is, the contribution made by water vapour to the total air pressure. If  $e$  is the variable vapour pressure at air temperature  $T_a$ , and  $e_a$  is the saturated vapour pressure at  $T_a$ , then,

$$h\% = \frac{100e}{e_a} \quad (1)$$

Obviously, if the air being examined is saturated  $e = e_a$  and  $h = 100\%$ , but if the air is absolutely dry  $e = 0$  and  $h = 0$ .

## Wet and dry bulb psychrometer

The Assmann psychrometer will give accurate readings over a wide range of air temperatures, and is often employed as a

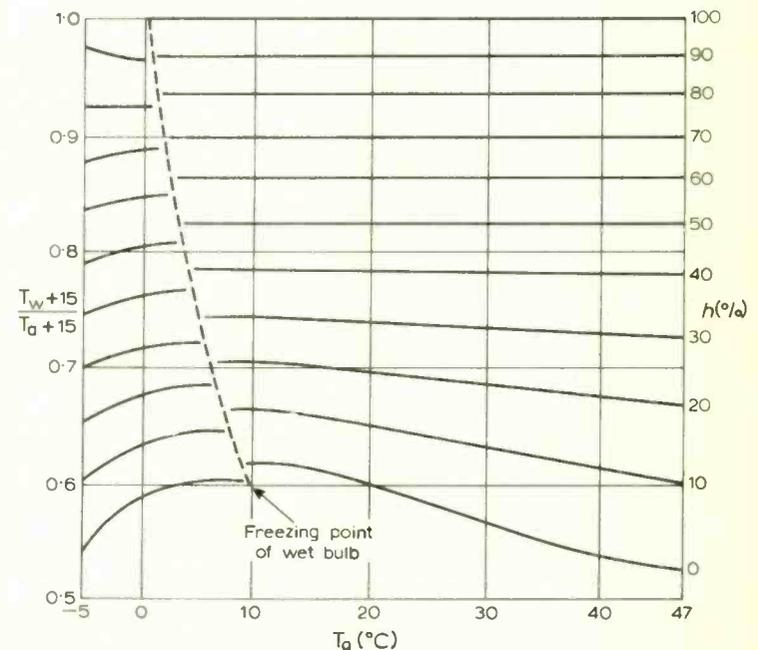


Fig. 1. Humidity curves based on  $(T_w + 15)/(T_a + 15)$  versus  $T_a$ .

secondary standard for calibrating other types of hygrometer. Basically, the Assmann consists of two mercury thermometers which are aspirated at a constant rate by a small clockwork or electric fan. While one thermometer serves to display air temperature, the other is cooled by evaporation of water from a moist muslin sleeve surrounding the thermometer bulb. A humidity value can be obtained from the two temperatures with the aid of formulae or, more conveniently, a set of hygrometric tables<sup>1</sup>. It will be evident that the Assmann psychrometer is cumbersome in use, and does not provide a direct output for control applications. An obvious line of thought is to replace the two mercury thermometers by thermistors, and use their negative temperature characteristic to provide outputs which are then processed to yield a voltage analogue of humidity.

The relationship between vapour pressure  $e$  and wet and dry bulb temperatures  $T_w$  and  $T_a$ , is given by,

$$e = e_w - Ap(T_a - T_w) \quad (2)$$

where  $e_w$  is the saturated vapour pressure at  $T_w$ ,  $A$  is a constant determined by the ventilation rate and mechanical construction of the hygrometer, and  $p$  is atmospheric pressure. For an Assmann psychrometer aspirated by an airflow of more than 3.6 metres/sec (where pressure is in millibars and temperature °C)  $A = 6.66 \times 10^{-4}$  when  $T_w$  is above 0°C. When the wet bulb is covered by ice

1. Hygrometric Tables, Part 3. (Aspirated Psychrometer readings degrees Celsius) Met.O.265C. H.M. Stationery Office 1964.

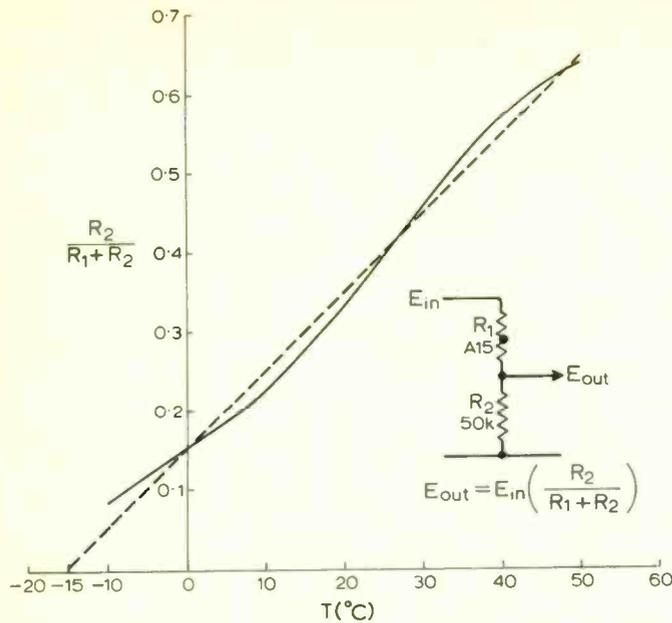


Fig. 2. Performance of potential divider with a thermistor which gives an output nearly proportional to  $T + 15$ .

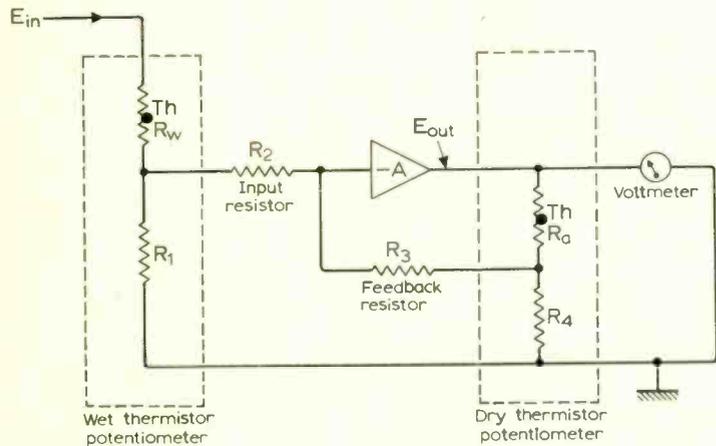


Fig. 3. Basic circuit using an operational amplifier which gives an output nearly proportional to  $(T_w + 15)/(T_a + 15)$ .

$A = 5.94 \times 10^{-4}$ . Below 3,000 ft,  $p$  can be taken as a constant 1,000 mb. A table of saturated vapour pressures will give  $e_a$  for equation (1) and  $e_w$  for equation (2).

Although the above equations could possibly be implemented with, say, a couple of diode function generators, a summing amplifier, and an analogue division circuit, the necessary equipment would be costly. However, a search for a more simple relationship between  $T_w$ ,  $T_a$ , and  $h$  reveals that the gradient  $\Delta T_w/\Delta T_a$  is almost constant for fixed levels of  $h$  over a wide range of  $T_a$ . If a plot is made of several values of  $h$  on a  $T_w$  versus  $T_a$  graph, it will take the form of a series of straight lines originating from a point near  $-15^\circ T_w$  and  $-15^\circ T_a$  on a Celsius scale. The situation is made clearer by Fig. 1, where  $(T_w + 15)/(T_a + 15)$  versus  $T_a$  presents  $h$  as a set of almost horizontal curves, with the resulting humidity scale on the right-hand side. Fig. 1 curves were obtained by calculation from hygrometric tables, and show the transition between the two values for  $A$  at the point where the wet bulb freezes. Because an attempt has been made to simplify the original law, accuracy falls at low temperatures and at low humidity levels, and the resulting humidity scale is not linear. Nevertheless, if a simple circuit can be devised to yield the quotient  $(T_w + 15)/(T_a + 15)$ , the output function will represent high levels of humidity with reasonable accuracy over a wide range of air temperatures above about  $5^\circ\text{C}$ .

**Thermistor characteristic**

Thermistor characteristic curves are invariably plotted against a logarithmic resistance scale, and it is difficult to obtain selected values from them. Given three or four measured values of thermistor resistance at known temperatures, however, the characteristic can be plotted with fair accuracy from the formula

$$R_{th} = ke^{B/T} \tag{3}$$

where  $R_{th}$  is the thermistor resistance,  $k$  is a constant determined by substituting known values of  $R_{th}$ ,  $B$  is the characteristic temperature obtained from manufacturer's data, and  $T$  is the temperature in degrees Kelvin. A table can be prepared from formula (3) which gives selected values of resistance over the required temperature range.

If a thermistor is used as one arm of a potential divider, an

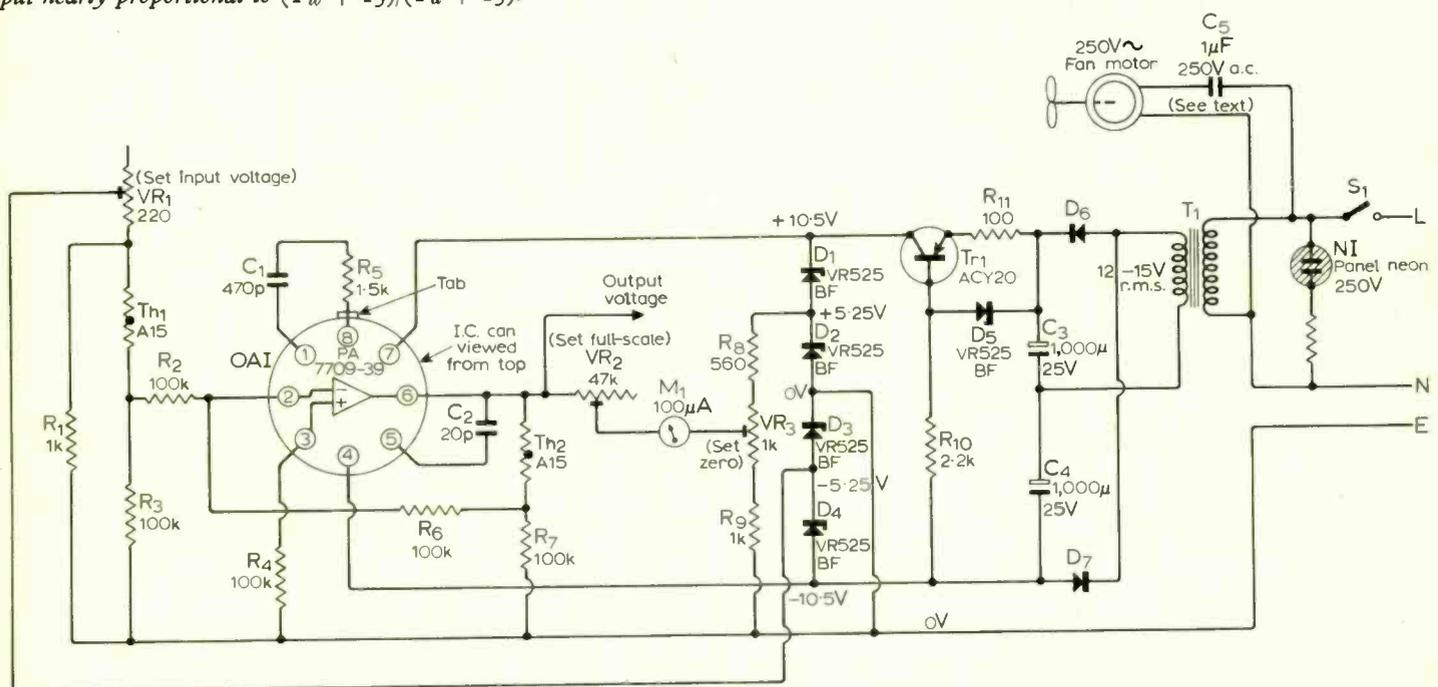


Fig. 4. Complete circuit diagram of the hygrometer.  $R_1$ - $R_4$ ,  $R_6$ ,  $R_7$  should be 2% high-stability resistors and  $R_{11}$  10% wire-wound 1W; other resistors can be 10% carbon types. Except  $R_{11}$ , all resistors are 0.5W.  $C_1$  and  $C_2$  are 125-V polystyrene types. Diodes  $D_1$  and  $D_5$  are A.E.I. VR 525BF and  $D_6$  and  $D_7$  are A.E.I. S7 403-F, while  $T_1$  is Mullard ACY 20. The operational amplifier is PA 7709-39 (Philco Ford) available from Rastra Electronics Ltd., 275 King Street, Hammersmith, London W.6.

output approximating to a linear relationship between temperature and resistance can be obtained. Looking at Fig. 2 a thermistor type A15 is allied with a 50 kΩ resistor, and the resulting potential divider output curve falls close to a straight line based on  $T + 15$  degrees Celsius. As we are interested here in the quotient of two such thermistor thermometer outputs, non-linearity errors are not quite so bad as they would appear to be from Fig. 2, provided that tracking between the two thermistors is good.

**Division circuit**

The division circuit of Fig. 3 is of the type employed in analogue computers, except that here temperature dependent potentiometers replace conventional potentiometers. The operational amplifier of Fig. 3 supplies an output  $E_o$  which is related to input  $E_{in}$  in the following way.

$$E_o = - E_{in} \frac{\frac{R_1}{(R_{thw} + R_1)R_3}}{\frac{R_4}{(R_{tha} + R_4)R_2}} \quad (4)$$

Assuming that

$$\frac{R_1}{(R_{thw} + R_1)} \approx T_w + 15, \text{ and } \frac{R_4}{(R_{tha} + R_4)} \approx T_a + 15, \text{ and}$$

$R_2 = R_3$ , then,

$$E_o \approx -E_{in} \frac{T_w + 15}{T_a + 15} \quad (5)$$

Thus, the output from the wet thermistor potentiometer has been divided by the output from the dry thermistor potentiometer.

In practice, resistors  $R_2$  and  $R_3$  will load the thermistor potentiometers because the amplifier input is at virtual earth, but this can be obviated by making the parallel combinations  $R_1, R_2$ , and  $R_3, R_4$ , equal to 50 kΩ. Another practical point is that an output corresponding to  $h = 0\%$  will not be zero volts, therefore an offset voltage must be supplied to the voltmeter to give the required suppressed zero.

**Thermistor hygrometer circuit**

The complete hygrometer circuit appears in Fig. 4.  $VR_1$  sets the negative input voltage across wet thermistor potentiometer  $Th_1$  and  $R_3$ .  $R_2$  is the operational amplifier input resistor and  $R_6$  the feedback resistor, while the dry thermistor potentiometer consists of  $Th_2$  and  $R_7$ . The i.c. operational amplifier chosen for use with the hygrometer has an open-loop gain  $>5,000$ , and is contained in an eight lead TO-5 can.  $C_1$  and  $R_5$  provide input frequency compensation, and  $C_2$  output frequency compensation, to ensure stability with capacitive output loads of less than  $0.05 \mu F$ . It is anticipated that many currently available i.c. operational amplifiers will operate satisfactorily in the Fig. 4 circuit, although the lead connections may differ.

In Fig. 4, the power supply is composed of a 12-15V r.m.s. output mains transformer, with voltage-doubler  $C_3, C_4, D_6$ , and  $D_7$  to give a smoothed d.c. output in the region of 35V. A string of zener diodes  $D_1-D_4$  is supplied from a constant-current source  $Tr_1, D_5$ , and  $R_{11}$ ; this arrangement conveniently allows a centre-tap as well as two intermediate voltages.

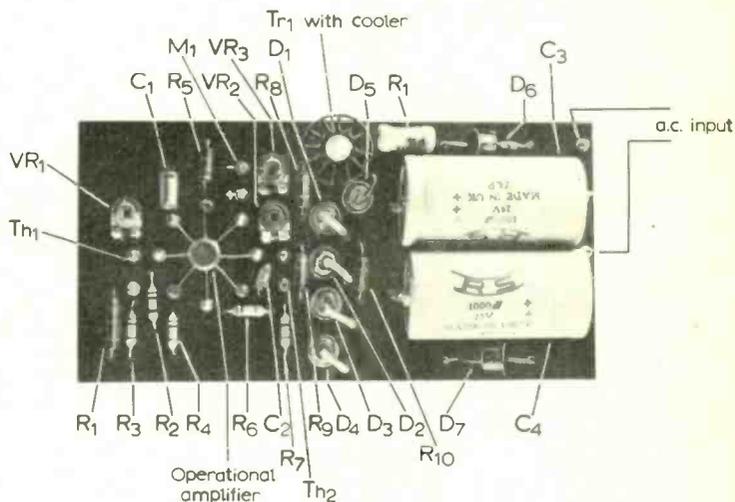
The positive offset voltage for the meter is obtained from potential divider  $R_8, VR_3$ , and  $R_9$ . Meter sensitivity is controlled by  $VR_2$ . It is thus possible to expand or contract the meter scale to obtain optimum accuracy over the desired range of operating temperature. In addition, the operational amplifier output is capable of driving a load of up to  $600\Omega$  to operate an external humidity control switch.

Because of their short life, small d.c. motors are not suitable for continuous ventilation of the wet thermistor. A shaded pole or similar 250V a.c. motor will give adequate ventilation without

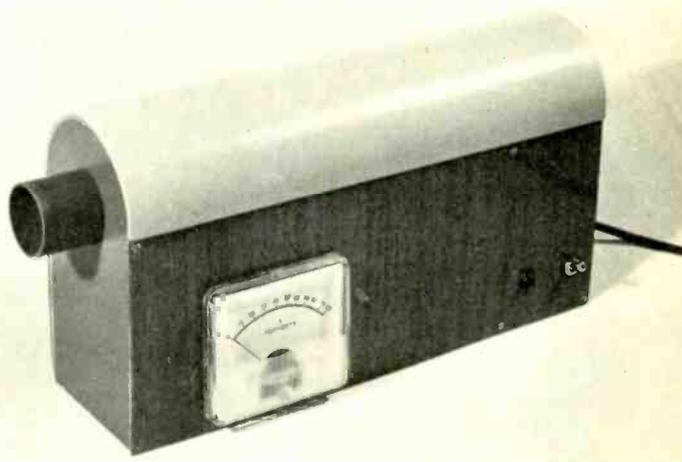
excessive heat if it is underrun on a supply of about 50-100V r.m.s., achieved by placing an appropriate value of capacitor in series with the motor ( $C_B$ ).

**Constructional notes**

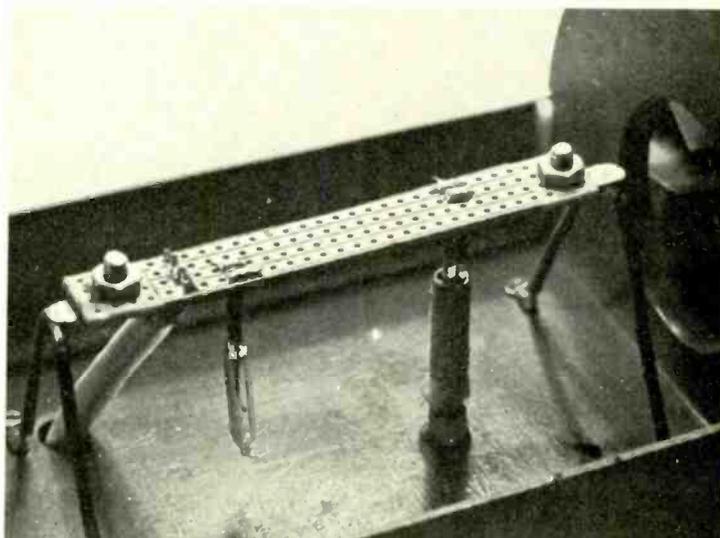
If suitable precautions are taken to ensure freedom from temperature and air pressure gradients around the thermistors, the way in which the instrument is arranged can depend on individual circumstances and preferences.



*This photograph shows the layout of the main components.*



*General view of the complete instrument.*



*Close-up of the dry (left) and wet (right) thermistors and their mount.*

The layout of the prototype hygrometer is depicted in Fig. 5, and in the photographs. No attempt was made to achieve a compact layout as space was not at a premium. There is no particular reason why the hygrometer should not be miniaturised for desk-top use if so desired.

In Fig. 5, the hygrometer case is made up of four compartments, air-sealed from each other by strips of draught excluder on the two side panels. An air duct forms the top of the case, and is ventilated by a centrifugal impeller, with the two thermistors mounted on a strip of Veroboard inside the duct. The wet thermistor is enclosed by a thin brass sleeve, and this is covered by a single layer of muslin. Underneath the wet thermistor is a container holding about 100cc of distilled water; enough for continuous operation over several weeks at normal levels of humidity. The muslin is long enough to act also as a wick, which dips into the water container. Housed in the fan motor compartment is the mains transformer and  $C_5$ , with the neon indicator and on-off switch mounted on the side panel. The remaining compartment, underneath the air intake, contains the circuit panel and humidity meter. The purpose of the air-filter bag shown in Fig. 5 is to prevent the ingress of large particles which could cause damage to the thermistors and fan blades.

Pressure gradients will inevitably occur within a system of

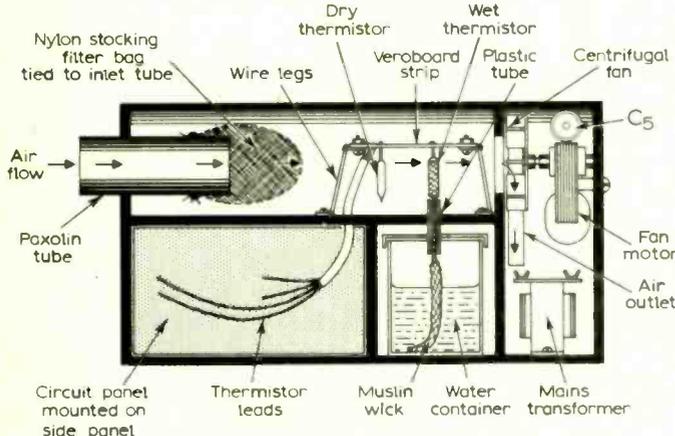


Fig. 5. General form of construction adopted.

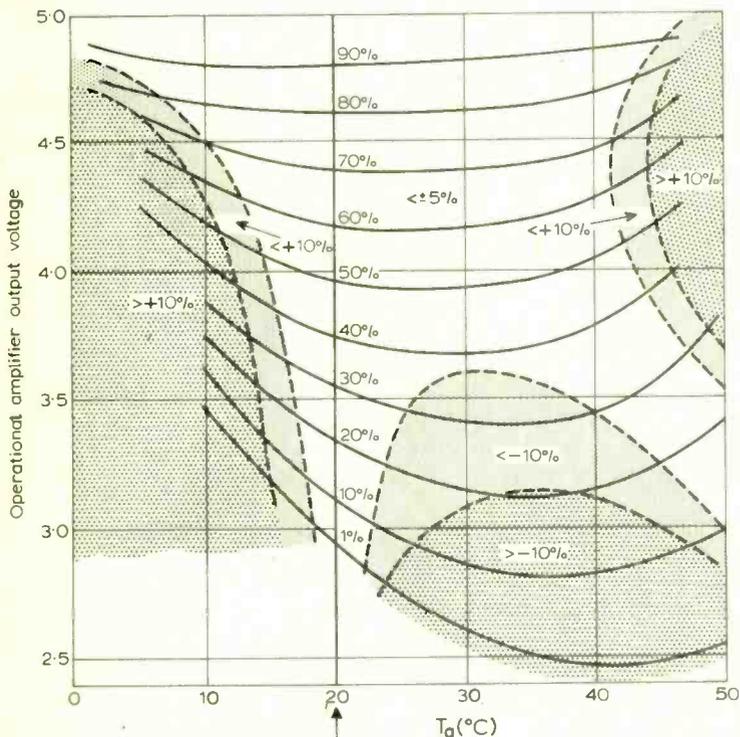


Fig. 6. Thermistor hygrometer error distribution for calibration at 20°C.

**Table 1**

| Meter   | Scale | Calibration |
|---------|-------|-------------|
| $\mu A$ |       | $h\%$       |
| 0       | 0     | 0           |
| 14      | 10    | 10          |
| 25      | 20    | 20          |
| 36      | 30    | 30          |
| 47      | 40    | 40          |
| 58      | 50    | 50          |
| 66      | 60    | 60          |
| 75      | 70    | 70          |
| 84      | 80    | 80          |
| 93      | 90    | 90          |
| 100     | 100   | 100         |

**Table 2**

| Voltmeter Offset Voltages |                |
|---------------------------|----------------|
| Calibration at $T_a =$    | Offset voltage |
| 10°C                      | +3.45          |
| 15°C                      | +3.15          |
| 20°C                      | +2.9           |
| 25°C                      | +2.7           |
| 30°C                      | +2.55          |
| 40°C                      | -2.4           |

forced-air flow. It may be that the air in the immediate vicinity of the wet thermistor is found to be slightly above or below atmospheric pressure. It is possible to compensate for this constant pressure deviation, without affecting accuracy, by suitable adjustment of  $VR_2$  and  $VR_3$ . More serious, however, is a reduction of air flow caused by a partly-blocked air intake. Quite apart from a general lowering of pressure within the air duct, the reduced flow will modify the calibration constant  $A$  in equation (2), and thus introduce serious errors.

The thermal inertia of the thermistors used in the hygrometer is such that the instrument will take about 39 seconds to respond to a 10% increment of humidity, which is considerably faster than the majority of direct-reading hygrometers. However, a rapid response also gives rise to overshoot when abrupt changes of air temperature are experienced. A slow response can be achieved, without increasing the thermal capacity of the thermistors, by placing a large-volume cotton-wool filter in front of the air intake. The cotton wool acts as a kind of integrator, by taking up and releasing moisture slowly, and also buffers sudden changes of temperature.

Meteorological advice suggests that the muslin on an Assmann hygrometer wet bulb should be changed before it becomes dirty. Tests with the thermistor hygrometer show that dirt certainly does increase the apparent temperature of the wet thermistor by reducing evaporation, but it is usually sufficient merely to wash the muslin wick after it has become noticeably blackened by dirt. The frequency of washing will depend on the air being sampled. In a grimy room heated by an open fire, the wick becomes dirty after barely 12 hours running time, but in normally clean air the hygrometer will run for several weeks without needing any maintenance.

Table 1 will facilitate calibration of the humidity meter scale, and is derived from calculations based on standard hygrometric tables and thermistor characteristics.

**Setting up the hygrometer**

Prior to wetting the muslin wick, measure with a voltmeter the voltage between the operational amplifier output and the earth rail, and adjust  $VR_1$  for a reading of 5V. Next, establish the correct offset voltage for a desired mean air temperature by adjustment of  $VR_3$ , after referring to the Table 2. Offset voltage is measured between the slider of  $VR_3$  and earth. Next, set  $VR_2$  for a full-scale deflection of the humidity meter.

It is as well to check for good tracking of the two thermistors, still with the muslin unmoistened, by placing the instrument first in a refrigerator and then in a warm oven. Ignoring temporary overshoot caused by abrupt temperature changes, look for a steady full-scale deflection of the humidity meter over 0 to 50°C, within about  $\pm 2\%$  at the extreme limits of temperature.

The above procedure is sufficient to calibrate the low humidity coverage of the thermistor hygrometer, but takes no account of high humidity errors caused by those small air pressure gradients when the ventilating fan is in operation. The simplest way of calibrating the high humidity end of the hygrometer scale is to operate the hygrometer in a saturated atmosphere. Construct a simple sling psychrometer from two mercury-in-glass thermometers taped to a wooden dowel. Place a single layer of muslin around the bulb of one thermometer and moisten with distilled

water. Take the improvised sling psychrometer out of doors early in the morning, after there has been an appreciable fall of rain and the sky is still clouded over, and wave it vigorously to and fro for several minutes. If both thermometers continue to display the same reading, the atmospheric humidity will be 100%. Set up the thermistor hygrometer close to the ground, with the muslin wick moistened, the fan operating, and the air duct cover in place, and then trim  $VR_2$  for a humidity meter reading of 100%.

### Performance and operation

The chart Fig. 6 gives calibration curves and a typical error distribution when the hygrometer is calibrated for a mean air temperature of 20°C. It can be seen that if the hygrometer error is not to exceed  $\pm 5\%$ , the permissible air temperature variation is only 18.5–22°C at a humidity level of 1%, but increases to 15–42°C at 50% humidity. When the instrument is calibrated for a mean air temperature of 10°C or less, the limits of air temperature variation become very close, even at high humidities. Also, if  $T_w$  is below 0°C, the muslin wick will freeze and cut off the supply of water to the wet thermistor.

From the above it is evident that the thermistor hygrometer is not suitable for use at temperatures near the freezing point of water, and is not very accurate at low humidity levels. Nevertheless, with its wide humidity coverage, and satisfactory performance at higher temperatures, the hygrometer will operate well in indoor environments in temperate and tropical climates.

As has already been mentioned, the operational amplifier output voltage is available for control purposes, and could also be employed for driving a chart recorder or telemetry link. In some cases it will be necessary to supply an offset voltage when zero output is required at zero humidity, which entails a floating output. Circuit details will depend on the particular application, but in the case of a simple on-off switch which operates equipment for wetting or drying air, the hygrometer operational amplifier could feed a simple Schmitt trigger and relay.

## Flying Laboratories

Signals radiated by radio navigational aids for civil aviation are periodically carefully checked by ground maintenance engineers and are continually sampled automatically by monitoring equipment to ensure that proper signals are being radiated. However, the signals may be modified in a manner which is not detectable by ground measurement (for example, by reflection from terrain or man-made objects at comparatively large distances from the transmitting aerial systems) and the consequent deficiencies in the signal can only be determined by making measurements in the air, i.e. by flight inspection. All the radio navigation aids installed and operated in the U.K. by the National Air Traffic Control Services are therefore calibrated and regularly checked by the Civil Aviation Flying Unit of the

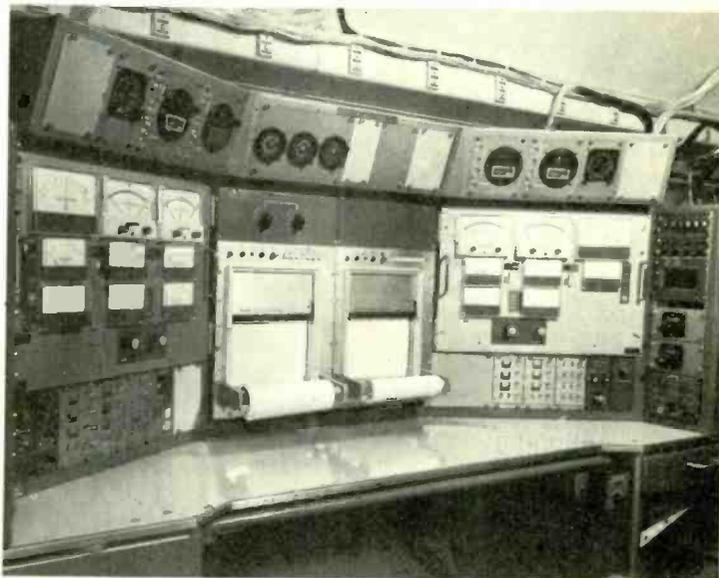
Board of Trade. This unit, which was formed in 1944 and costs about £1M a year to operate, has recently taken into service two new Hawker Siddeley 748 aircraft fitted with the latest equipment for the flight inspection of nav aids. The handing over of the two new HS 748 aircraft, bringing the fleet up to 17, afforded us an opportunity of seeing the Unit.

Between three and four hundred flight inspections covering all the civil v.h.f. omni-ranges (v.o.r.s) and distance measuring systems and most of the civil instrument landing systems and radar approach aids in this country are carried out annually by C.A.F.U. All these tests require navigation and flying to a high order of accuracy and demanding a great deal of care in the preparation and operation of the measuring equipment used for the work and in the post flight data analysis processes. The data thus gathered are used to assist the N.A.T.C.S. to maintain the internationally agreed standards required of radio navigation and communication systems for civil aviation.

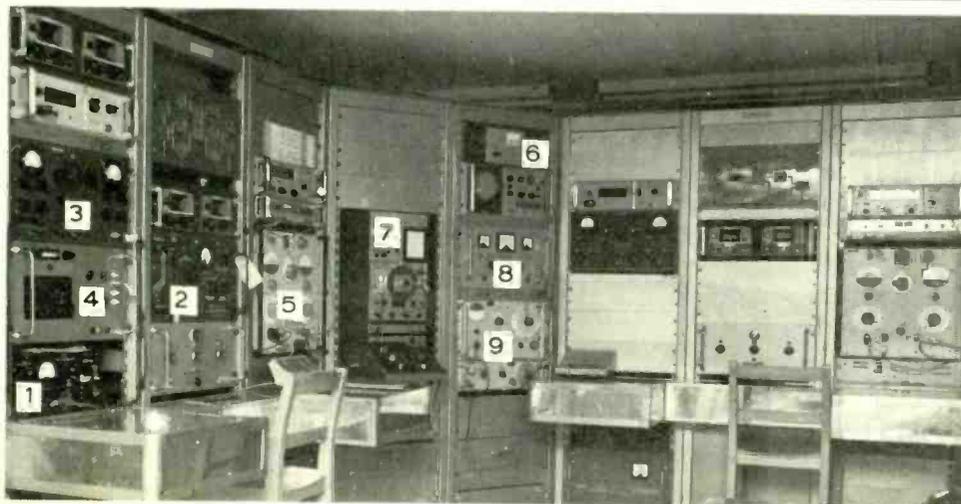
In order to maintain the accuracy of the equipment used in the aircraft for the inspection and recording of the nav aids, a standards laboratory has been established at Stansted and the aircraft are in essence "transfer standards". Some idea of the standard maintained can be gathered from the fact that for i.l.s. the glide path error is not more than 0.25 inch (in height) and azimuth is within 2.75 inches.

In addition to these routine tests, aids are subjected to an exhaustive initial scrutiny at installation, to prompt inspection if at any time there is evidence of possible deficiency, and to immediate examination if an accident should occur when an aid has been involved. Another C.A.F.U. task is the flight testing of new types of radio and radar systems.

In addition to its main task of flight inspection the unit also examines civil pilots' flying ability.



*One of the two flight checking positions in the new aircraft. The one shown here handles i.l.s. and the other up to four v.o.r. or two TACAN checks simultaneously.*



*(Left) The C.A.F.U. standards laboratory at Stansted. The annotated instruments are: 1, v.o.r. standard; 2 and 3, v.o.r. tones generator and r.f. signal generator; 4 and 5 i.l.s. tones generator and signal generator; 6, off-air (200 kHz) standard frequency receiver; 7, prototype "Modscope"—i.l.s. modulation measuring oscilloscope; 8, i.l.s. precision calibrator to determine zero d.d.m. (difference in modulation depth); and 9, wave analyser.*

# News of the Month

## European broadcasting satellite

A new European consortium (COMSET—Communications European Satellite Team) led by the French company Thomson-CSF, has submitted a bid to ESRO to provide a European communications satellite which will carry sound and television programmes within the Eurovision countries and Africa, and will be operated by the European Broadcasting Union responsible for operating the Eurovision network. The proposed satellite system will allow the simultaneous exchange of two colour television programmes and ten sound channels between ground terminals situated in Europe and in Africa. Each of these stations will be able to use the satellite both for the transmission and reception of programmes. Command and telemetry systems will be provided separately, as will a channel for the exchange of engineering service messages.

The British representative in the consortium is GEC-Marconi Electronics Ltd. Other countries participating in COMSET are Sweden, W. Germany, Italy, the Netherlands and France.

Since the announcement of the formation of COMSET we have been notified of another European consortium to provide the E.B.U. satellite. It includes companies in Germany, the U.K. (British Aircraft Corporation), Sweden, Belgium, France and Italy.

## Four-in-one television receiver

Family arguments as to which television channel to watch will be a thing of the past for those who can afford a new television receiver which is manufactured by the German firm Nordmende and marketed in the U.K. by British Relay. The new receiver has a 63cm (25 inch) colour tube with three smaller, 14cm (5.5 inch), monochrome tubes ranged below it. The main programme of interest can be viewed on the colour tube while the three monitors can each show a different programme. Any of the programmes being shown on the monochrome monitors can be switched to the main screen if desired. Sound for the three monitor channels is available at sockets for connection to earphones if required.



*Nordmende's four-tube television receiver being marketed in the U.K. by British Relay.*

The first set is on show in London at 84 Victoria St., S.W.1, and other demonstration models will shortly be on show in Birmingham and Edinburgh.

Although primarily intended for the use of actors, critics and television correspondents British Relay will make the receivers available on the retail market for about £850 should there be any demand.

## Trade Union for professional engineers

The United Kingdom Association for Professional Engineers (UKAPE) has launched a recruiting drive which started with a press conference in London recently. "The aims of the Association are to protect the individual from exploitation by unprincipled employers and unions, to promote his interests, to improve his conditions of employment and to regulate the relations between him and his employer."

In a statement the vice-president of UKAPE, R. L. Clarke, said: "We are most concerned by the fact that professional engineers are often separated through having to join unions which are at odds with one another". Mr. Clarke went on to say that he hoped that relations with other unions would be friendly and that the Association

had no ambitions outside the engineering profession. UKAPE is non-political and seeks no affiliations.

All professional engineers who are members of one of the fourteen institutions within the Council of Engineering Institutions (C.E.I.) are eligible for membership in UKAPE.

The aims of UKAPE cannot be satisfied by the institutions federated under C.E.I. as these are not constituted to handle protection or negotiation, in fact the interests of the chartered engineer could conceivably conflict with the interests of pure learning and an institution could not be on both sides of the fence at the same time. Also the institutions, because of their very nature, cannot give UKAPE any form of financial support. Because of this the Association is to be financed by subscription (full member—£6 and associate member—£4 10s per annum). The Engineers Guild is urging all its members to join the new association. Application forms can be obtained from: UKAPE, 400-403 Abbey House, 2 Victoria Street, London S.W.1.

## Film on i.c. production

The latest 24-minute colour film added to the Mullard Film Library is called "Something big in microcircuits". It gives a detailed account of the various processes in the production of integrated circuits at the Mullard plant at Southampton. The film, which includes some excellent macrophotography of devices in various stages of production, is both interesting and informative. Copies (16mm) are available on free loan in the U.K. from Mullard Film Library, 269 Kingston Road, London S.W.19.

Incidentally, although Mullard produce a large quantity of semiconductors they do not require "over 1000 tons of silicon a week" at the Southampton factory as was stated on p.517 last month. That quantity lasts them a year!

## Radio and TV relay

Speaking at the annual luncheon of the Relay Services Association of Great Britain, Ralph Gabriel (chairman of the council) criticized the "pettifogging restrictions" under which relay companies are operating and also of the competition likely to come from the new Post Office.

He cited the American Federal Communications Commission's report on "communal antenna television" under which companies in the States will be permitted to relay *any* programmes (in this country they are limited to those normally receivable in the area) and may originate programme material (which is taboo in the U.K.) and in fact any C.A.T.V. system with more than 3,500 subscribers is required as a condition of its licence, to originate programmes to a significant extent.

Mr. Gabriel, who is chief engineer of Rediffusion, also spoke of the selection of programmes by the "dial-a-programme" system which, if it were permitted in this country, might well find a ready market in the U.S.A.

## Earth stations for Hong Kong and Jamaica

In a £2.7M contract the Marconi Company are to build satellite earth stations in Hong Kong and Jamaica for Cable & Wireless. Both stations will have paraboloids of 29.6 metres (97ft) diameter. The new aerial will be Hong Kong's second, the first was also built by Marconi, enabling simultaneous communications to both the east and the west. Hong Kong's first station together with the Marconi installation at Bahrain are said to be the first civil 90ft. aerials (and there are 23 of them) to meet all eighteen parts of the Comsat specification.

On completion of the new aerial, Hong Kong will be able to communicate with the United States, Australia, Japan and Thailand via the Pacific satellite and with the U.K., Bahrain, East Africa, India, Indonesia, Lebanon, Pakistan and Singapore or Malaysia via the Indian Ocean satellite.

Jamaica's station will allow communication to the western countries using the Atlantic Ocean satellite.

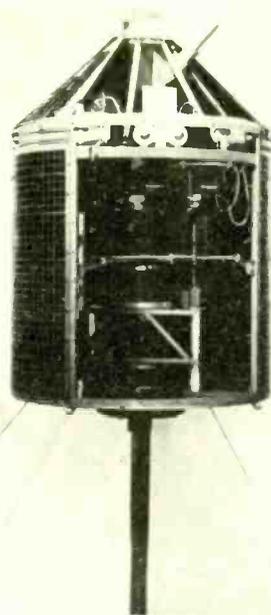
The principal standard of performance used by Comsat is the G/T figure, defined as the measure of aerial gain to the noise temperature of the system, measured at the input to the first stage of the receiver. The Comsat specification, defined by the Interim Communications Satellite Committee, calls for a G/T of 39dB and preferably better than 40.7dB, measured at the centre frequency in the receiving band with an aerial elevation of 5° above the horizon. The figure achieved for the first Hong Kong station was 41.3dB and slightly less for the Bahrain station but still above 40.7dB.

A vernier servo loop operates in conjunction with the more conventional conical scan system used to "hold" the satellite. The vernier servo eliminates the small but rapidly changing pointing errors which occur in high winds. This will mean that the station will be able to operate in marginal weather conditions with winds gusting at up to 80 m.p.h.

Contributing to the low noise figure is a new design of azimuth beaming which assists in keeping the aerial accurately aligned with the satellite. This employs a system of plastic pads running on machined steel bearing surfaces which are lubricated by a continuous feed. However, the aerial will still operate if the oil feed fails. Another advantage of this system is that the plastic bearing can be changed while the aerial is still in operation. When it is considered that the rotating section of the aerial weighs 200 tons, this is no small achievement.

## R.S.R.S. Open Days

Open days were held on 23rd and 24th October at the Science Research Council's Radio and Space Research Station at Ditton Park, Slough, Bucks., at which displays illustrating the work carried out there were arranged. The work is concerned with the propagation of radio waves and related physics. The ionosphere and the effects on it of electromagnetic and particle radiation from the sun, the tropo-



*Cut-away view of the 157-pound, German-built GRS-A (German Research Satellite), the first spacecraft in a co-operative programme between the Federal Republic of Germany and the American National Aeronautics and Space Administration. The satellite will study the earth's radiation belts, the auroral zone and the effects of solar proton events.*

sphere and the effects on it of meteorological factors are among the matters to which primary attention is paid.

The work, both experimental and theoretical, is being carried out with the very practical end of improving communications by a better understanding of propagation. The radio frequencies covered range from 10kHz to 1000GHz and the distances being studied range from a few metres to several earth radii. Rockets and satellites are employed in this work.

The major part of the work is carried out at Slough, but there are four outstations; at Chilbolton, Hants., where there is a large steerable aerial; at Winkfield, Berks., where satellite tracking and data acquisition is carried out in conjunction with N.A.S.A.; at Singapore and in the Falkland Islands.

## An Englishman's home is his office?

To mark its rebirth as a public corporation the Post Office in collaboration with the Council of Industrial Design has organized an exhibition at the Design Centre, 28 Haymarket, London S.W.1. Open until December 13th the exhibition describes existing services offered by Post Office telecommunications and outlines developments in design and technology from Edwardian times to the present day with a prediction for the future. By 1990 (more probably 2000) it will be possible for many office workers to be able to stay at home and talk to business colleagues by viewphone, transmit data and plans by television or

facsimile equipment, and communicate with computers and information services by telex and visual display units.

The viewphone screen will probably have about 230 lines, and the method used in linking sound and vision channels will depend on the demand for such a system. It would be possible to transmit the sound as a p.c.m. code in the vision signal, but this method would exclude the system from the standard telephone network using microwaves.

It is forecast that by 1980 about 64% of all households will have a telephone—instead of the present 30%. There will be a very rapid increase in the use of data transmission and a continued large-scale expansion of the telex services.

## 1969-70 Faraday lecture

This year's Faraday lecture tour will start on November 18th at Rugby, Staffordshire, and will spotlight, as it has done in the past, aspects of modern electrical and electronic science and technology in straightforward language with particular emphasis on practical demonstrations.

The lecture, which is arranged by the I.E.E., is to be given by J. H. H. Merriman and is called "People, Communications and Engineering". Mr. Merriman is the senior director (development) with the British Post Office and also member for technology on the Board of the Post Office Corporation. The deputy lecturer is C. H. May who is a staff engineer in the Post Office Telecommunications Department. The lecture will be given in thirteen towns in the British Isles.

## S.R.C. annual report

The Science Research Council's report for the year 1968-69 has just been published and is available from H.M.S.O. for 8s 6d. Apart from various organizational matters the report gives facts on all manner of research projects being carried out up and down the country and in Europe and makes very interesting reading.

One of the announcements made in the report is that the University Science and Technology Board is to be dissolved and its place taken by two boards one responsible for science and the other for engineering.

## Selling Colour

Mullard have produced a quick-reference manual entitled "Selling Colour—A Promotion Pack for dealers". This contains largely information which has already reached dealers from many different sources, but is here collated. In addition to advice on demonstrating and selling, it contains maps and estimated dates for the start of new colour transmissions.

It is available only to dealers and in the first place to those in the initial BBC-1 and I.T.V. colour areas. Applications for a copy should be made to Distributor Sales Division, Mullard Ltd., Mullard House, Torrington Place, London W.C.1.

# Diode Line Pulse Shaper

## Circuit for use with t.t.l. gate

by B. L. Hart,\* B.Sc., M.I.E.R.E.

Typical logic voltage levels for the t.t.l. gate<sup>1</sup> are  $V_{OUT(1)} = 3.3$  V and  $V_{OUT(0)} = 0.2$  V (at a sink current of 16 mA). Thus when it is desired, as in the field of nuclear pulse instrumentation, to drive d.c.-terminated low-impedance coaxial cable, the outer conductor of which is earthed, a voltage-level compatibility problem arises.

The interface circuit arrangement shown inside the dashed square in Fig. 1 has proved useful for cable driving. Operation is as follows: when the input at A is at logic 0 it acts as a sink for the current in  $R$ , point B is at  $\{V_{OUT(0)} + V_{D1}\}$  and point C is at earth because,

$$\{V_{OUT(0)} + V_{D1}\} < \{V_{\gamma D2} + V_{\gamma D3} + V_{\gamma D4}\} \quad (1)$$

where  $\gamma$  indicates "threshold-of-conduction" level and  $V_{D1}$  = forward voltage drop in  $D_1$ .

When A is at logic 1, C assumes a potential  $V_0$  where,

$$V_0 = \{V - V_{D2} - V_{D3} - V_{D4}\} \times \frac{R_T}{R + R_T} \quad (2)$$

provided,

$$V_{OUT(1)} > \{V_0 + V_{D2} + V_{D3} + V_{D4}\} \quad (3)$$

Variation of  $V$  permits control of output pulse amplitude.

In the circuit used  $D_1, D_2$  are hot-carrier

diodes (Hewlett-Packard type HP5082-2301).  $D_1$  cuts off without significant carrier storage when the logic level changes from 0 to 1 permitting a flat-topped output pulse, while rapid switch off in  $D_2$  ensures no significant reverse current in  $R_T$  and hence no undershoot in the output for the reverse logic-level change.  $D_3$  and  $D_4$  are Si diodes type TMD7000 (Transitron): these are micro-versions of the closely specified SG5000 (IN4308). The noise margin,  $V_{NMO}$ , for logic level 0 is given, from equation (1), by

$$V_{NMO} = \{V_{\gamma D2} + V_{\gamma D3} + V_{\gamma D4} - V_{OUT(0)} - V_{D1}\} \quad (4)$$

Obviously  $V_{NMO}$  may be improved by adding a diode in series with  $D_2$ : this is permissible providing equation (3) is still true when allowance is made for the extra diode drop. Circuit waveforms are shown in Figs. 2 to 5. If the connection from the t.t.l. unit is short the waveform at A is clean but when the interconnection comprises, as in the present case, a length of twisted-pair reflection effects, well discussed in the literature,<sup>2</sup> are observed, as in Fig. 2. The negative portion of the waveform following the 1 → 0 transition may be reduced in amplitude by the connection of a diode, shown dotted as  $D_5$  in Fig. 1.) No trouble due to reflection occurs providing  $V_{NMO}$  is not exceeded. Figs. 3 and 4 show, on an expanded time and voltage scale, details of the leading and trailing edges of the waveform at C. Fig. 5 shows that delay-line differentiation is possible when a length of cable (RG213U) shorted at the far end is

connected to C. The magnitude of the negative-going pulse for undistorted output depends on  $V_{NMO}$ . In cases where it is desirable to use a fixed voltage supply  $V$ , the resistor  $R$  may be replaced by a variable current source, such as a suitably biased common-base transistor stage with a potentiometer in its emitter circuit.

### References

1. "Texas Instruments Semiconductor and Components Data," Book 2, 1968.
2. "Simple graphical method to determine line reflections between high-speed-logic elements". M. Abdel-Latif and M. J. O. Strutt, *Electronics Letters*, Nov. 1968, Vol. 4, No. 23, pp 496-498.

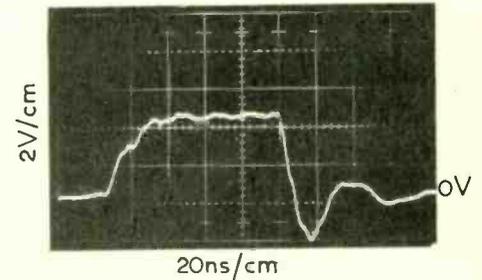


Fig. 2. Input waveform at A in Fig. 1.

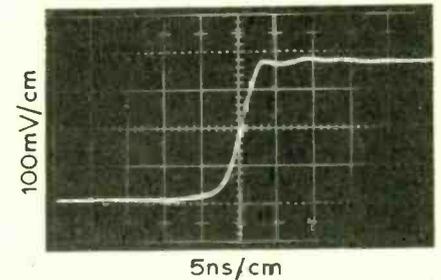


Fig. 3. Leading edge of output waveform at C.

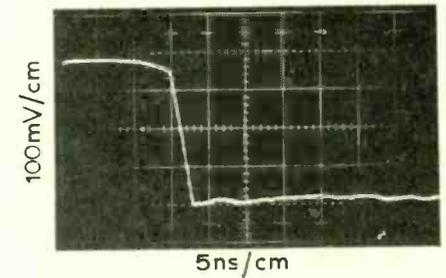


Fig. 4. Trailing edge of output waveform at C.

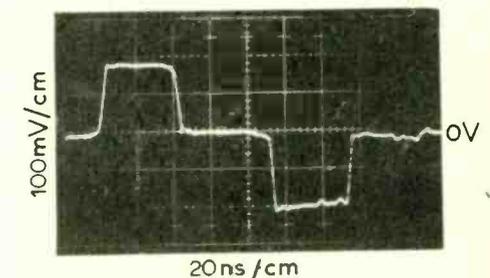


Fig. 5. Waveform at C with shorted line connected at C.

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

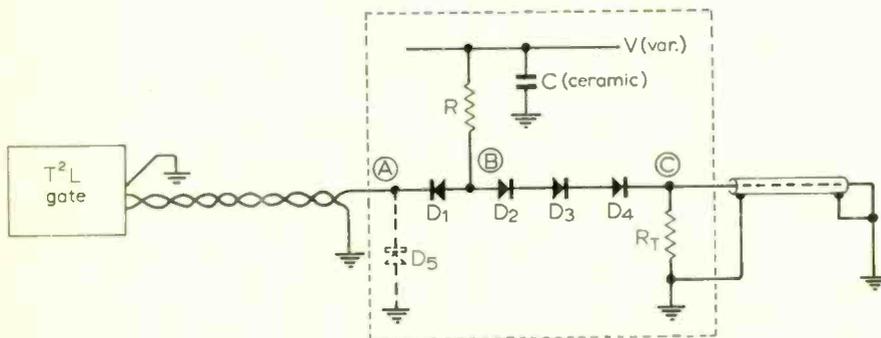


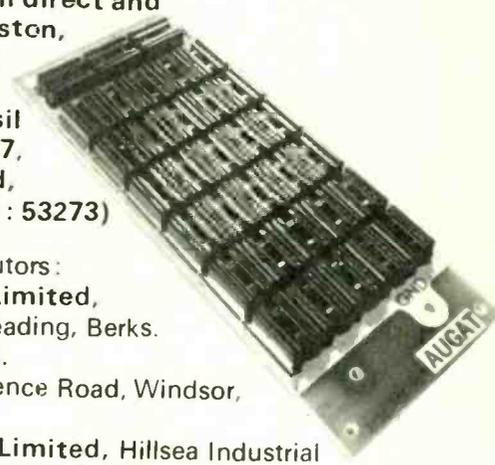
Fig. 1. Diode pulse shaper.  $D_1, D_2 =$  HP5082-2301 (Hewlett-Packard);  $D_3, D_4 =$  TMD7000 (Transitron);  $T^2L$  gate = SN7400 (Texas);  $R = 1$  k $\Omega$  (Metal Film);  $R_T = 50$   $\Omega$  B.N.C. termination.

# Packaging? 'Augat' have time-and-cost saving all wrapped up

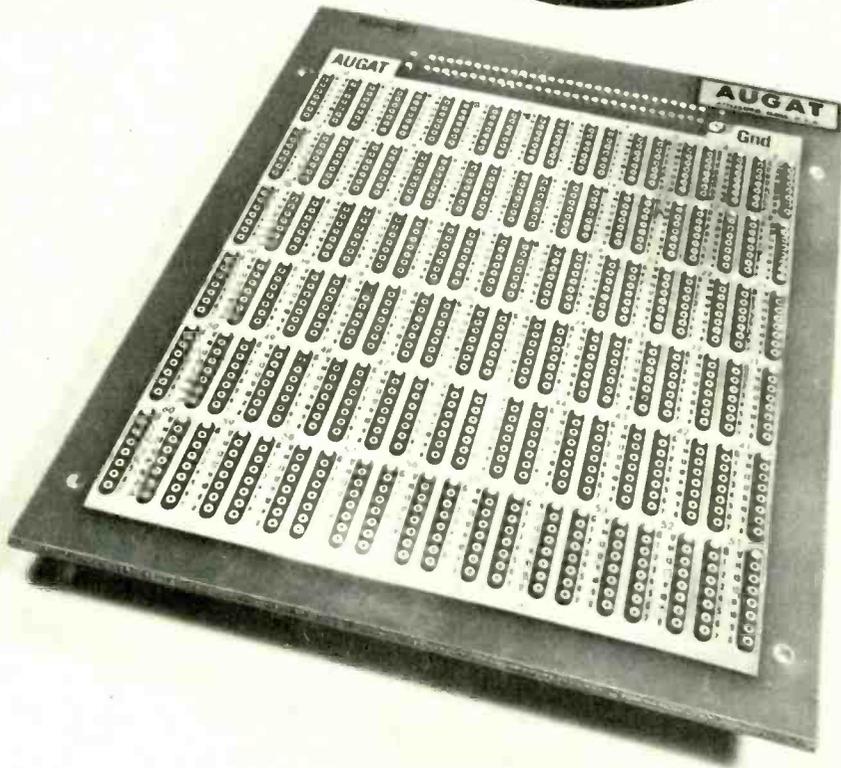
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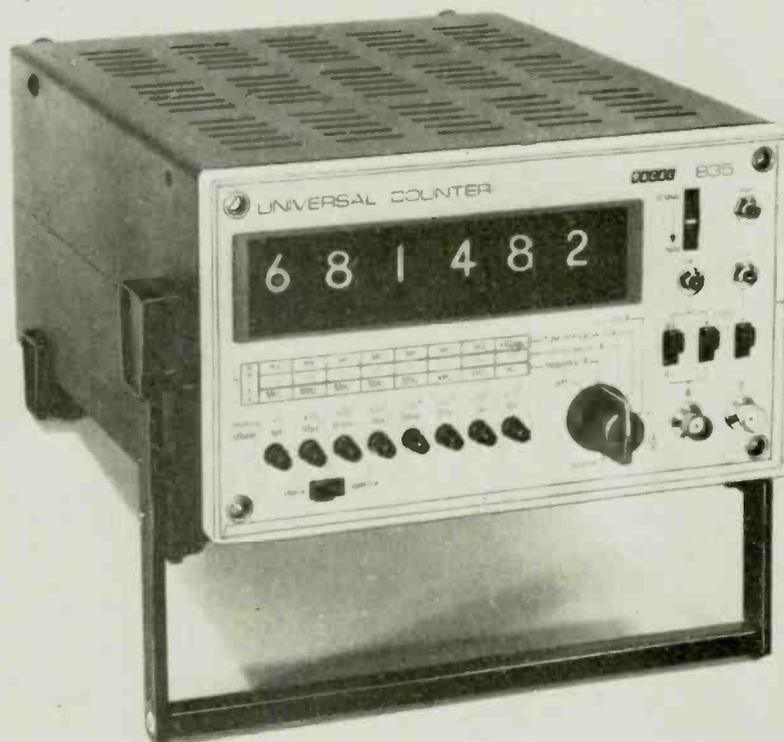
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# Letters to the Editor

*The Editor does not necessarily endorse opinions expressed by his correspondents*

## Transistor distortion characteristics

I have read with interest the article by Mr. Linsley Hood in the November issue. Mr. Hood has come to the conclusion that his amplifier stage gives more distortion for low collector currents and high  $h_{fe}$ s. He has shown 13 curves to prove his point, but he has not made any attempt to explain why the situation is so troublesome to audio pre-amplifier designers.

If we take the BC109 as an example and try to control the collector current from an ideal voltage source applied to the base, what will happen? Suppose that the transistor has the recommended quiescent point of  $I_C = 2\text{mA}$  and  $U_{CE} = 5\text{V}$  with  $h_{FE}$  and  $h_{fe}$  of approximately 300. The base current of the transistor will of course be  $I_B = I_C/h_{FE} = 2/300\text{mA} \approx 7\mu\text{A}$ .

When a voltage source of, say,  $E_s = 10\text{mV}$  r.m.s. is applied to the base, this will appear across the  $h_{ie}$  of the transistor and give a change of base current. For BC109  $h_{ie} = 4.5\text{k}\Omega$  for the mentioned quiescent point, and the change in base current will be approximately  $\pm 10\sqrt{2}/4.5\mu\text{A} \approx \pm 3\mu\text{A}$ , which is almost  $\pm 50\%$  of the quiescent base current! The collector current is of course  $h_{fe}I_b$  and will also make a 50% swing, from 1mA to 3mA.

A look at the  $h_{ie} = f(I_C)$  curve published by Telefunken shows a very great dependence. For  $I_C = 1\text{mA}$ ,  $h_{ie} \approx 9\text{k}\Omega$  and for  $I_C = 3\text{mA}$ ,  $h_{ie} \approx 3\text{k}\Omega$ , a change with a factor 3! Thus the base current will not follow a linear relationship to the source voltage, neither  $I_b = f(E_s)$  nor  $I_c = f(E_s)$  will be straight lines.

A high value of quiescent base current (low  $h_{FE}$  and/or high  $I_C$ ) will obviously make things brighter, at least as far as distortion is concerned. If this is not possible, one solution is to make certain that the change in base current comes from a current source, for example a preceding stage with high output impedance. An f.e.t. common-source stage will do admirably as it can be regarded as a voltage controlled current source if drain resistance is high compared to the  $h_{ie}$  of the following transistor.

The other solution is to use negative feedback from an un-bypassed emitter resistor  $R_e$ . This will appear (for the source voltage) as a resistance of the value  $h_{fe}R_e$  (approx.) in series with the  $h_{ie}$  and so the change of  $h_{ie}$  will be negligible if  $h_{ie} \ll h_{fe}R_e$ . This is exactly what Mr. Hood has done in circuit D of his article. He also mentions that the distortion

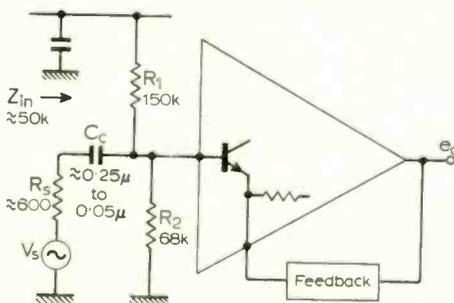
factor increases with a decrease of un-bypassed resistance. The open loop gain is said to be about 8000 and the  $47\Omega$  resistance will probably appear as a  $47 \times 8000 \approx 400\text{k}\Omega$  resistance in series with the input impedance of the first transistor.

Conclusion: The important thing for a transistor voltage amplifier stage is that  $I = f(E_s)$  is a straight line. The influence of the non-linearities of transistor input impedance should be minimized by applying a high (equivalent) resistance in the signal path of the input.

PER ENGSTRÖM, Lund Institute of Technology, Sweden.

## Noise in transistor amplifiers

While working with amplifiers using input and feedback stages similar to that outlined, a curious low-frequency noise was encountered. The amplitude and frequency were Gaussian in nature and extended from approx 5Hz to 100Hz. However, this noise was much greater than the normal wideband noise inherent in all amplifiers.



The Johnson noise contributed by  $R_s$  ( $\approx 600\Omega$ ) is fairly low. However, some noise is injected into base by transistor action; there is also a considerable amount of noise contributed by  $R_1$  and  $R_2$ . The sum of this Gaussian noise appears at the junction of  $R_1$  and  $R_2$ , so we can represent the source impedance of such a noise generator by the lowest impedance that contributes to it, i.e. parallel impedance of  $R_1$  and  $R_2$ . This is approximately  $50\text{k}\Omega$ .

This noise generator, with its  $50\text{k}\Omega$  source resistance, appears across the

reactance of  $C_c$  added to  $R_s$ . Thus one would have expected this noise to be low. However, the reactance of  $C_c$  ( $0.25\mu\text{F}$ ) rises considerably at 5–10Hz. Thereby,  $R_s$  and  $C_c$  form a shunt low-pass filter for the noise source, injecting into the amplifier all the low-frequency components arising within the Gaussian distribution of the noise.

When  $C_c$  was increased to  $10 \sim 16\mu\text{F}$ , the effect disappeared, leaving only the normal Gaussian noise. The noise level, as monitored on a peak programme meter, dropped, by  $-6\text{dB}$ , as would be expected because of the nature of the unintended filter.

It is possible to select low-noise components for  $R_1$ ,  $R_2$  and transistor but then it is always possible to secure an additional  $-6\text{dB}$  change in noise level by just increasing  $C_c$ . In fact there is then no advantage in using expensive components for  $R_1$  and  $R_2$  since trouble might later arise when they begin generating noise near end of life. Also, it is no longer possible to change  $R_1$  and  $R_2$  if one begins to use them in integrated form.

The corollary is that one would be well advised in having selected as large a value of  $C_c$  as is practicable, such that the reactance of  $C_c + R$  at 5Hz or so does not increase substantially above  $Z_{in}$  for the particular amplifier. Most high-quality amplifiers, operational amplifiers and all integrated d.c. and operational amplifiers will readily respond to 5Hz or so and since most high-input impedance stages use similar potential dividers, this factor should be carefully weighed. When  $R_s$  is comparable to  $Z_{in}$ , the problem should not arise of course.

R. THANKY,  
London N.19.

## Stereo decoder adaptor

Having seen the circuit for a stereo decoder adaptor in "Circuit Ideas" in the September issue I am prompted to send you a much simpler circuit which I have been using for several months.

Instead of having a variable gain amplifier on each channel a 0.5 attenuator is placed before the decoding matrix when a mono programme is being received. With a mono signal  $Tr_9$  saturates and earths one end of the attenuator chain formed by the two  $10\text{k}\Omega$  resistors. Thus only half the mono sign is applied to the matrix. On stereo  $Tr_9$  is off and the full signal is applied to the matrix. The  $100\text{k}\Omega$  resistor ensures that the  $1\mu\text{F}$  capacitor does not have to change its charge when going from mono to stereo.

A. ROYSTON,  
University of Warwick,  
Coventry.

## Local radio

In the reference to local radio in your November Editorial you say "While the use of such (directional) aerials would certainly avoid the stations causing interference with other transmitters sharing the frequencies, it would not eliminate interference from Continental stations". This would indeed be the case if the

operating frequencies of the proposed British Local Radio System were indiscriminately chosen, without regard to those stations which are capable of causing interference with United Kingdom transmitters.

My company has carried out exhaustive tests in many parts of the United Kingdom. These tests demonstrate that, of some twenty-five channels selected for initial evaluation, at least eleven are suitable for use in some, if not all, of the areas which would probably be served by British Local Radio. In addition, these channels would be available under the terms of Article 8\* of the Copenhagen Convention.

Using no more than eight of the channels it would be both technically and legally possible to operate at least one hundred low-power medium frequency stations in the British Isles, each one of which would be sixty miles from its nearest neighbour on the same frequency.

Many critics of this proposal overlook the fact that very few of the proposed stations would need to cover a service area greater than five miles in diameter. In consequence, not more than fifteen of the stations would utilize a power in excess of 1.5kW, whilst the vast majority would use 500 watts or less. (Incidentally, although 100 stations are theoretically possible, my company is of the opinion that not more than fifty would be economically viable).

The credibility of this statement is clearly demonstrated by the performance of some existing B.B.C. stations. Current B.B.C. Engineering Information Department lists show 43 low-power medium frequency stations (of 2kW or less) as operational in the United Kingdom. Between them they carry all the B.B.C. domestic services, and they all operate from early morning until about midnight. The 1484-kHz transmitter at Bournemouth is on the air from 05.00 until 02.00 the following morning. This station was opened as recently as November 1968, and it is difficult to imagine that it would have been authorized if the Engineering Department of the B.B.C. and the Broadcasting Department of the Post Office (responsible for ensuring the observance of the Radio Regulations of the International Telecommunications Union and issuing licences for the operation of transmitters) had not been satisfied that it would provide a satisfactory service within the area it was designed to serve.

The Bournemouth transmitter is of particular interest in that it uses an International Common Frequency, and, in consequence, shares this frequency with some 150 other stations throughout Europe. Nevertheless, to quote the words of the B.B.C. Engineering Information Service, "It provides a perfectly acceptable signal in the town of Bournemouth".

If further evidence were needed what better authority could be quoted than Lord Hill, Chairman of the B.B.C. who is reported as having said recently "I hope there is going to be some medium-wave reinforcement for local radio—a question we are now discussing with the Post Office Minister who has the authority for frequency allocation". His Lordship went on to say that there was some availability of medium wavelengths, and that medium frequency local broadcasting was technically possible "or we should not be

putting it to The Minister". The Director General of the B.B.C. said much the same thing two days earlier.

To sum up, providing that the main criteria of low power, suitably engineered aerial systems, and an intelligent selection of operating frequencies are observed, there is no reason to doubt that a chain of local radio stations could be established in the medium-frequency band.

DEREK FARADAY,  
Commercial Broadcasting Consultants Ltd.  
London, W.C.2.

\* This permits modifications to the European Frequency Allocation Plan provided agreement is reached between Administrations operating in the channel.—ED.

I could not agree more with your November Editorial particularly in connection with the subject raised in Mr. Uden's interesting letter appearing in the same issue.

The B.B.C. claims to offer a v.h.f. service and yet Radio 1 is always regarded as the poor relation by "Aunty".

There are several programmes transmitted only by Radio 1 which would benefit the listener if they were available on the interference-free, high-quality v.h.f. service; and yet listeners must tolerate, at best, low bandwidth audio and, at worst, high distortion and frequent fading.

Another important factor is the education, if I may use the word, of the general public; many individuals have never heard "live" music and have come to regard the m.w. "sludge" as the real thing.

We are supposed to be in an age of technical innovation and development, particularly in the field of electronics and communications, and yet an important part of our radio service is still living in the dawn era of wireless.

E. W. FIRTH,  
Saltney,  
Chester.

## Combating television interference

I read with great interest the letter from S. E. Jones, regarding the suppression of television interference, in your February 1969 issue. I was immensely happy to note that the method tried by Mr. Jones is basically the same as the one tried by me here some two years back. Since our TV receiving aerial is very near the high power s.w. transmitting centre, the intensity of the harmonic interference used to be very severe. One of the harmonics—which happened to be 240kHz below the TV carrier—was very strong and when it came up, the picture and the sound as well used to be wiped off completely. To eliminate this interference the method tried was as follows: The interfering signal was picked up from another three-element yagi and fed into a single stage v.h.f. amplifier in which the phase and gain of the harmonic could be adjusted by means of the tuning and gain controls respectively. The output of the amplifier was then fed into the television receiver input where the TV aerial was already

connected. The length and polarity of the cable from the pick-up aerial was adjusted suitably so that the amplifier tuning point is optimum, i.e., with minimum gain. Even after tuning the amplifier for best results, there used to be some faint lines on the picture of varying intensity on account of the modulation on the interfering signal. This was also reduced considerably by introducing a filter (with 12dB cut off for  $240 \pm 10\text{kHz}$ ) in series with the video input to the picture tube.

T. S. VASAN,  
Delhi,  
India.

## Tolerance!

What a consolation it was to read Mrs. Dinsdale's "Living with Hi-Fi" in the November issue! For years I had wondered if my husband was unique in involving the whole household when designing and constructing electronic equipment; but now I know there are others, the upheavals will seem more tolerable.

I can go one stage further though. Our son of 15 has "adopted" electronics and his "bed-room" is full of equipment in various stages of development. So when the air is full of talk of "pots, resistors, capacitors, etc." and conversation too highly technical for our ears, my daughter and I retire to the kitchen and prepare to "feed the brutes".

At least Mrs. Dinsdale has good music to listen to sometimes!  
MAUREEN NELSON-JONES,  
Bournemouth, Hants.

## Wireless World Diary

Clearer type, enlarged page size (75 x 128mm) and therefore larger diagrams, and a complete revision of the information in the 64-page reference section make the Wireless World Diary 1970 even more useful than its predecessors. It still has a week-at-an-opening diary section and costs 10s (leather) and 7s (rexine). It will be available on December 1st. Postage, if ordered from Dorset House, Stamford St., London S.E.1, is 4d.

# Logic Symbols

## A quick look at the new British Standard

The shapes and symbols used to portray logic functions are as varied as they are numerous. The time taken to discover what the symbols mean in any particular case can be appreciable and sometimes even then the function is uncertain.

To combat this the British Standards Institution has produced BS3939, section 21, "Pure logic and functional symbols" which drastically alters earlier British Standards on the subject to bring them in line with the International Electrotechnical Commission's proposals made at a meeting in Stockholm in September 1967.

The symbols are intended for use in any branch of logic engineering, be it electrical, electronic, pneumatic, hydraulic or mechanical.

The basic gate symbol is shown at (a) and is the half moon shape. The new symbols also show the logic convention in use at any particular point in the diagram as shown at (b) and (c). The gate shown at (a) therefore has a positive logic input and output. Mixed positive and negative logic inputs and outputs may be employed.

The symbol at (d) shows a gate with an inhibiting input (shown by the bar) and a negated output (the circle). A negated inhibiting input is shown at (e). The oblique line of (f) indicates an executive, strobe or clock input. The five basic functions AND, OR, NAND, NOR, NOT are shown at (g) to (k). The symbol of (l) is an identity element, or equivalence element, where the output represents "1" only when all the inputs are also "1".

Multistable elements have a square for each stable state, so the symbol at (m) is a bistable. It has one input. The application of a "1" at this input would cause a "1" output from the upper square. The input lines can be drawn with the same negating and inhibiting symbols as used for the gates. A stepping input is shown at (o). Outputs are drawn from the appropriate squares as illustrated at (p). A quasi stable state is portrayed as a shaded triangle and *t* is the quasi stable duration. For distributed OR or AND connection the symbol is the diamond of (r) with a "1" or "&" adjacent to the diamond as appropriate.

The BS states that large blocks of logic may be denoted by a suitably labelled square with appropriate inputs and outputs. We have devised our own two; (s) is used at the very beginning of a system design and (t) is often appropriate a little later on!

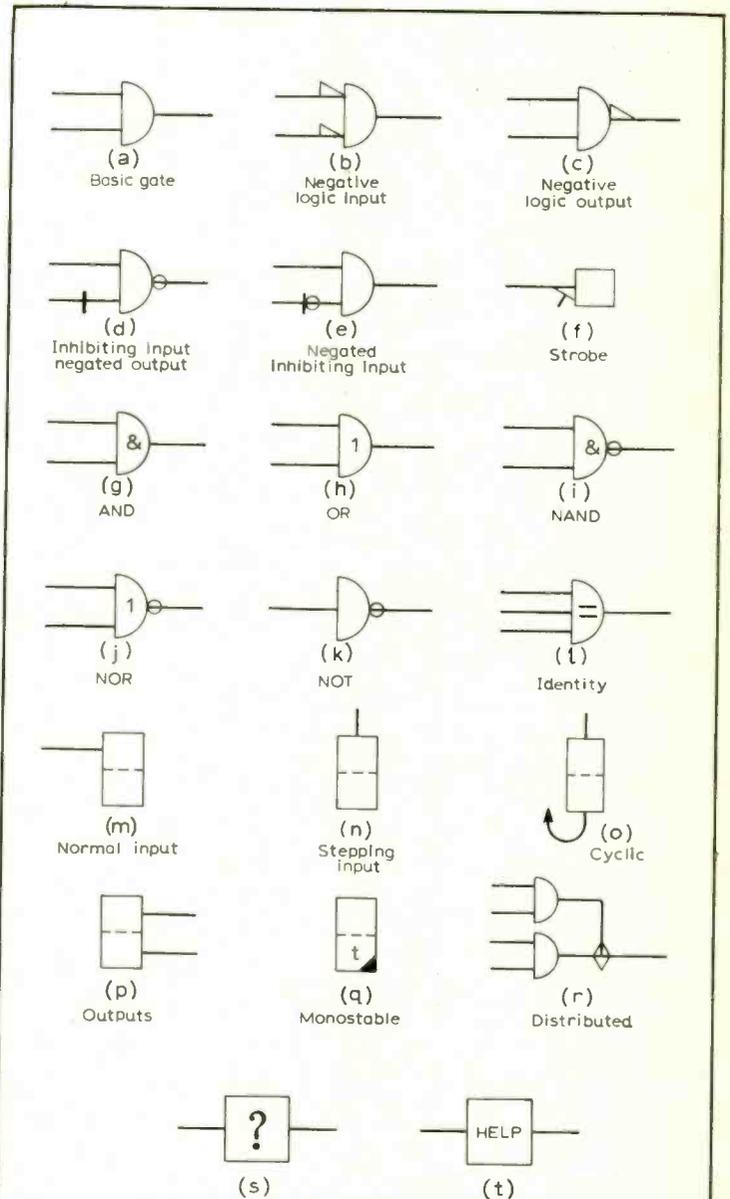
The identification of signal lines follows what is now accepted as almost standard practice. The signal name should relate to the "1" state of that signal and a bar placed over the signal name refers to the logic negation of the signal.

e.g.  $\overline{\text{SUM}}$  = the logic negation of SUM.

This labelling is the subject of only one limitation, the NAME and NAME labels must not be used to indicate the two states of the same signal at different times.

This has been just a quick look at BS3939, Sect. 21. For more information the BS is available from the British Standards Institution, 2 Park St., London W.1, price 12s.

BEGINNING



Some of the new logic symbols are shown above and it can be seen that these differ a good deal from the earlier standard which used a circle as the basic gate symbol. The only change that is really likely to cause confusion is the use of the bar, in gate symbols, to represent inhibition instead of negation as was done earlier. It would be a good idea if manufacturers would, in addition to adopting the new standard, agree as to which logic convention should be used to specify the function their components perform.

# Active Filters

## 5. An integrator and a lag in a loop

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

Practical circuits for realising the theoretical schemes discussed in Part 4 will use feedback in one form or another to stabilize amplifier gain. One of the simplest arrangements for a 2nd-order filter is a feedback loop containing an integrator and a lag, and in many cases this allows a circuit using only one amplifier.

Analysis shows, however, that high *Q* factor calls for a wide spread of capacitance values (or *CR* products) and high amplifier gain. In general, therefore, the arrangement is most suitable for low *Q* factors.

### Shunt feedback—the virtual earth principle

When the amplifier is sign-reversing, negative feedback can be applied by the "see-saw" arrangement of impedances shown in Fig. 1. As *A* tends to infinity the driving voltage at the input of the amplifier,  $-V_o/A$ , tends to zero. This leads to the concept of the virtual earth and the idealized relationship

$$\frac{V_o}{Z_o} = -\frac{V_1}{Z_1} \quad \text{or} \quad \frac{V_o}{V_1} = -\frac{Z_o}{Z_1} \quad (1)$$

If  $Z_o = Z_1$  the magnitude of the overall gain is unity, and the circuit gives the superficial appearance of being an example of 100% feedback. The correct analysis, however, is that the feedback fraction  $\beta = Z_1/(Z_o + Z_1)$ , and that because of "potting down" by the same two impedances the effective input voltage is  $V_1 Z_o / (Z_o + Z_1)$ .

When a second input channel is added  $V_1$  and  $V_2$  are summed, ideally, according to the equation

$$V_o = -\left\{ \frac{Z_o}{Z_1} V_1 + \frac{Z_o}{Z_2} V_2 \right\} \quad (2)$$

### Finite gain

When allowance must be made for the finite gain of a practical amplifier the equivalence shown in Fig. 2 can be used. This result is established by finding the shunt impedance to earth which makes the input current *i* the same for the two versions of the circuit.

It can be seen that to a first approximation

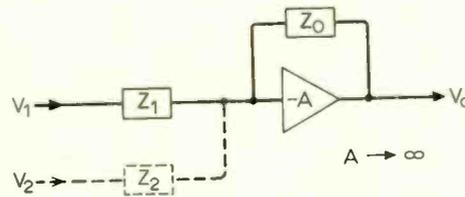


Fig. 1. Basic arrangement for applying feedback and adding signals by the shunt or virtual-earth method

the overall gain of a shunt-feedback circuit will be affected by finite amplifier input impedance only if this is comparable with the equivalent shunt impedance  $Z_o/(A + 1)$ . The correct analysis of the circuit outlined in the preceding section, however, shows that the operation of the circuit is seriously affected (in zero drift, signal/noise ratio, linearity, for example) if the amplifier input impedance is equal to or less than the net parallel value of  $Z_o, Z_1, Z_2$ , etc., (Fig. 1), and in general this is a condition to be avoided.

### Lag-and-integrator loop

In Part 1 under the heading *direct synthesis* it was shown that the response of the second-order low-pass network, Fig. 3(a), can be reproduced by an active system containing a lag and an integrator in a feedback loop; i.e. (when  $\beta = -1$ )

$$G(p) = \frac{\mu}{1 + \mu} = \frac{1}{1 + \frac{1}{q}pT + p^2T^2} \quad (3)$$

if

$$\mu = \frac{1}{1 + qpT} \cdot \frac{1}{pT/q} \quad (4)$$

### Blumlein (or Miller) integrator

The most familiar electronic integrator is the feedback type shown in Fig. 4(a). From eqn. (1), when  $A \rightarrow \infty$ ,

$$\frac{V_o}{V_i} = -\frac{1}{pCR} = -\frac{1}{pT} \quad [T = CR] \quad (5)$$

There is, therefore, for the lag-and-integrator loop shown in Fig. 3(b) a minus sign in front of the expression for  $\mu$ , and the loop is closed in the correct sense by adding  $V_{out}$  to  $V_{in}$ . The boxes in the diagram are

intended to indicate that the several parts of the loop are effectively isolated by buffers.

The internal gain of an integrating amplifier limits the performance of an active filter. The equivalent circuit, Fig. 4(b), shows that when allowance is made for finite amplifier gain the integrator degenerates to a simple lag, time constant  $(A + 1)CR$ , multiplied by the gain factor *A*; i.e.

$$G(p) = \frac{A}{1 + (A + 1)pCR}$$

$$G(\omega) = \frac{A}{1 + (A + 1)j\omega CR} \quad (6)$$

A perfect integrator,  $G(p) = 1/pCR$ ,  $G(j\omega) = 1/j\omega CR$ , gives a constant phase

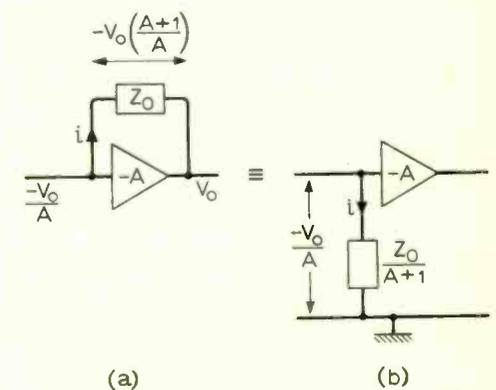


Fig. 2. Mathematical equivalent of an amplifier with a shunt feedback impedance

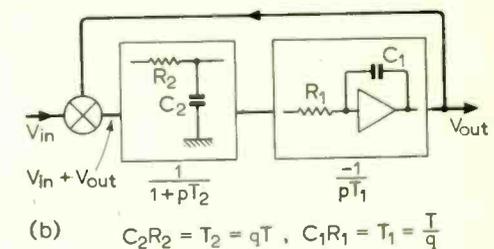
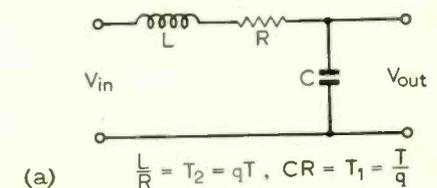


Fig. 3. (a) a 2nd-order passive low-pass network; (b) an active equivalent, a lag-and-integrator loop

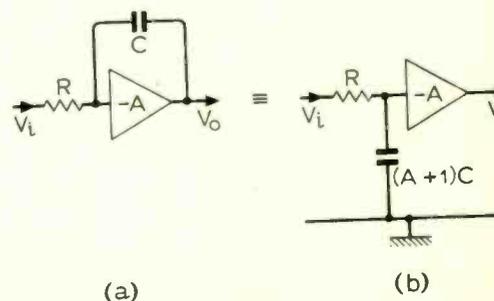


Fig. 4. The equivalence shown in Fig. 2 applied to a Blumlein feedback integrator

\*Royal Radar Establishment.

shift of 90°, and an amplitude response that falls indefinitely at -6 dB/octave from zero frequency to infinite frequency and passes through  $|G(j\omega)| = 1$  at  $\omega CR = 1$ . The "curves" numbered (1) in Fig. 5 correspond. The gain of an imperfect (finite-gain) integrator levels off at low frequency to the value  $A$ , and equn. (6) shows that the phase shift falls short of 90° by  $\theta$ , given by

$$\tan\theta = 1/\omega(A+1)CR \quad (7)$$

Thus when  $A \gg 1$ , at the approximate unity-gain frequency  $\omega = 1/CR$ ,  $\theta = 1/(A+1) = 1/A$  approx., and below this frequency  $\theta$  increases (i.e., the phase shift  $\phi$  decreases) until at zero frequency  $\phi = 0$ . These characteristics are indicated in Fig. 5 by the curves numbered (2).

**The Q factor of an integrator**

Finite gain is to an integrator the equivalent of series resistance to an inductor or

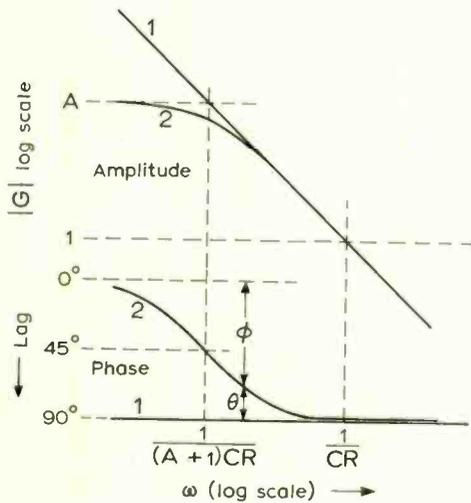


Fig. 5. Amplitude and phase curves for an ideal integrator (1), and a finite-gain integrator (2)

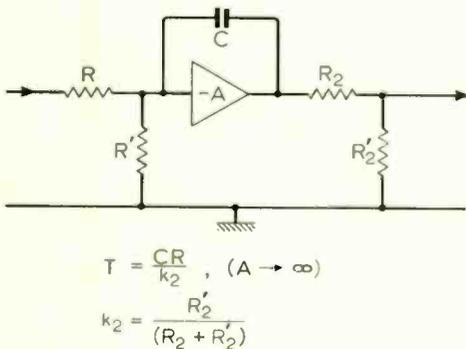


Fig. 6. Showing loss of effective gain by passive attenuation

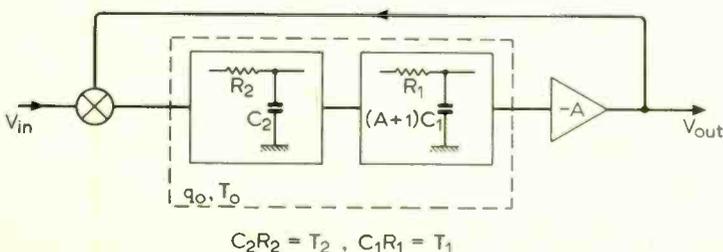


Fig. 7. The two-lags-and-gain equivalent of a lag-and-integrator loop with finite gain integrator

parallel resistance to a capacitor, and similarly limits the Q factor that can be obtained in a resonant loop. Also similarly the quality of an integrator can be defined as the ratio of the part of the output in quadrature with the input to the part in phase. Hence, from equns. (6) and (7)

$$Q = 1/\tan\theta = (A+1)\omega CR \approx A\omega CR, \quad (8)$$

and it is useful to notice that at  $\omega = 1/CR$

$$Q = A+1 \approx A. \quad (9)$$

In a lag-and-integrator loop, however, the undamped resonant frequency  $\omega_c = 1/qCR$ ; i.e., a frequency  $q$  times below the unity gain frequency of the integrator (equn. (4)). The effective Q factor of the integrator in such a loop is therefore  $A/q$  approx., which  $< A$  when  $q > 1$ .

The potential zero-frequency loop gain  $A$  is often in practice eroded by the presence of attenuating networks. Fig. 6 shows that these may be of two types, exemplified by  $R'$  acting in conjunction with  $R$ , and by a network such as  $R_2', R_2$  outside the integrator feedback loop. Both reduce the zero-frequency gain—by factors  $k_1 = R'/(R+R')$  and  $k_2 = R_2'/(R_2+R_2')$  respectively—and so reduce  $Q$  by these factors.  $R'$  may represent the input resistance of a transistor amplifier, and it is important to note that there is a serious reduction in  $Q$  if  $R \gg R'$ .

By applying Thévenin's theorem, or otherwise, it is easily found that in the ideal case,  $A = \infty$  (and  $k_1 > 0$ ), the presence of  $R'$  leaves the voltage transfer ratio unaltered,  $1/pCR$ , and therefore has no effect on tuning. The presence of  $R_2', R_2$ , on the other hand, directly affects the open-loop transfer function, and in the ideal case is equivalent to having in the loop an integrator with

$$G(p) = -k_2/pCR. \quad (10)$$

Comparison with  $G(p) = -1/pT$  gives  $T = CR/k_2$ ; i.e., the "T" of the integrator is multiplied by  $1/k_2$ . The effect of  $k_1$  and  $k_2$  on tuning in the presence of finite  $A$  is dealt with in a later section.

**Effect of finite gain in a 2nd-order loop**

Substituting the equivalent form, Fig. 4(b), of a finite gain integrator for the ideal integrator in Fig. 3(b) gives Fig. 7, which shows the equivalence to a two-lag loop with negative gain, and the results obtained in Part 4 can be applied. In particular, the open-loop  $q_0$  is increased by the factor  $\sqrt{(A+1)}$ ,

$$q = q_0(A+1)^{1/2} \quad (11)$$

and since for two buffered lags the maximum value of  $q_0$  is  $1/2$  (obtained when the two time constants are equal, i.e.,  $(A+1)T_1 = T_2$ )

$$q_{max} = \frac{1}{2}(A+1)^{1/2}. \quad (12)$$

In general,  $q_0$  is given by substitution in equn. (4), Part 3, as

$$\frac{1}{q_0} = \left(\frac{(A+1)T_1}{T_2}\right)^{1/2} + \left(\frac{T_2}{(A+1)T_1}\right)^{1/2} \quad (13)$$

and therefore, from equn. (11),

$$\frac{1}{q} = \left(\frac{T_1}{T_2}\right)^{1/2} + \frac{1}{A+1} \left(\frac{T_2}{T_1}\right)^{1/2} \quad (14)$$

Thus the ideal value of  $q$  (the value when  $A \rightarrow \infty$ ) is given by

$$\frac{1}{q_i} = \left(\frac{T_1}{T_2}\right)^{1/2}, \quad (15)$$

and equn. (14) may be written

$$\frac{1}{q} = \frac{1}{q_i} + \frac{q_i}{A+1} \quad (16)$$

Now the undamped resonant frequency  $\omega_c = 1/T = 1/q_i T_1$  (see equn. (4) and Fig. 3), and substitution in equn. (8) shows that  $(A+1)/q_i$  is the Q of the integrator at  $\omega_c$ . Hence

$$\frac{1}{q} = \frac{1}{q_i} + \frac{1}{Q \text{ of integrator}}. \quad (17)$$

And as at  $\omega_c$  the frequency-response function of the lag  $= 1/(1+jq_i)$ ,  $q_i$  may be identified as the Q of the lag at  $\omega_c$ . Equn. (16) may therefore be further rewritten as

$$\frac{1}{q} = \frac{1}{Q \text{ of lag}} + \frac{1}{Q \text{ of integrator}} \quad (18)$$

This is an example of the general principle that circuit losses add directly, and that hence Qs add by reciprocals. The principle is very useful for finding the Q factor of practical circuits, especially when the alternative involves handling a long and cumbersome transfer function.

In practical circuits  $A$  is usually  $\gg 1$  and is not known precisely. There is then no sensible distinction between  $A$  and  $(A+1)$ . It seems unnecessary, however, in the algebra constantly to refer to this approximation.

The solution to equn. (16) gives the value of  $q_i$  that has to be set in to the design to achieve the desired value of  $q$ ,

$$\frac{1}{q_i} = \frac{1}{2q} \left\{ 1 \pm \left( 1 - \frac{4q^2}{A+1} \right)^{1/2} \right\}. \quad (19)$$

Fig. 8, which is a plot of  $q$  against  $(T_2/T_1)^{1/2}$ , i.e. against  $q_i$ , with  $A$  as parameter, clarifies the relationship. For the moment only positive values of  $A$  (negative values of amplifier gain,  $-A$ ) are of interest; i.e., that part of Fig. 8 below the diagonal representing  $A = \infty$ . For  $4q^2 < (A+1)$ , i.e.  $q < q_{max}$ , equn. (19) gives two real values of  $q_i$ ; but the value given by taking the negative value of the square root should not be used as it corresponds to the region beyond the point where  $q_{max}$  has been reached, and in this region  $q$  is very sensitive

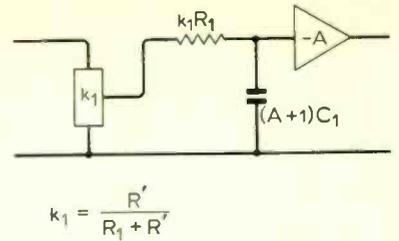
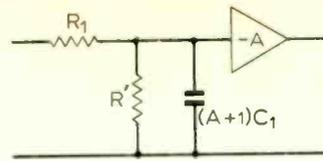
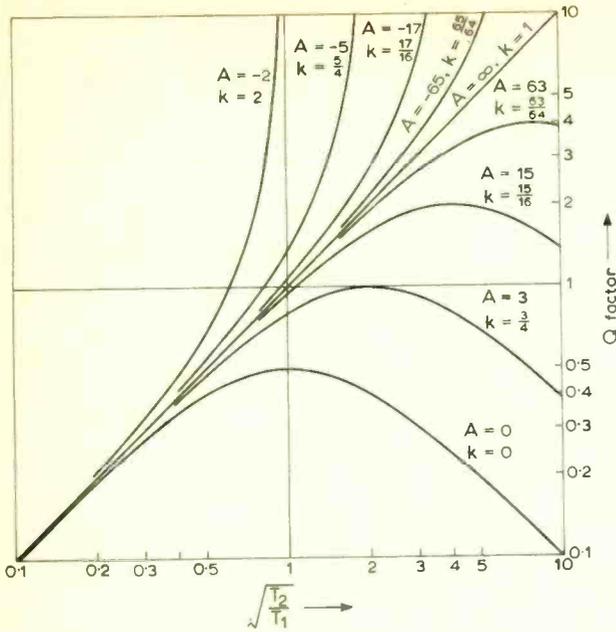


Fig. 9. Equivalent circuits for the integrator when the amplifier has finite gain and input resistance

(Left) Fig. 8. Illustrates equn. (16). Shows the effect of internal gain,  $A$ , and the ratio,  $T_2/T_1$ , on the  $Q$  factor of a lag-and-integrator loop

to changes in  $A$ . Indeed "designable" circuits, which can accommodate large uncertainties in the value of  $A$ , should use values of  $A$  which give  $q$  close to  $q_1$ .

Fig. 8 will be recognised as a duplicate of Fig. 9 of Part 4, the parameters  $A$  and  $K$  being related by

$$K = A/(A + 1), \quad (20)$$

which gives

$$A = K/(1 - K); \quad (21)$$

and this foreshadows an important identity that will be proved later in the analysis of the Sallen-and-Key circuit.

### Effect of finite gain on $T$

In the basic lag-and-integrator loop shown in Fig. 3(b), and in equivalent form in Fig. 7,  $T (= 1/\omega_c)$  is not affected by  $A$ . The open-loop transfer function is

$$\frac{A}{(1 + pT_2)\{1 + p(A + 1)T_1\}}$$

and so  $T_0 = \{(A + 1)T_1T_2\}^{1/2}$ . But, as shown in Part 4, closing the loop divides  $T_0$  by  $(A + 1)^{1/2}$ . Hence closed-loop  $T = (T_1T_2)^{1/2}$  and is independent of  $A$ . If, however, there is attenuation  $k_2$  in the loop as given by  $R_2', R_2$  in Fig. 6,

$$T = \frac{(A + 1)T_1T_2^{1/2}}{k_2A + 1}$$

and so

$$\omega_c^2 = \frac{k_2}{T_1T_2} \left\{ 1 + \frac{1 - k_2}{k_2(A + 1)} \right\} \quad (22)$$

Similarly for attenuation by  $R', R_1$  (Fig. 9), although  $k$ , does not does not give a large change in  $\omega_c$

$$T_0^2 = k_1(A + 1)T_1T_2 \quad (23)$$

and so, since

$$T^2 = T_0^2/k_1(A + 1)$$

$$\omega_c^2 = \frac{1}{T_1T_2} \left\{ 1 + \frac{1 - k_1}{k_1(A + 1)} \right\} \quad (24)$$

### Sensitivity to component values

For the passive LCR network, Fig. 3(a), the parameters  $T$  and  $q$  are defined by

$$T = (LC)^{1/2} \text{ and } q = \frac{1}{R} \left( \frac{L}{C} \right)^{1/2} \quad (25)$$

For the ideal active system ( $A \rightarrow \infty$ ), Fig. 3(b),

$$T = (C_1R_1C_2R_2)^{1/2} \text{ and } q = \left( \frac{C_2R_2}{C_1R_1} \right)^{1/2} \quad (26)$$

Thus, by inspection of equns. (25) and (26), any variations in  $C_1$  and  $C_2$  have the same effect as variations in  $L$  and  $C$  respectively. Considering the arbitrary situation where  $R_1$  and  $R_2$  are in error in opposite directions and become, say,  $xR_1$  and  $R_2/x$ , there is no change to  $T$  and the effect on  $q$  is the same as if  $R$  changed to  $xR$ . On the other hand, if  $R_1$  and  $R_2$  are in error in the same direction and become  $xR_1$  and  $xR_2$ , there is no change to  $q$  but  $T$  becomes  $xT$ ; i.e., the effect is the same as if  $L$  and  $C$  change to  $xL$  and  $xC$ . Other situations lie somewhere between, so it may be concluded that the active system behaves in an essentially similar manner to the passive prototype.

### Effect of parasitic phase lags

The effect of additional lags in the loop can be deduced from the Bode plots (i.e., the amplitude and phase plots of  $\mu\beta$ ), and in many practical cases a simple addition of phase angles at the frequency of unity loop gain gives sufficient information.

The curves numbered (1) in Fig. 10 represent the loop gain of an ideal integrator-and-lag loop of arbitrary  $q$  (2 approx. in the Fig.), and the curves numbered (2) and (3) the individual characteristics of the lag and of the integrator respectively. For the moment the additional lag, curve (4), is ignored. As  $q$  increases the curves for the lag and the curves for the integrator move further apart, those for the lag towards lower frequencies and those for the integrator towards higher frequencies; and

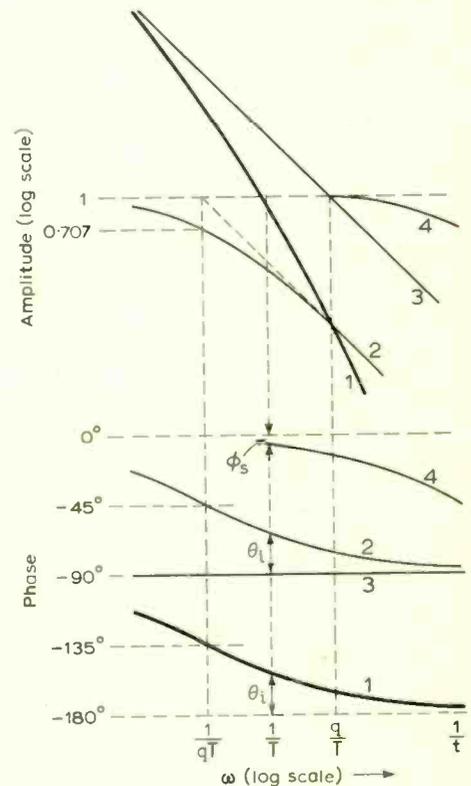


Fig. 10. Amplitude and phase curves, open loop

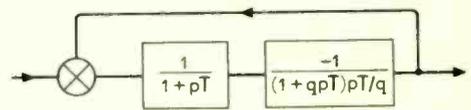


Fig. 11. System when extra lag, time constant  $t$ , is introduced into the loop

the amplitude curve of the loop characteristic moves nearer to the level 1 at  $\omega = 1/T$ .

Now since the integrating amplifier gives a sign reversal, the critical phase lag for the loop is  $180^\circ$ ; and in the ideal case, since the phase lag of the integrator is a constant  $90^\circ$ , the angle  $\theta$  by which the loop phase shift falls short of  $180^\circ$  is the angle by which the phase shift of the lag falls short of  $90^\circ$ , and is therefore given by  $\tan \theta = 1/\omega T_2 = 1/\omega q T$ . Hence at the approx. unity-loop-gain frequency  $\omega_c = 1/T$

$$\tan \theta = 1/q, \quad (27)$$

which gives, as examples, the following pairs of values of  $q$  and phase margin:  $q = 1, \theta = 45^\circ$ ;  $q = 2, \theta = 26.5^\circ$ ;  $q = 10, \theta = 5.7^\circ$ ; etc. For high values of  $q$ , at  $\omega_c$

$$\theta \text{ (in radns)} = 1/q \text{ approx.} \quad (28)$$

Consider now the introduction of a small additional lag, time constant  $t$ , into the loop as shown in Fig. 11. This adds the curves (4) to Fig. 10. It is a characteristic of a simple lag (Figs. 3 and 4, Part 2) that a significant phase shift appears at frequencies where there is still little fall in the amplitude response. Thus, for example, at (corner frequency)/10 the gain is 0.995, while the phase lag is already  $5.7^\circ$ ; and even at (corner frequency)/2, where the phase lag is  $26.5^\circ$ , the gain has only just fallen below 0.9. Therefore, since in a practical filter the additional phase lag must be small if the filter is to be "designable", it is reasonable to assume that for any such lag the time constant  $t \ll T$ , and that in the critical region around  $\omega_c (= 1/T)$  only the phase shift of the additional lag need be considered.

This will be

$$\phi_s \approx t/T \text{ radns approx.}, \quad (29)$$

and the net phase margin will be

$$\theta_m = \theta_i - \phi_s = \frac{1}{q_i} - \frac{t}{T} \quad (30)$$

where  $\theta_i$  and  $q_i$  are the ideal values; i.e., the values when there is no additional lag. The trend of the Nyquist plots for conditions where the above analysis is valid is shown in Fig. 12.

Stability in a mathematical, or Nyquist, sense requires that  $t < T/q$ . Stability in the engineering, or everyday, sense of ensuring a stable effective  $q$  will generally require that  $t \ll T/q$ , so that the unwanted phase lag is small compared with the intended phase margin; but if the circuit is such that  $t$  is known with some precision, then  $q_t$  may be reduced to compensate. Several additional lags of time constants  $\ll T$  may be added and treated as one

$$\Sigma \phi_s = (t_1 + t_2 + \dots)/T \quad (31)$$

A lag internal to an amplifier is effectively divided by the zero-frequency gain around the local feedback loop. Thus in an integrator, if the amplifier is stabilized with a single dominant lag of time constant  $\tau$ , there is added phase shift approximately equivalent to an additional lag of time constant  $\tau/A$ . This explains why an operational amplifier, z.f. gain = 3,000 (say), which when stabilized shows a corner frequency at 100 Hz, can be suitable for use in a filter with corner, or resonant, frequency at some thousands of Hz, provided the stabilization does not seriously affect the output available at these frequencies. There is also an increase in the effective  $CR$  product equal to  $1/\omega'$ , where  $\omega'$  is the frequency where the amplifier characteristic crosses unity gain. But this is unlikely to be of importance except in a high- $q$  circuit.

The summation of phase angles described above is virtually an extension of the summation of the reciprocals of  $Q$ -factors given in eqn. (17), and when the approximations given apply, the net phase margin is given by

$$\frac{1}{q} = \frac{1}{q_i} + \frac{1}{Q} - \sum \frac{t}{T} \quad (32)$$

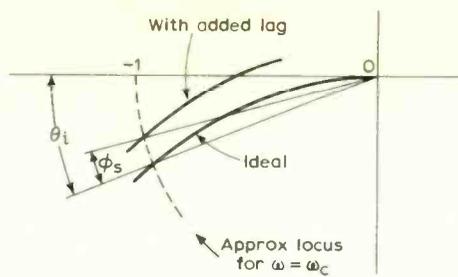


Fig. 12. Shows trend to Nyquist plots when the additional phase angle  $\phi_s \ll \theta_i$ , the ideal phase margin

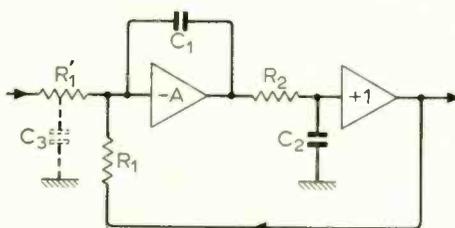


Fig. 13. Integrator-and-lag circuit using two amplifiers

At low frequencies where stray capacitance is low compared with the working capacitances, unwanted lags are of little account; especially when simple amplifiers are used which need little or no Nyquist stabilization, and when  $q$  is moderate or low and there is a comfortable phase margin. The circuit is in any case not very suitable for high  $q$ . When high-gain amplifiers are used, however, it is likely that except at very low frequencies the maximum practical value of  $q$  will be set by unwanted lags, and that the value will fall with increase in  $\omega_c$ .

### Implementation

An obvious way of setting up an integrator-and-lag loop is shown in Fig. 13. With present-day amplifiers, and with  $R_1 = R_1'$ , the nominal zero-frequency loop-gain may be 5,000; which gives  $q(\text{max}) = 35$ , a nominal 10% loss of  $q$  from finite amplifier gain for  $q \approx 20$ , and a 1% loss for  $q \approx 7$ . For 3rd-order response a lag can be introduced by tapping  $R_1'$  and connecting a capacitance to earth. With the tap at the centre this lag has time constant  $= C_3 R_1'/4$ .

If  $R_1'$  is removed, the virtual earth at the input of the integrator provides a natural low-impedance node for current input. Provided the source resistance  $R_s \gg R_1$  the z.f. loop gain  $\rightarrow A$ , and the benefits of high internal gain with almost 100% feedback are obtained. If an extra lag is to be used to give a 3rd-order filter, it must now be placed after the resonant loop. It should be remembered that for frequencies below cutoff most of the input current flows through  $R_1$ , and at frequencies above cutoff through  $C_1$ . The latter point is important if out-of-band currents of considerable magnitude must be accepted—for example carrier frequency and harmonics from a rectifier—and it is essential that the output of the integrating amplifier should accept such currents without overload.

Whatever the economic and other advantages of silicon integrated circuits, it

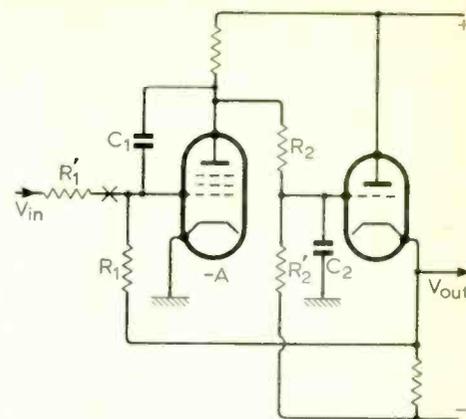
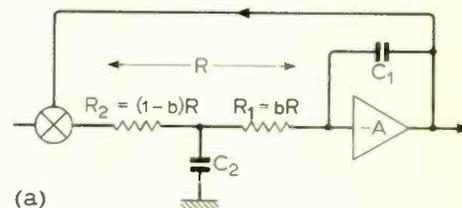
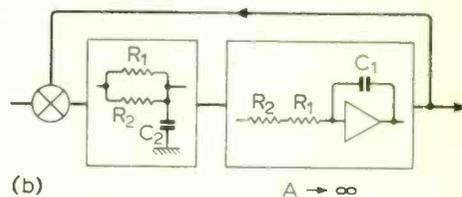


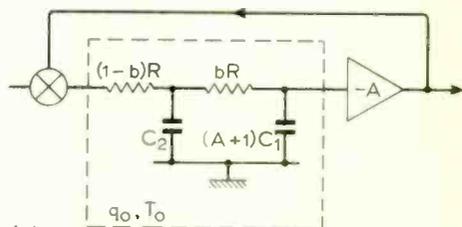
Fig. 14. Representative of simple circuits possible for low  $q$  applications



(a)



(b)



(c)

Fig. 15. (a) loop with lag and integrator not isolated by a buffer; (b) equivalent circuit when  $A = \infty$ ; (c) equivalent circuit when  $A < \infty$

may still be useful to point out that technically for low- $q$  applications there is no need for very-high-gain amplifiers; and Fig. 14 shows a circuit used by the authors before the days of the transistor, which illustrates most of the principles involved. A typical application was following a phase-sensitive detector of current-output type, when the input current was taken straight to point X.

The ideal design equations are:

$$T_2 = qT = k_2 C_2 R_2 \quad (33)$$

where

$$k_2 = R_2' / (R_2 + R_2'); \quad (34)$$

$$T_1 = T/q = C_1 R_1 / k_2. \quad (35)$$

The z.f. loop gain (if  $R_s \gg R_1$ ) is  $k_2 A$ , so

$$q_{\text{max}} \approx \frac{1}{2} (k_2 A)^{\frac{1}{2}}. \quad (36)$$

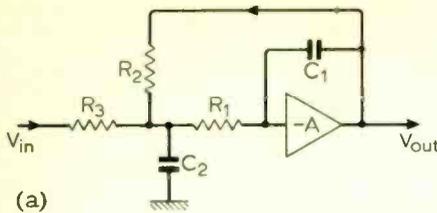
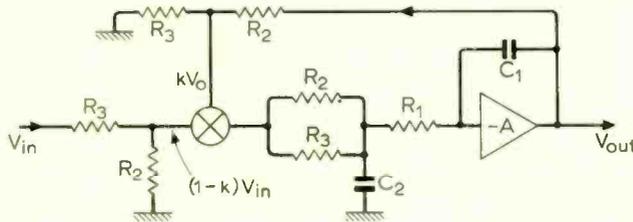
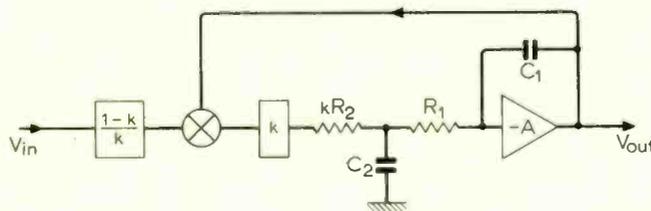


Fig. 16. (a) The Rauch circuit; (b) intermediate step leading to the equivalent circuit (c)



(b)  $k = \frac{R_3}{R_2 + R_3}$ ,  $(1-k) = \frac{R_2}{R_2 + R_3}$ ,  $\frac{1-k}{k} = \frac{R_2}{R_3}$



(c)  $T_2 = \frac{C_2 R_1 k R_2}{R_1 + k R_2}$ ,  $T_1 = \frac{C_1 (R_1 + k R_2)}{k}$   
 $\frac{V_{out}}{V_{in}} = \frac{R_2}{R_3} \frac{1}{1 + \frac{1}{q} \rho T + \rho^2 T^2}$

It is of no great consequence if the cathode-follower gain is somewhat  $< 1$ ; it merely means that the effective  $k_2$  in eqns. (35) and (36) is somewhat smaller than the  $k_2$  given by eqn. (34). When input currents of considerable magnitude must be handled, the points already mentioned must be watched.

**Lag-and-integrator loops using one amplifier**

Fig. 15(a) shows a schematic of a lag-and-integrator loop in which the integrator follows the lag, and in which the lag and the integrator are not isolated from each other by a buffer. The placing of the integrator second gives the circuit the advantage that when  $q$  is high no large voltage is built up in the middle as in the previous arrangement. A usually more important change arises from the absence of buffering: when the circuit is drawn in equivalent form as in Fig. 15(c) a 2nd-order CR network appears; and since in practice this must give  $q_0 < \frac{1}{2}$ , the complete circuit must, for a given  $A$ , give a lower  $q_{max}$  than circuits which can have  $q_0 = \frac{1}{2}$ .

When  $A \rightarrow \infty$  the equivalent circuit of Fig. 15(b) applies,

$T_1 = T/q = C_1(R_1 + R_2) = C_1 R$  (37)

and

$T_2 = qT = C_2 R_1 R_2 / (R_1 + R_2) = b(1-b)C_2 R$ . (38)

With  $A$  finite the equivalent circuit is as shown in Fig. 15(c), and eqn. (11), Part 3, gives

$\frac{1}{q_0} = \left( \frac{(A+1)T_1}{T_2} \right)^{\frac{1}{2}} + \frac{1}{b} \left( \frac{T_2}{(A+1)T_1} \right)^{\frac{1}{2}}$  (39)

and for the maximum value of  $q_0$

$q_m = \sqrt{b/2}$  (40)

The relationship  $q = q_0(A+1)^{\frac{1}{2}}$

$\frac{1}{q} = \left( \frac{T_1}{T_2} \right)^{\frac{1}{2}} + \frac{1}{b(A+1)} \left( \frac{T_2}{T_1} \right)^{\frac{1}{2}}$  (41)

Hence if  $R_1 = R_2$ , since  $b = \frac{1}{2}$ ,

$q_m = 1/2\sqrt{2}$  [when  $C_2 = 2(A+1)C_1$ ] (42)

and

$q_{max} \approx \frac{1}{2} \left( \frac{A}{2} \right)^{\frac{1}{2}}$  (43)

**The Rauch circuit**

The above analysis may be applied to the well known Rauch circuit, Fig. 16, if allowance is made for the extra attenuation of the input signal and of the feedback. The ideal ( $A \rightarrow \infty$ ) design formulae are easily derived with the help of the equivalent circuit of Fig. 14(c), following the intermediate step shown in Fig. 14(b). Commonly the circuit is arranged for unity gain at zero frequency,  $R_2 = R_3 = R$  (say).

Then, if also  $R_1 = R$  (as in the circuit for  $q = 1$  shown in Part I)

$C_1 = C/3q$  (44)

$C_2 = 3qC$  (45)

where

$C = T/R$ .

With finite gain, and  $R_1 = R_2 = R_3$ , the z.f. loop gain is  $A/2$  (if there are no other resistances in shunt from the virtual earth to ground) and  $b = \frac{2}{3}$ . This gives

$q_m = \left( \frac{1}{6} \right)^{\frac{1}{2}}$  (46)

and

$q_{max} \approx \left( \frac{A}{12} \right)^{\frac{1}{2}} = \frac{1}{2} \left( \frac{A}{3} \right)^{\frac{1}{2}}$  (47)

**Conferences and Exhibitions**

Further details are obtainable from the addresses in parentheses

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**Reliability in Electronics**  
 (I.E.E. Savoy Place, London W.C.2.)

**OVERSEAS**

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 (Madeline M. Henderson, Center for Computer Sciences and Technology, National Bureau of Standards, Room B226-Inst., Washington, D.C. 20234).

Dec. 8-9 Chicago  
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 (C. Hepner, Zenith Radio Corp., 6101 W. Dickens Ave., Chicago, Ill. 60639)

Dec. 8-10 Chicago  
**National Electronics Conference and Exhibition**  
 (N.E.C., Oakbrook Exec. Plaza 2, 1121 W. 22 St., Oak Brook, Ill. 60521)

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**Applications of Simulation**  
 (P. J. Kiviat, Simulation Assoc. Inc., 10884-Santa Monica Blvd., L.A. Calif.)

Dec. 8-10 San Francisco  
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 (R. A. Rohrer, Fairchild Semiconductors, 4001 Junipero Serra Blvd., Palo Alto, Calif.)

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**Application of Magnetism in Bio-engineering**  
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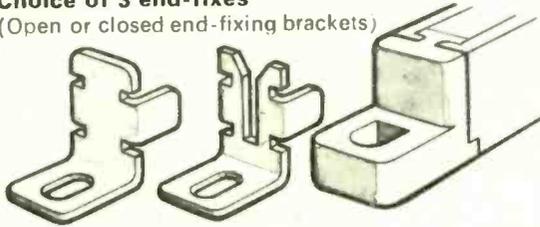
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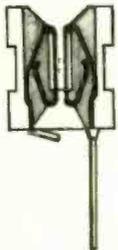
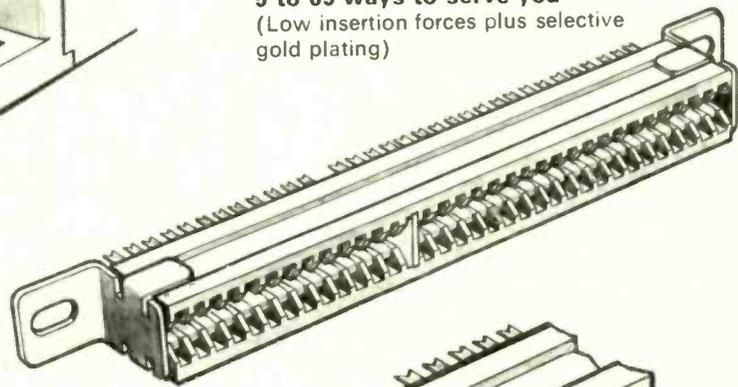


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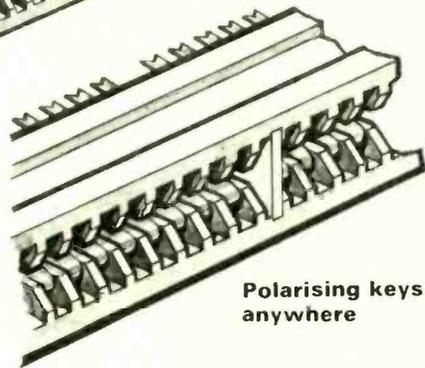
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# London's Audio Fair

## A look at the arrangements and a selection of products

This year's London Audio Fair which was held at Olympia for the first time can, and will, be rated a great success. Although tiring and nerve-racking the experience for any audio enthusiast—a genus, not a species remember—must have been exhilarating. As usual engineering personalities associated with complex and expensive equipment designs or with revered articles in learned journals were there in the flesh—not aloof, detached, and unavailable, but marshalling the columns, patiently answering any number of naïve questions, and generally sweating and swearing like the rest of us.

All in all there was a democratic fellowship, a commonality of single purpose, and the circumstances which can so thoroughly humanize are beyond praise, but deserve careful analysis.

The category audio enthusiast, we have said, is a genus. Having said this we must acknowledge the countless species. The audio enthusiast may have lots of money or very little: he may build all his own equipment or buy some commercial gear: he may put performance well before appearance; etc. etc. We all know this, but two facts must be emphasized if we are to keep the audio world in perspective. First, virtually "perfect" performance regardless of cost is attainable and a very close approximation to this can be attained at much much less than the cost of typical systems of commercial equipment. Secondly, our notion of audio fidelity is not a simple instinctive response but represents a stage in our aural education, and this fact goes towards explaining the value of the Audio Fair demonstrations. The owner of equipment providing a particular grade of sound will, during his rounds, hear standards new to him. If he can assimilate the experience his notion of fidelity will be advanced and he will be at once both elated and depressed! It is worth mentioning a remark heard outside one of the demonstration rooms—"It goes down to twenty cycles so it should be a perfect loudspeaker shouldn't it?"

Each listening room measured 20 x 16 feet and was about 8 feet high. Seats were arranged to cover about half the floor area and the equipment, depending of course on the manufacturer's products, stood at the far end away from the door. Most rooms had noisy extractor fan in one corner—usually

just above the right-hand channel loudspeaker(s). A few had no fan but a permanently open door (Mordaunt-Short and Goldring) and K.E.F. had a pair of air-conditioning units which operated between sessions.

In all these demonstrations the sound was supposed to tell the story and sell the goods. Yet the rooms defeated the object of the exercise on three counts. (1) Though the walls were quite adequately insulated against outside noise the extractor fan contributed enough noise to drown ambient sounds in the programme material and thus destroyed realism. (2) Being so small and often over-full of listeners the room's cut-off frequency was rather high and thus bass performance was often disappointing. (3) The flexible walls tended to resonate at various frequencies giving unusual colouration to speakers.

The only demonstrations which got round this problem had the speakers positioned against the rear wall or had the speaker mounted in a solid framework. Goldring went a step further and employed special "monitor" units built on the transmission line principle—an inverted horn—which, unlike most speakers, gives even performance in very different circumstances.

To these criticisms—which are the reasons why visitors to the Audio Fair should not be expected to believe their ears on all occasions—must be added one more. Even if the listening rooms were acoustically excellent how could one judge, say, a new cartridge? Not, as it seems to be generally assumed, by playing it without comparison in a named system. Very few visitors to the Fair are likely to have exactly the arm/amplifier/speaker combination as that demonstrated. Perhaps the best answer is simply to have cartridges of different makes demonstrated in turn by different manufacturers in a listening room set aside for the purpose. (Any amplifier/speaker combination of good overall quality could be used.) Tape decks and even radio tuners could be compared in this way.

Apart from the live demonstrations the Audio Fair could be only an audio supermarket with the goods on view and data sheets to indicate performance.

Accepting that Olympia has proved itself able to contain multiple live demonstrations the following recommendations are made. (1) That extractor fans be housed at the end of a

tube connected to the listening room. (2) That each room be enlarged if possible to say 25 feet in length. (3) That short of having plaster-board walls, rigid panels be fixed where possible especially for demonstrations employing direct radiator loudspeakers.

In discussing new equipment that seems of especial interest it seems sensible to proceed from signal sources through to the speakers.

The M15 range of moving magnet cartridges with replaceable styli now offered by Ortofon have a frequency response of 20Hz to 20kHz  $\pm 2$ dB (20Hz to 10kHz  $\pm 1$ dB), a channel separation of 30dB (at 1kHz), a recommended stylus pressure of 1.5g, and an output of 12mV (into 47k  $\Omega$ ) from a normally recorded level. No transformer is required. A variant range, the MF15, is available for heavier duty work such as on automatic record changers and for playing 78 r.p.m. records. Metrosound (Sales) Ltd., Cartersfield Road, Waltham Abbey, Essex.

From Bang & Olufsen the Beogram 1800, a semi-automatic record-player unit, features a pickup arm with built-in bias compensation, and uses the new SP10A cartridge. The arm operates automatically on pressing a button. At the end of the record the arm lifts and the motor is automatically switched off.



Provision has been made for a pre-amplifier which is simply pushed into a slot in the base. Specification includes a wow figure of  $\pm 0.2\%$  peak and a rumble level better than 35dB below reference voltage from pickup at 10cm/s. Speeds are 45 and 33 $\frac{1}{3}$  r.p.m. with  $\pm 5\%$  fine speed adjustment. Stylus pressure is adjustable up to 3.5g. The cartridge specification includes frequency response 15Hz–25kHz  $\pm 3$ dB, channel separation better than 20dB between 500Hz and 10kHz, output of 5mV (into 47k  $\Omega$ ) at 5cm/s, compliance of  $25 \times 10^{-6}$ cm/

dyne, and recommended stylus pressure of 1g. Bang & Olufsen U.K. Ltd., Eastbrook Road, Gloucester.

The Truspeed is a new turntable and pickup combination from Leak. Frequency response is said to be free from resonance in the range



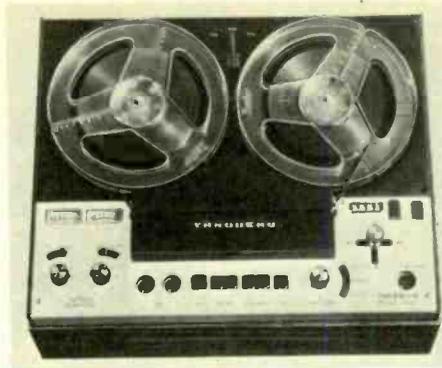
20Hz—20kHz and stereo separation better than 25dB at 1kHz. Wow is less than 0.1% and flutter less than 0.02%. The unit as illustrated costs £65 13s 3d. H. J. Leak & Co. Ltd., Brunel Road, London W.3.

The Goldring Lenco turntable model GL69 has a continuously variable speed adjustment (30—86 r.p.m.) and the pickup arm has a removable plug-in shell which can accommodate all standard fixing cartridges for both mono and stereo reproduction. Both the height of the arm and the position of the stylus in the headshell can be adjusted to give opti-



mum tracing. The stylus pressure is adjustable (by sliding counterweight) and the pickup can be lowered on to the record by means of a viscously damped lowering device. A plinth-mounted version (GL 69/P) is also available. The L 69 pickup arm which is fitted to the GL 69 is also available separately. The chassis version of the GL 69 costs £25 1s 6d. Goldring Manufacturing Co. (G.B.) Ltd., 486-488 High Road, Leytonstone, London E.11.

Two new tape decks were demonstrated by Tandberg. The 6000X (illustrated) costing £194, comes in two-track and four-track versions. It has provision for magnetic and ceramic cartridge inputs, independent record and playback systems, sound on sound facilities, a centre channel amplifier, four way mixing, and a 25dB limiter. Wow and flutter figures given are 0.07%, 0.14%, and 0.28% at 7½, 3¼, and 1⅞ i.p.s. respectively. The 1600X is a very simple deck, costing £89. It has a frequency response similar to that of the



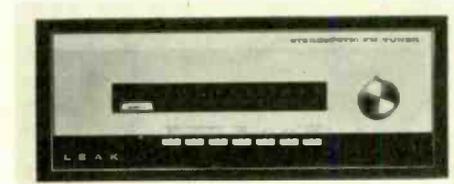
6000X but has not quite as good a signal-to-noise ratio. Farnell Tandberg Ltd, Hereford House, Vicar Lane, Leeds 2.

The Variocord 263 from Uher is a stereo tape recorder with interchangeable head mounts allowing a quick change-over between ¼-track and ½-track recording. A comparator controls tape tension during record, playback, rewind and breaking. This contributes to the wow and flutter figure of ±0.05% at 7½ i.p.s.



This recorder has a frequency range of 30Hz—20kHz at 7½ i.p.s. At 3¼, and 1⅞ i.p.s. the upper limit is 15 and 8kHz respectively. Each channel amplifier can deliver 4W into 4Ω. Bosch Ltd., Rhodes Way, Radlett Road, Watford, Herts.

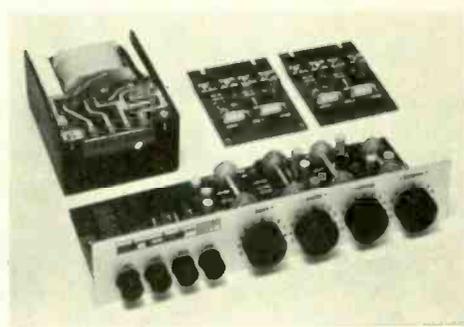
The Stereofetic f.m. tuner from Leak has high sensitivity, low distortion, and four unusual controls. One button is pressed to search for stereo transmissions (mono signals being automatically muted). Two press buttons control the noise level during stereo reception giving, all in all, three intermediate steps between mono and full stereo. A 'mono lock' can be used to obtain a mono effect even with the 'stereo only' button pressed. Also, an a.f.c. control is included. Specifications for perfor-



mance include a.m. suppression of 50dB and a signal-to-noise ratio of 60dB. Five filters are included to eliminate whistles when using a tape-recorder. Price of chassis model £56 11s: wood case model £63 14s 5d. H. J. Leak & Co. Ltd., Brunel Road, London W.3.

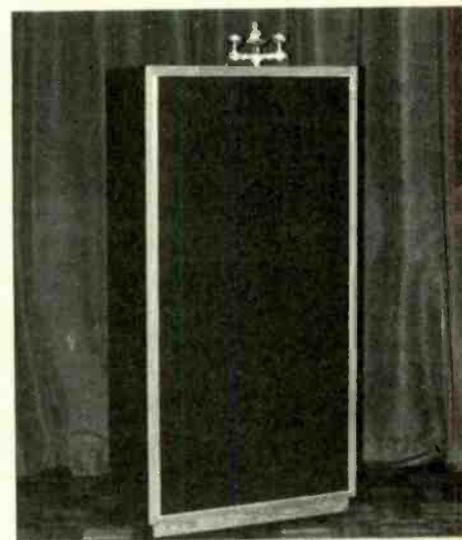
A stereo f.m. tuner with a sensitivity of 1μV for 30dB signal-to-noise ratio was displayed by Revox. The input section features dual gate f.e.t.s and quadruple variable capacitor tuning while the i.f. strip consists of a passive Gauss filter followed by an i.c. amplifier of 5MHz bandwidth. Delay lines are employed for demodulation without reducing the bandwidth. A 76kHz oscillator runs phase-locked to the subcarrier and supplies—after binary scaling—the switching frequency to the stereo demodulator. The A76 tuner costs 155gn. C. E. Hammond & Co Ltd, 90 High Street, Eton, Berks.

The Sinclair Project 60, comprising a Stereo Sixty pre-amp, two Z30 power amps, and a power supply is a low-distortion integrated system. The instruction manual



is comprehensive and seems to leave nothing to chance. It should be noted that though the Z30 amplifiers are advertised as being capable of delivering 24W continuous sine-wave this power level can only be delivered into 3Ω with a rail just above 30V. With a 12-volt rail and a 16Ω load the maximum continuous output power is reduced to 0.75W. Sinclair Radionics Ltd, 22 Newmarket Road, Cambridge CB5 8DU.

Howland-West were demonstrating I.M.F. transmission-line speakers. At low frequencies the line adds acoustic mass to the diaphragm,



doubles its effective area, and more than halves diaphragm motion. At higher frequencies the line absorbs the back wave from the driver. A professional monitor



# Electronically Stepped Curve Tracer

## Equipment for displaying transistor characteristic curves and load lines on a c.r.o.

by A. J. Sargent

The principle of a simple curve tracer in which base current is stepped by means of a manually operated switch has been described in a previous *Wireless World* article<sup>1</sup>. The arrangement provides a useful aid for students, and inspired the development of an electronic stepping circuit with provision for displaying load lines.

The principle of operation is the same as in the original article and is illustrated by Fig. 1. The collector-emitter p.d. is swept in half-wave rectified pulses and provides the c.r.o. X-deflection signal. The test transistor current flowing in  $R_Y$  develops the Y-deflection p.d. Base current is stepped in equal increments by the staircase generator on successive sweeps of the collector voltage and recycles back to zero after the required number of steps. The polarity of the collector supply p.d. and of base current increments is reversed by the switch  $S_3$  for p-n-p or n-p-n operation and for diode forward and reverse characteristics. The magnitude of base current steps is selected by switch  $S_4$ . The switch  $S_5$  allows an external load resistor to be connected in series with the transistor if required.

The electronic stepping circuit is shown in Fig. 2. A normal power supply provides 12V d.c. to the remainder of the stepping circuit.  $R_1$  and  $D_3$  produce a 6V, 50Hz square wave which is applied to the pump<sup>2</sup> formed by  $C_3$ ,  $D_4$ ,  $Tr_1$  and  $C_4$ . The values of  $C_3$  and  $C_4$  are chosen so that the p.d. across  $C_4$  is pumped up in 1V steps. One step occurs for each positive going edge of the square wave input. When  $C_4$  p.d. reaches the peak-point potential<sup>3</sup> of the u.j.t., the emitter-base 1 circuit becomes highly conducting and rapidly discharges  $C_4$  to the valley-point potential<sup>3</sup> of the u.j.t.  $Tr_2$  and  $Tr_3$  form an emitter-follower with high enough input impedance to ensure negligible sag of the staircase waveform due to charge leaking from  $C_4$ . The number of steps in the staircase can be controlled by  $RV_1$  which varies the interbase p.d. of the u.j.t. and so alters the peak-point potential at which  $C_4$  is recycled. The relative d.c. levels of the staircase output and the test transistor can be adjusted as required by means of  $RV_2$ . The waveforms obtained for the whole system with an n-p-n transistor are shown in Fig. 3. It is important to phase the supply transformer secondary windings so as to obtain the collector sweep p.d. during the second half of the step horizontal region as

shown in Fig. 3. If this is not done then the traces obtained are spoilt by the slow rising edges of the steps which cause base current to change during the collector sweep. Direct coupling to the c.r.o. X and Y plates is preferable, although the writer has obtained quite reasonable results by using a Telequipment Serviscope with direct Y coupling and a.c. coupling to the X plates. The recycling frequency is  $50/n$  Hz where  $n$  is the number of steps in the staircase. With 5 or more steps the recurrence frequency is rather slow and a long persistence tube would be an advantage.

Load-line display is obtained by connecting an external load resistor in series with the test transistor. Switch  $S_5$  serves this purpose in Fig. 1. The resulting traces are illustrated

in Fig. 4. The ends of the curves correspond with points on the required load line. The test transistor may be heated with the load in circuit and the resulting shift of the traces helps to give students a clear insight into the need for d.c. stabilisation in common-emitter circuits.

Most of the components used are no critical. Those needing some selection are  $D_3$  to obtain 1V steps, the base input resistors to obtain the required magnitude of current increments and  $R_Y$  to obtain Y deflection calibration. An alternative way of obtaining adjustment of step height is to tailor the value of  $C_3$  or  $C_4$ . The main transformer used must have two separate secondary windings. A Radiospares rectifier transformer with two 45V windings was

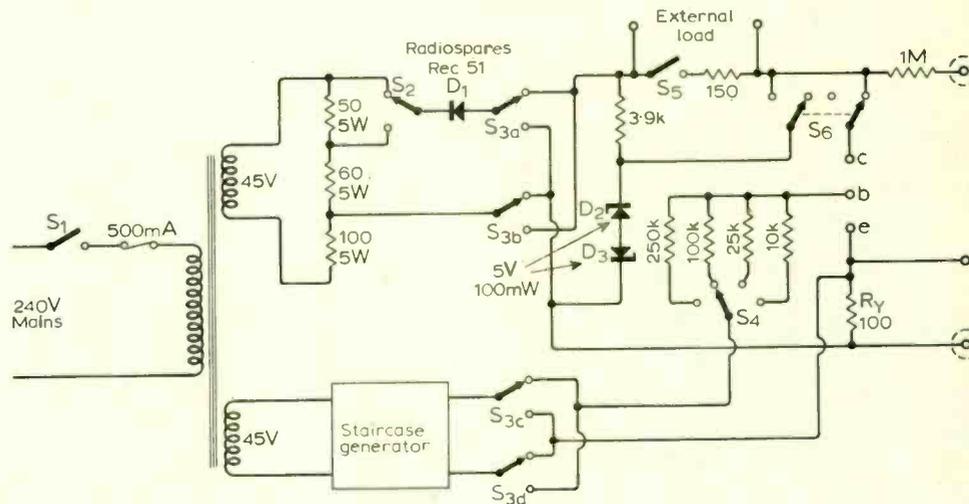


Fig. 1. Main circuit of curve tracer.

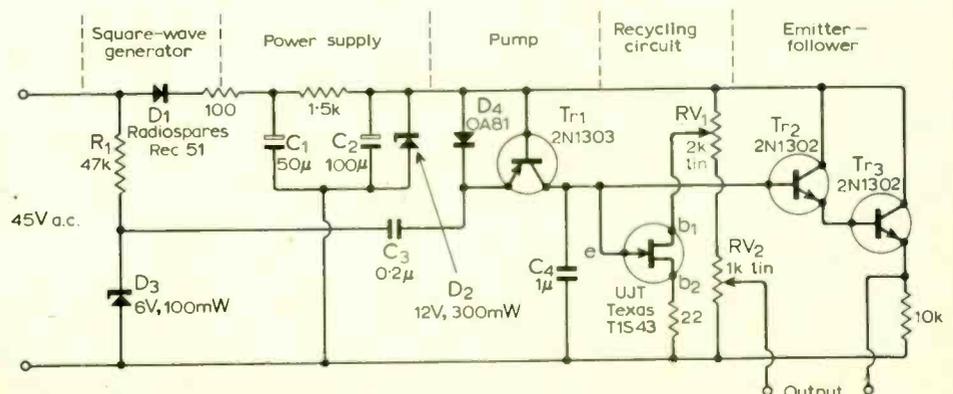


Fig. 2. Circuit of staircase generator.

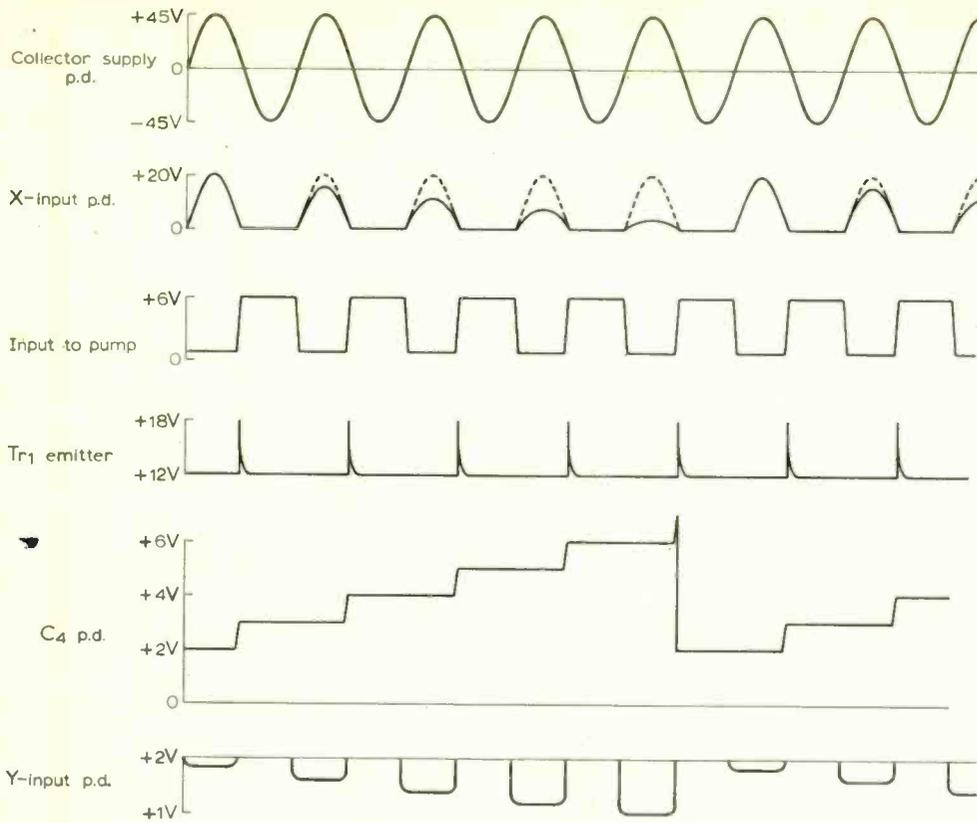


Fig. 3. Waveforms of potential with respect to staircase generator negative rail, when the test transistor is an n-p-n type with an external load.

used. A potential divider across one winding provides the collector sweep p.d., and this resistor chain should be ventilated and mounted well away from the rest of the circuit. A potentiometer could be used to give incremental control of collector voltage. Both windings need to be floating with respect to the c.r.o. earth terminal to allow them to take up varying potentials in both positions of the polarity switch. A complementary two-transistor bistable circuit<sup>2</sup> may be used to replace the u.j.t. if no unijunction transistor is available.

The Y scale is 10mA per deflection volt when  $R_Y$  has a value of 100Ω. The current scale of the displayed curves is obtained by dividing this figure by the volt/cm setting of the Y amplifier. For example, a setting of 0.5V/cm gives a current scale of 20mA/cm. The X scale can be calibrated in one of several ways. The test transistor may be replaced by a known resistor connected between collector and emitter terminals. This produces an oblique line trace whose slope is  $1/R$  mA/V where  $R$  is the resistance in kilohms. For example, a 1kΩ resistor gives 1mA/V so that the X scale can be calibrated by interpolation between X and Y scales. Another method is to connect the staircase p.d. to the X input with Y input disconnected. This gives a horizontal row of bright spots at intervals of 1V on the c.r.t. The method shown in Fig. 1 uses zener diodes as a calibration reference. When switch  $S_6$  is put in the calibration position the test transistor is disconnected and the zener diode reference potential is connected to the X input. The resulting trace is a horizontal line with a bright point at each end. The separation distance of the bright

points corresponds to the zener reference p.d. Two diodes are used so that the calibration system works irrespective of the position of the polarity switch. The calibration of base current increments depends on the values of the base input resistors. The potential applied to the resistors has 1V steps so that current increments are given by  $1/R_b$ . The values 250kΩ, 100kΩ, 25kΩ and 10kΩ give current steps of 4μA, 10μA, 40μA and 100μA

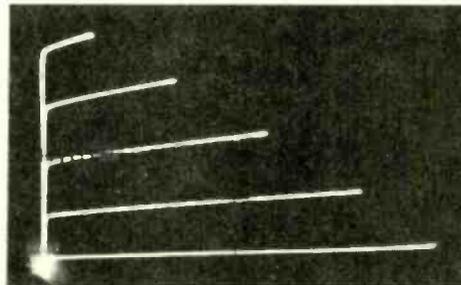
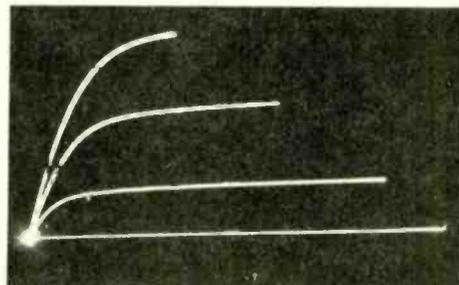


Fig. 4. Characteristic curves for (above) 2N1304— $\Delta I_b = 10\mu A$ ,  $I_c = 0.4mA/cm = 1.5V/cm$ , load = 5kΩ (belota) 2N3819— $\Delta V_{gs} = 1V$ ,  $I_d = 3.2mA/cm$ ,  $V_{ds} = 1.5V/cm$ , load = 560Ω



respectively. The adjustment of  $RV_2$  allows the first step to be set to give zero base current. This adjustment compensates for the valley-point potential of the u.j.t. and for the emitter junction volt drops of  $Tr_2$  and  $Tr_3$ .

The curve tracer has been used to display characteristics of junction transistors, field effect transistors and zener diodes. Temperature effects can be examined and if collector sweep p.d. is increased sufficiently then the avalanche region of characteristics can be displayed without damaging the transistor. The system is capable of considerable refinement but even in its simple form it provides a valuable teaching aid that is capable of yielding useful measurements.

REFERENCES

1. G. B. Clayton, 'Transistor Curve Tracing', *Wireless World*, June 1967.
2. D. E. O'N. Waddington, 'The Diode Transistor Pump', *Wireless World*, July 1966.
3. H. R. Henly, 'The Unijunction Transistor', *Wireless World*, March 1964.

Books Received

**Hi-Fi Year Book 1970** follows the same pattern as the previous issues. It presents in concise form detailed specifications and up-to-date prices for almost every item of hi-fi equipment currently available on the British market. Details are given of over 2,000 items from more than 300 manufacturers or importers, and there are over 700 illustrations. The first 54 pages are taken up by seven articles describing theoretical and practical points about speakers, tape recorders and radio tuners. Pp.431. Price 20s, postage 3s. IPC Electrical-Electronic Year Books Ltd, Dorset House, Stamford Street, London S.E.1.

**Classificatore Universale dei Transistori**, by Vittorio Banfi, is in two volumes. In Vol. 1 about 4,000 types of transistors with allowable dissipation in excess of 5W are described, and in Vol. 2 about 10,000 lower power devices are described. Data are presented in a very useful manner; e.g. power dissipation and cut-off frequency are given for identical conditions, and the grouping and subgrouping method used facilitates tracking down devices for specific applications. Antonio Benvenega, Editrice Antonelliana, Via Legnano 27, 10128 Torino, Italy.

**Radio Year Book 1969/70**, lists recent television sets, radiograms, record players, table and portable radio receivers, mains operated and battery tape recorders, and tape recording accessories. There are over 1000 entries and more than half are illustrated. The tape recorder section has been limited to models costing up to £130. (The more expensive tape recorders are to be found in "Hi-Fi Year Book".) Technical details of models are given along with addresses and telephone numbers of suppliers and makers. Two articles, one on television the other on v.h.f. radio, take up the first 16 pages. Pp. 215. Price 15s, postage 2s 6d. IPC Electrical-Electronic Year Books Ltd, Dorset House, Stamford Street, London S.E.1.

# Simple Linear A.C. Voltmeter

by G.W. Short\*

A simple single-stage transistor amplifier can be used to improve the linearity of a rectifier type a.c. voltmeter without altering its sensitivity. This is often useful when an ordinary d.c. meter with a linear scale has to be adapted for a.c. measurements. Simply adding a rectifier would spoil the linearity and render the original calibration unusable; at least over the lower part of the scale. If the voltages to be measured are less than about 1 V there is no easy way out of the problem, and if a rectifier is used, the meter scale must either be re-calibrated or, more probably, a fairly elaborate amplifier-rectifier circuit with at least two transistors must be employed.

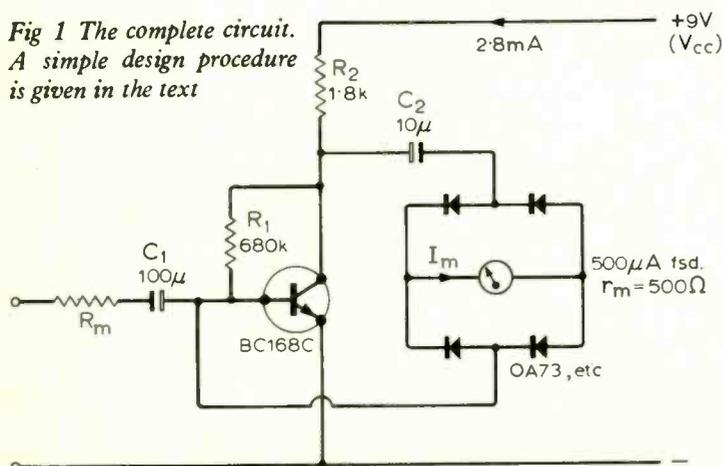
The circuit described here is for use with inputs which are too large to justify building a sensitive millivoltmeter but small enough to impair linearity, from say, 1 to 10 V r.m.s.

A relatively simple active circuit (Fig.1) is sufficient to produce a very worthwhile improvement in linearity at this sort of input level while leaving the meter sensitivity virtually unchanged. Meter multiplier resistances can be added and are calculated on the basis of the d.c. characteristics of the meter movement, or if desired, an existing multiplier can be used.

Operation of the circuit is quite straightforward. The meter is connected between output and input of the amplifier stage, thereby introducing a large amount of negative feedback. Study of the circuit will show that the signal source must supply slightly more r.m.s. current than is needed for normal meter full-scale deflection. The extra current being the base input current of the amplifier transistor. Looked at in a slightly different way, the feedback current which flows via the meter back to the base cancels all of the input signal current except that which is needed to drive the transistor.

If the transistor gives a high current gain the base current is so small that it can be neglected. If, for example, the working current gain is 200—readily obtainable with modern transistors

Fig 1 The complete circuit.  
A simple design procedure  
is given in the text



—then the input signal current for f.s.d. need only be about 0.5% greater than the nominal meter f.s.d. current. In practical applications a 0.5% error is negligible.

## Linearizing action

To account for the improvement in linearity it is easiest to consider signal voltages rather than the signal currents. The non-linearity of a rectifier-meter results from the fact that the diodes used pass very little current until their forward zener voltage is exceeded. An ideal rectifier would pass no current at all until forward biased by a voltage equal to the forward zener voltage and thereafter its forward resistance would fall to zero and unlimited current would flow. All practical rectifiers have finite forward resistances and curved voltage-current characteristics which blur the non-linearity somewhat, but it is still there. In this circuit, the diodes are in the negative feedback path. If the voltage across the diodes is too small to overcome the forward zener voltage then the negative feedback is small. Small feedback, however, implies high gain. It follows that for very small inputs, the input signal is subject to something approaching the non-feedback gain. A small signal voltage at the base is sufficient to produce enough amplified voltage at the collector to bias the diodes to conduction, whereupon negative feedback is increased and the amplification made more or less independent of the transistor characteristics.

To put some numbers in, if germanium diodes are used in a bridge rectifier circuit, then the total forward bias needed to overcome the zener voltage is about 500mV. If the stage gain (base to collector) is 100, then an input of 5mV peak at the base will just make the rectifiers conduct strongly. The non-linearity is thus reduced by a factor approximately equal to the voltage gain. The figure of 100 for voltage gain is quite practical, as mentioned earlier. With this order of amplification, and an input of 1 V or more for f.s.d., the non-linearity is compressed into the first tenth of the scale, or less, and is negligible for most purposes.

## Circuit design

The circuit is not unduly sensitive to variations in supply voltage or transistors (provided that  $h_{fe}$  is high). With the capacitance values shown in Fig. 1 and a multiplier resistance  $R_m$  of 1 k $\Omega$  (the lowest practicable value for the f.s.d. of 500  $\mu$ A chosen) the response is 10% down at 7 Hz. The upper frequency limit depends on the compactness of the wiring and the rectifiers. Using point contact diodes, with an amplifier built on a tag strip supported by the meter terminals, the upper limit was about 3 MHz. Ordinary copper oxide meter rectifiers will give improved linearity but a much lower cut-off frequency.

A step-by-step design procedure is given below. This makes provision for moderately peaky waveforms by allowing for peak voltages and currents five-times the r.m.s. values.

## Design Procedure

- $I_m$  = meter current for full scale deflection.
- $r_m$  = meter coil resistance.
- $V_f$  = forward drop of diode at  $5 \cdot I_m$
- (1)  $I_C$  =  $5 \cdot I_m$
- (2)  $V_{CE}$  =  $5 \cdot I_m r_m + 2V_f$
- (3)  $R_1$  =  $h_{fe}(V_{CE} - 0.7) / I_C$  for silicon transistors  
 $R_1$  =  $h_{fe}(V_{CE} - 0.2) / I_C$  for germanium transistors
- (4)  $R_2$  =  $(V_{cc} - V_{CE}) I_C$
- (5)  $R_M$  =  $V_{IN}(\text{f.s.d.}) / I_m$
- (6)  $C_1$  >  $10 / (2\pi f_{MIN} \cdot R_M(\text{MIN}))$
- (7)  $C_2$  >  $1 / (2\pi f_{MIN} \cdot R_2)$

# Stereo Image Width Control

A circuit designed to give linear control of the width of a stereo image

by A. Roberts

Although modern stereophonic recordings of music are steadily improving, one still comes across disc recordings in which the apparent image width or spread of stereo reproduction is unsatisfactory. In some cases excessive crosstalk between channels reduces the image width. On the other hand, the increasingly popular technique, used mainly in light music, of recording the left and right channels with little or no crosstalk, produces odd effects such as "hole in the middle". To get the best results, some degree of control over the image width at the reproducer appears to be desirable.

There are several well known ways of controlling stereophonic image width. The most popular method involves matrixing the left hand (*a*) and right hand (*b*) signals into *a* + *b* and *a* - *b*, introducing relative attenuation between these signals, and then matrixing the modified outputs into *a'* and *b'* by addition and subtraction as before. It is difficult to include gain in such circuits and the necessary laws of the controls are usually not easy to obtain with normal components.

The circuit described below provides gain and gives fairly linear control of the output image width from 0% (mono) to approximately 165% of the image width, using two ganged linear controls.

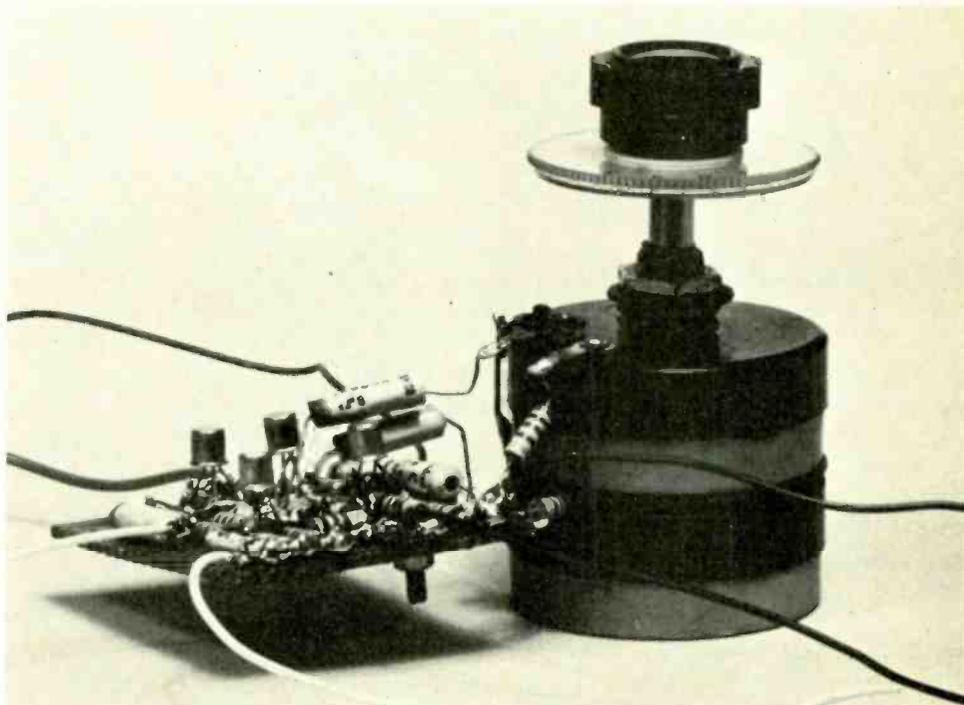
The action of the circuit (Fig. 1) is quite simple. Cross-coupling the emitters of the two transistors *Tr*<sub>1</sub> and *Tr*<sub>2</sub> by *R*<sub>*x*</sub> introduces a negative component of crosstalk in the emitter currents. This in itself would produce image widening if *R*<sub>*y*</sub> were not present. When *R*<sub>*y*</sub> is a short-circuit the outputs are made common, and the image width is zero. When

$$R_y = \frac{R_x R_z}{R_w}$$

it cancels the effect of *R*<sub>*x*</sub> and there is no widening of the image. If *R*<sub>*y*</sub> is greater than

$$\frac{R_x R_z}{R_w}$$

the output image is widened since not all of the negative crosstalk currents at the emitters is removed by *R*<sub>*y*</sub> at the collectors. The two outputs *V*<sub>*a*'</sub> and *V*<sub>*b*'</sub> (Fig. 1) can be written as, *V*<sub>*a*'</sub> = -*p*(*V*<sub>*a*</sub> + *nV*<sub>*b*</sub>) and *V*<sub>*b*'</sub> = -*p*(*V*<sub>*b*</sub> + *nV*<sub>*a*</sub>), where *n* is variable between +1 and -0.25 for the practical circuit. The factor *p* is also controlled to



give constant subjective loudness, independent of the width setting. For a more detailed analysis, see Appendix 2.

### Practical circuit

The prototype (Fig. 2 and photograph) was designed to operate at a signal level of -10 dBm (250 mV r.m.s.) with unity gain and an overload factor of 18 dB (clipping occurs at about 1.75 V r.m.s.). Such conditions should satisfy most users, more complicated techniques are needed to operate at higher levels without drastically increasing the rail voltage. The control, *R*<sub>7</sub> and *R*<sub>13</sub>, is a two-gang 1 kΩ linear wire-wound potentiometer, connected so that the wipers move apart on the circuit diagram to increase the image width.

The transistors *Tr*<sub>3</sub> and *Tr*<sub>4</sub> allow separation of the a.c. and d.c. collector loads of *Tr*<sub>1</sub> and *Tr*<sub>2</sub>, since they both operate as current sinks to the d.c. components of *Tr*<sub>1</sub> and *Tr*<sub>2</sub> collector currents. The circuit equations are functions of the emitter and collector resistor networks of *Tr*<sub>1</sub> and *Tr*<sub>2</sub>, and so the output load resistances must be large compared with the collector network in order to eliminate errors. However,

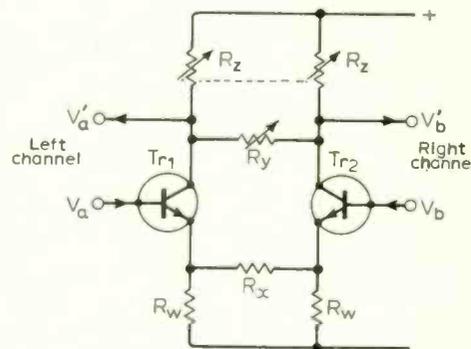


Fig. 1. Basic a.c. circuit of the design.

transistors *Tr*<sub>3</sub> and *Tr*<sub>4</sub> also operate as emitter followers of the collectors of *Tr*<sub>1</sub> and *Tr*<sub>2</sub>, providing good output isolation and low source impedances for the outputs. In fact the resistances presented to the collectors of *Tr*<sub>1</sub> and *Tr*<sub>2</sub> by *Tr*<sub>3</sub> and *Tr*<sub>4</sub> are respectively *R*<sub>8</sub> and *R*<sub>11</sub>, each in parallel with the output load impedance multiplied by the *h*<sub>*f**e*</sub> of the transistors *Tr*<sub>3</sub> and *Tr*<sub>4</sub>. This is effectively 30 kΩ each, much larger than the network of *R*<sub>8</sub>, *R*<sub>7</sub>, *R*<sub>13</sub>, *R*<sub>14</sub>. The output source resistance has been measured at about 30 Ω.

The circuit has only one drawback, it needs to be driven from low impedance signal sources to avoid major discrepancies between theoretical and practical responses. This is because the emitter resistances of  $Tr_1$  and  $Tr_2$  must be small compared with the emitter network.

Now,

$$R_e = \frac{R_s}{h_{fe}}$$

where  $R_s$  is the source resistances and  $h_{fe}$  is approximately 400 for 2N930 transistors. Thus for  $R_e$  to be less than 5  $\Omega$ ,  $R_s$  must be less than 2 k $\Omega$ . These values introduce approximately 0.5% error in the responses.

Overall d.c. feedback is applied to stabilize the operating conditions, the two feedback paths have a common decoupling capacitor  $C_5$ , so that relative drift in the two channels

is eliminated. This is desirable since it removes d.c. from  $R_{10}$ . Any d.c. present in  $R_{10}$  would reduce the clipping level of the circuit.

As expected, the gain/frequency characteristic is a straight line between 15 Hz and 50 kHz,  $\pm 0.5\%$ . The input resistances are basically those of the bias chains, and distortion is typically -45 dB of second harmonic, relative to the working level, 250 mV. The minimum impedance the circuit can drive to full output is 750  $\Omega$ .

In practice the amplitude and crosstalk responses are precisely those predicted mathematically in Fig. 4. Since the crosstalk coefficient  $n$  is basically logarithmic over a large section of the control range, the image of a stereo signal processed by the circuit has width nearly linearly dependent on the control setting. This relationship holds until the image fills the available

sound stage, i.e. at least part of the image appears to come from one loudspeaker directly. If it is attempted to further widen the image, the extremes will "fold back" towards the centre and become indistinct, because the two channels have some negative correlation. The effect is similar to that of phase reversal of one channel. Fig. 5 shows the output crosstalk of a stereo signal pair processed by the circuit, when 10 dB crosstalk is present in the inputs. Comparisons between this and published curves of image width versus crosstalk<sup>1</sup> show that the relationship between image width and control setting is very nearly linear.

Because of the large amounts of d.c. and a.c. negative feedback employed, the functioning of the circuit is independent of the transistor parameters, provided that  $h_{fe}$  is large. The measured  $h_{fe}$  of the 2N930 transistors used in the prototype was greater than 400 in each case. BC109s are suitable alternatives, particularly in view of their low cost and extremely low noise figure.

<sup>1</sup> Harwood, H. D., "Stereophonic Image Sharpness", *Wireless World*, July 1968.

**Acknowledgement**

The author wishes to express his thanks to the Director of Engineering of the British Broadcasting Corporation for permission to publish this article.

**Appendix I**

The outputs  $V_a'$  and  $V_b'$  (Fig. 1) are to follow the equations  $V_a' = -p(V_a + nV_b)$  and  $V_b' = -p(V_b + nV_a)$  where  $V_a$  and  $V_b$  are the two inputs. When  $n = 0$  the outputs are the unmodified inputs, multiplied by  $p$ , which in the practical circuit under these conditions is unity. There will be a statistical correlation between  $V_a$  and  $V_b$  in general, therefore the subjective loudness of the outputs will rise as  $n$  is increased towards +1, since when  $n = 1$ ,  $V_a' = -p(V_a + V_b)$  and  $V_b' = -p(V_b + V_a)$ . Accordingly, the factor  $p$  is reduced to 0.625 for the mono condition, i.e. a 4 dB reduction in gain.

When the circuit is used to compensate for unwanted crosstalk, the inputs can be expressed in the form,  $V_a = a + mb$  and  $V_b = b + ma$  where  $a$  and  $b$  are the "true" left and right channels respectively. The operation,  $V_a + -p(V_a + nV_b)$  results in,

$$V_a' = -p(a + mb + mna + nb) = -p[a(1 + mn) + b(m + n)]$$

Now if  $n = -m$ , then  $V_a' = -pa(1 - m^2)$ , i.e. crosstalk is eliminated and the output is reduced in amplitude by  $(1 - m^2)$ . To compensate for this gain reduction,  $p$  is increased to 1.12 for the condition when  $n = -0.25$ , i.e. a 1 dB rise.

**Appendix 2**

Fig. 3 shows the equivalent a.c. circuit of Fig. 2, using the small signal equivalent circuit of the transistors, modified for simplicity. If the emitter voltage source resistance  $R_e$  is small, the emitter voltages

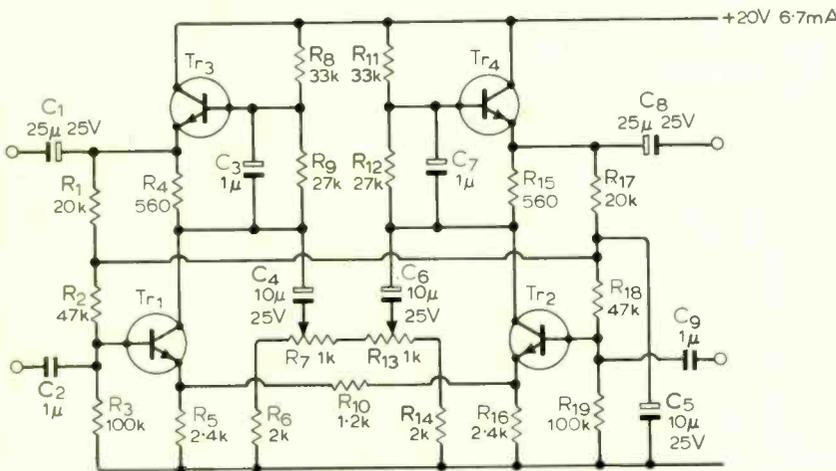


Fig. 2. Practical circuit for construction.  $R_7$  and  $R_{13}$  are ganged.

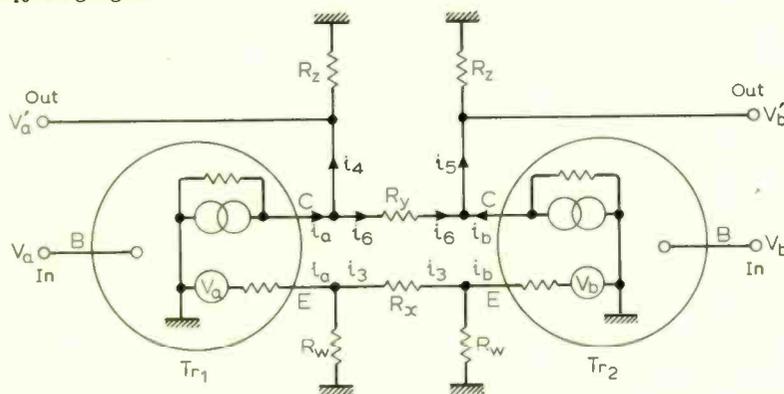


Fig. 3. Equivalent circuit of Fig. 1.

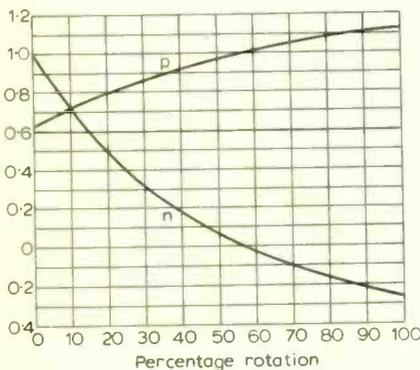


Fig. 4. Calculated response of the control circuit.

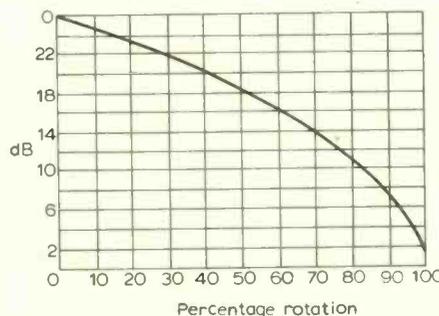


Fig. 5. Crosstalk coefficient of processed signals, when input crosstalk is 10 dB.

are  $V_a$  and  $V_b$  respectively. Stating Kirchoff's current junction law at the emitters,

$$I_a - I_1 + I_3 = 0$$

and

$$I_b - I_2 - I_3 = 0$$

$$I_a + \frac{V_b - V_a}{R_x} - \frac{V_a}{R_w} = 0$$

and

$$I_b - \frac{V_b - V_a}{R_x} - \frac{V_b}{R_w} = 0$$

Thus:

$$I_a = V_a \frac{(R_x + R_w)}{R_x R_w} - \frac{V_b}{R_x}$$

and

$$I_b = V_b \frac{(R_x + R_w)}{R_x R_w} - \frac{V_a}{R_x}$$

So there is a negative crosstalk component in the emitter currents. If the source resistance  $R_c$  is taken into account the equations become rather complicated, but if  $R_c'$  is very large and the load resistance can be neglected, then application of Kirchoff's law at the collectors gives,

$$I_a - I_4 - I_6 = 0$$

and

$$I_b - I_5 + I_6 = 0$$

Adding,

$$I_a + I_b = I_4 + I_5$$

Therefore,

$$V_b' = -V_a' - \frac{R_z}{R_w}(V_a + V_b)$$

Substitution, manipulation and rewriting give,

$$V_a' = -mp(V_a + nV_b)$$

and

$$V_b' = -mp(V_b + nV_a)$$

where  $m$  is a constant, equal to the circuit gain when  $n$  is zero, i.e. when  $R_x R_z = R_w R_y$ . With the component values of the practical circuit (Fig. 2)

$$m = 1 \text{ and } R_w = 2.4 \text{ k}\Omega$$

$$R_x = 1.2 \text{ k}\Omega$$

$$R_y = 2x \text{ k}\Omega$$

$$R_z = (3 - x) \text{ k}\Omega,$$

where  $x$  is the fractional rotation of the control (between 0 and 1).

Fig. 4 shows the predicted characteristics of  $p$  and  $n$ . It is a simple matter to arrange for the circuit to have gain. For a gain of  $m$ , the collector components  $R_6, R_7, R_{13}$  and  $R_{14}$  should all be multiplied in value by  $m$ . Alternatively the emitter components  $R_5, R_{10}, R_{16}$  could all be divided in value by  $m$ . Obviously the biasing should be recalculated to ensure efficient usage of the rail voltage.

# Variable Capacitance Diode

The variable-capacitance diode, or varactor as it is often called, is now quite widely used for tuning purposes, but little information about it seems to have been published. The capacitance of any semiconductor junction diode which is reverse biased varies with the magnitude of the reverse bias, the capacitance decreasing with the applied voltage. In ordinary diodes the capacitance is associated with quite high resistive losses, but in the special varactor diodes these losses are sufficiently reduced for them to be very useful devices for tuning purposes.

One example of the varactor is the Motorola 1N5145A. At 4V reverse bias this has a capacitance of  $27\text{pF} \pm 1.3\text{pF}$  and a nominal capacitance ratio of 3.4 (minimum ratio 3.2) when the applied bias is changed to the maximum rated value of 60V. The nominal minimum capacitance is thus  $7.85\text{pF}$ . In practice one cannot achieve quite such a small minimum capacitance because it is necessary to restrict the reverse bias to less than 60V in order that 60V is not exceeded under worst-case conditions. The  $Q$  is 200 at 50MHz which is a good deal higher than that of the average inductor with which it will be associated.

The law of variation with voltage is, approximately, an inverse square-root one. However, series fixed capacitance is usually needed to allow the application of the reverse bias and a tuned circuit always has shunt capacitance so that the law of variation of frequency with voltage is quite a complex expression. It turns out in practice, however, that frequency is almost exactly proportional to the logarithm of the voltage.

Fig. 1 shows the circuit of an oscillator in which the frequency is controlled by a varactor diode. The circuit is basically that of a Colpitt's oscillator in which the 6.8-pF capacitor forms one of the split capacitors and the base-emitter capacitance of the transistor forms the other.

Fig. 2 shows the measured frequency of oscillation plotted against the reverse

bias voltage  $V_d$ . The amplitude of oscillation was about 1.1V peak. It must, of course, be less than the minimum reverse bias to prevent the varactor from conducting during part of the r.f. cycle. It should be much less to minimize capacitance variations during the cycle. It can be seen from Fig. 2 that only three of the points lie slightly off the straight line drawn through the other 10 points and it is probable that this is because of experimental errors.

This law of frequency variation will hold for any mid-band frequency as determined by the inductance, as long as the circuit continues to oscillate with the capacitance values given.

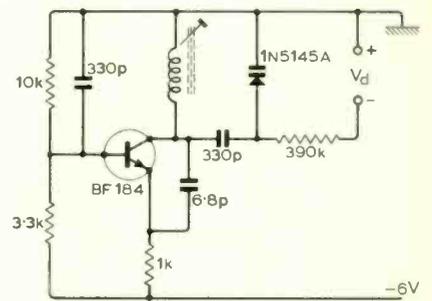


Fig. 1 Circuit of a transistor oscillator using a varactor diode

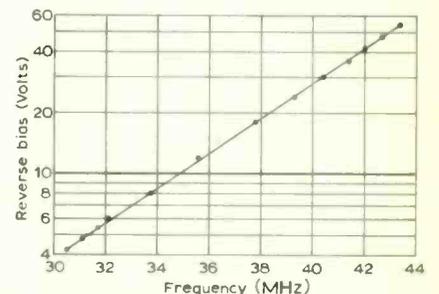


Fig. 2 Variation of oscillator frequency with varactor bias

# Wireless World Logic Display Aid

## 8: Some demonstration circuits. Using a large screen oscilloscope

designed by B. S. Crank\*

In this, the last article in the series, a few circuits will be described that may be used with the *Wireless World* Logic Display Aid to demonstrate various logic functions. Also a modification to the blanking arrangements allowing the instrument to be used with large, slow-scan demonstration oscilloscopes, will be discussed (See also "Letters to the Editor", p. 519, November issue).

### AND-OR demonstration unit

This unit consists of a box containing 32 switches arranged as per Fig. 91. The switches are grouped in sets of eight and are labelled A, B, C, D,  $\bar{A}$ ,  $\bar{B}$ ,  $\bar{C}$ ,  $\bar{D}$ . The variables represented by the switches in a particular group will be "ANDed" together when the appropriate switches are operated. For instance, if  $S_1, S_6, S_3$  and  $S_8$  are operated the display aid will show the function  $ABC\bar{D}$ . The TRUE variables are allocated red switches and the complements have black switches.

Switches operated in different groups will be "ORed" together. The exclusive OR function would be set up as follows:

$$\begin{aligned} \text{exclusive OR} &= A\bar{B} + \bar{A}B \\ &= S_1S_6 + S_{13}S_{10} \end{aligned}$$

Because there are four groups of switches Boolean expressions consisting of four sets of AND terms can be "ORed" together. Some examples are the binary SUM and CARRY equations:

$$\begin{aligned} \text{SUM} &= A\bar{B}\bar{C} + \bar{A}BC + \bar{A}\bar{B}C + ABC \\ \text{CARRY} &= ABC\bar{D} + \bar{A}BC + \bar{A}BC + ABC \end{aligned}$$

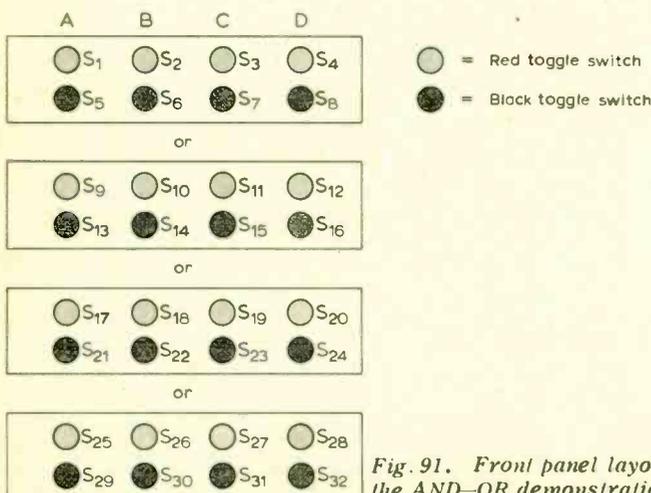


Fig. 91. Front panel layout of the AND-OR demonstration unit.

Basic facts like  $A\bar{A} = 0$  and  $A + \bar{A} = 1$  can be instantly demonstrated using the demonstration unit. It can also be used to demonstrate minimization ( $ABC\bar{D} + ABCD = ABC$ , etc.)

The switches used are miniature two-pole change-over types obtainable from G.W. Smiths. A 10% reduction on the catalogue price can be obtained if 32 are purchased.

Fig. 92 shows part of the circuitry of the demonstration unit. One four-input gate, expanded to nine inputs with five diodes, is used for each group of switches. The common point of the diodes is connected directly to the input node of the gate (pins 3 or 11 of ZN330E—see Fig. 29, June issue). Operation of a switch will connect the variable represented by that switch to one of the inputs of the gate for the particular group.

Fig. 93 shows the remainder of the circuitry which earths one of the inputs to the gate for a particular group of switches when all switches in that group are open. If this were not done, then, unless at least one switch in each group is operated, the output from the demonstration unit would permanently be at logical 1.

If the black switches are taken to represent the TRUE variable and the red the complement, and if the output of the unit is connected to the  $\bar{Z}$  input terminal of the display aid the unit will operate in negative logic and will therefore perform the NAND-NOR functions.

### Basic logic function unit

This consists of a box, which is plugged into the output variable socket of the display aid, and has outputs corresponding to the main logic functions. The front panel is shown in Fig. 94 and in use the Z input to the display aid is connected to one of the gate outputs on the front panel.

The circuit is shown in Fig. 95 where it can be seen that the OR function is obtained by feeding  $\bar{A}$  and  $\bar{B}$  and  $\bar{C}$  to a NAND gate. Wire-up the circuit as illustrated in Fig. 96 using two ZN362Es.

### Demonstrating sequential logic circuits

The output of the sequential logic circuits can be displayed on the instrument provided the frequency of operation is low enough to be followed with the eyes. All that needs to be done is to compare the output of the sequential circuit with the output variables of the display aid in such a way as to provide a Z output when both are in the same condition. In our example of Fig. 97 we have used a two-bit binary counter which can be made to cycle continuously or operate in a single shot mode. In the prototype of this circuit which was built on a single plug-in card, a four-bit counter was employed with an extra

\* Assistant editor *Wireless World*.

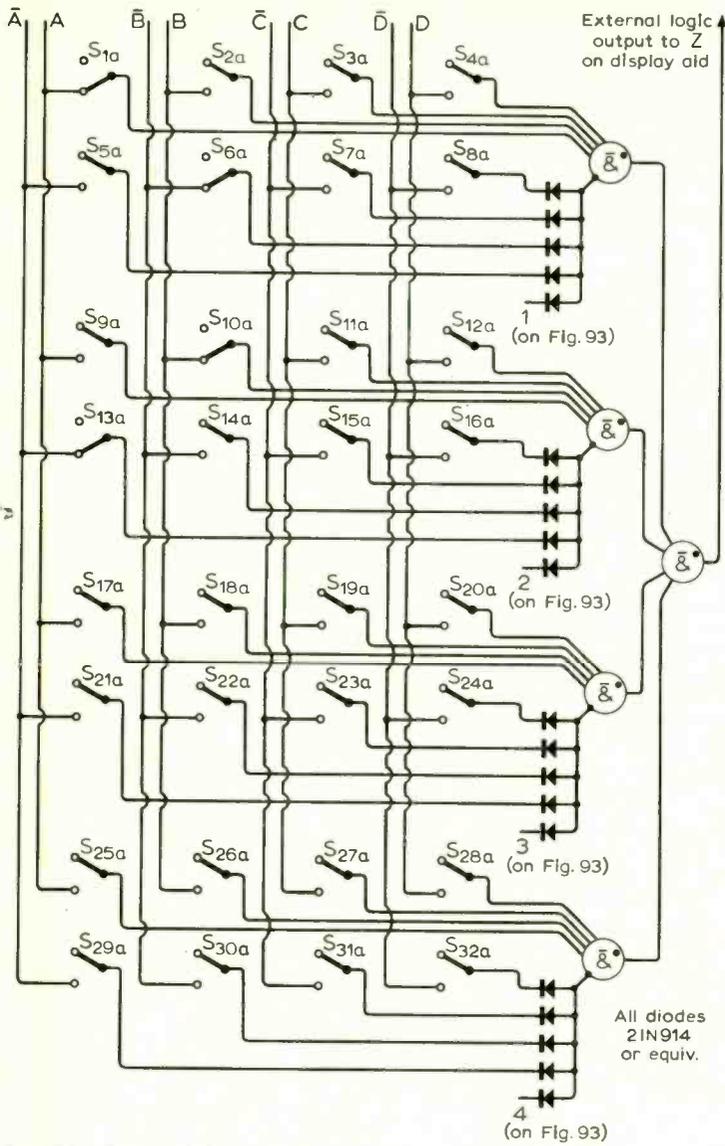


Fig. 92. Some of the switch wiring.

Fig. 93. The remainder of the switch wiring.

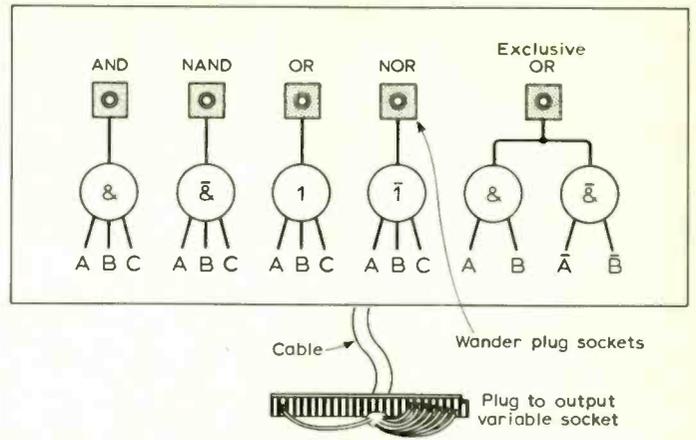
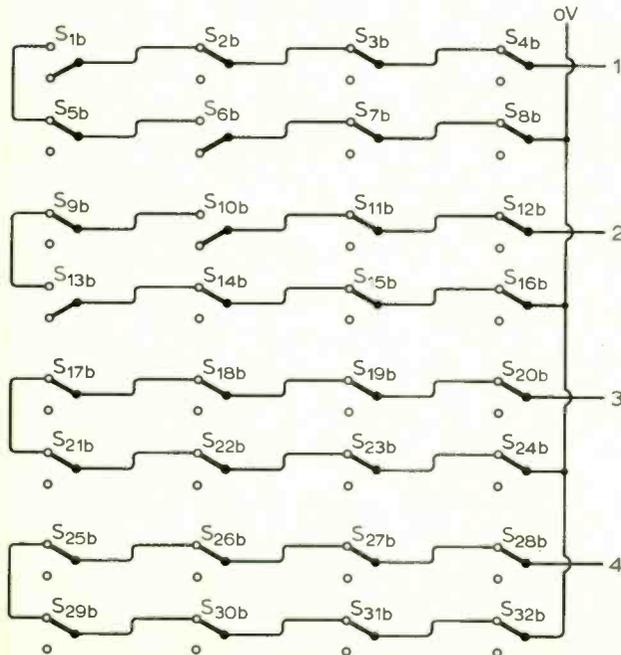
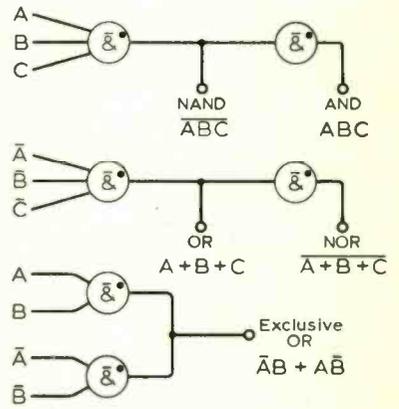


Fig. 94. Front panel of the basic logic function unit.

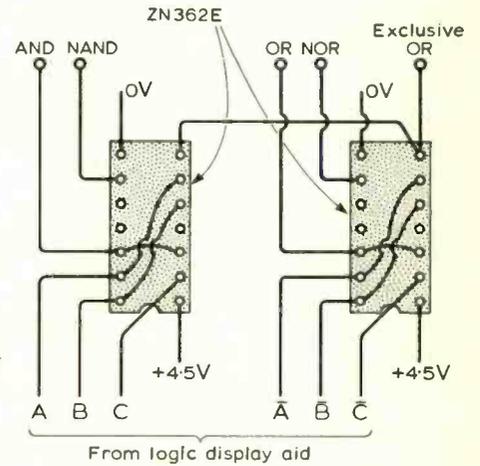
(Right)

Fig. 95. Showing how the basic logic functions are obtained with NAND gates.



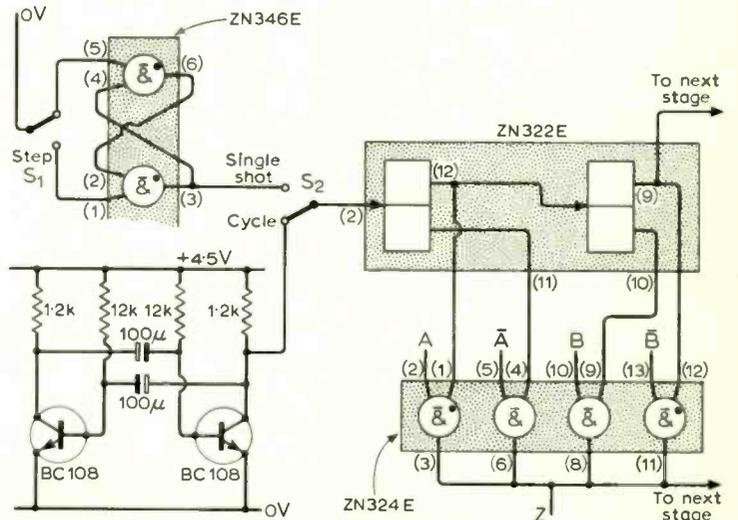
(Right)

Fig. 96. Practical wiring diagram of Fig. 95.



(Below)

Fig. 97. Demonstrating sequential circuits. A two bit counter which may be extended to four or six bits, depending upon instrument type.



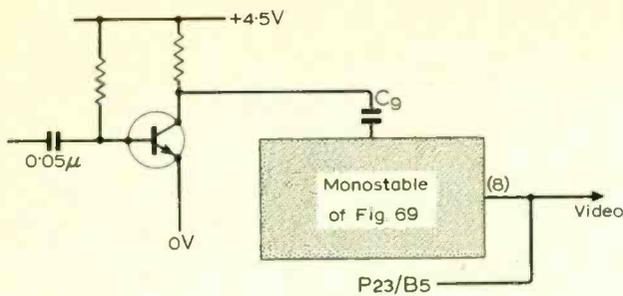


Fig. 98. Altering the blanking arrangements to give better performance and about 4V output for LAN Electronics' 19-inch oscilloscope.

switch which altered the length to three bits when required. The switch  $S_2$  allows the output of a low-frequency multivibrator for continuous operation, or a trigger circuit for single shot operation, to be selected.  $S_1$  causes the counter to increase one count at a time when  $S_2$  is in the single shot position.

The output of any sort of counter, be it n.b.c.d., Johnson, etc., can be displayed in this way so that all the possible states are seen in turn on the screen. The same limitations as for combinational circuits apply of course, three outputs for Venn diagrams and Truth tables or four or six outputs (depending on instrument type) for Karnaugh maps.

#### Using the instrument with a large oscilloscope

For a demonstration it was necessary to use a large 19-inch screen slow-scan oscilloscope. The particular instrument chosen was manufactured by LAN Electronics Ltd. An examination of the specification showed that the Z axis required a normal logic input of only about 4V for full modulation of the beam.

The circuit was altered accordingly using much the same principle as before. The blanking arrangements used in the display aid did not prove very satisfactory in this case as several of the dots appeared as lines.

The circuit of Fig. 98 was finally employed. The 60V power supply and the video amplifier were no longer required and were dispensed with. The transistor of Fig. 98 is normally held on by the base resistor. On the receipt of a negative transient from the clock generator the transistor switches off for a time determined by the  $0.05\mu\text{F}$  input capacitor. The pulse at the collector is used to trigger the monostable of Fig. 69 (Sept. issue) via  $C_9$ . The video output to the large oscilloscope was taken from the junction of the output of the monostable and the video output of the logic circuits. The monostable clamps the video output of the logic circuits and therefore the necessary delay between a clock pulse and the video output signal is provided.

To revert to modification -4 in the October issue it should have been mentioned that it is necessary to reduce the size of the clock generator capacitors to  $0.01\mu\text{F}$  to prevent flicker.

## Announcements

"Micro-electronics applied to digital systems" is the title of a course of lectures organized by the Electrical & Electronic Engineering Department of Sunderland Polytechnic. The lectures are offered both as an evening course and a day course commencing in January.

The Yorkshire Television careers film "I am an engineer—electrical", a 16mm black-and-white film lasting 20 minutes, is now available on loan from the Education Department, Institution of Electrical Engineers, Savoy Place, London W.C.2.

"Introducing metrication into your company" is the title of a one-day seminar organized by Business & Industrial Training Ltd, (161-166 Fleet Street, London E.C.4) in association with *Engineering Materials & Design* to be held at the following venues: Airport Excelsior Hotel, Manchester (December 2nd); Royal Garden Hotel, London (December 9th); Airport Excelsior Hotel, Birmingham (December 11th). The fee is £20.

Techmation Ltd are to hold an international seminar on analytical laboratory techniques at the Royal Garden Hotel, London W.8, from December 2nd to 4th. Tickets are available from Techmation Ltd, 58 Edgware Way, Edgware, Middx.

Pye of Cambridge Ltd is bringing together the aviation activities of Ekco Electronics Ltd in the radar field and those of Pye Telecommunications Ltd in the airport and ground-to-air communications field. The merged facility will become the **Ekco Electronics Aviation Division** of Pye Telecommunications on January 1st. In a parallel move, Ekco Electronics instrument activity will be re-named Ekco Instruments Ltd.

Interdata Inc., of Oceanport, New Jersey, has formed a wholly-owned British subsidiary to market its products. The new company, Interdata Ltd, Station House, Harrow Road, Wembley, Middx, will be responsible for the sale of the parent company's range of small, real-time, on-line control computers.

Following the introduction of an all-solid-state data transmission keyboard, the American company **Ikor Inc.** have opened a U.K. office at Chiltern House, Oxford Road, Aylesbury, Bucks, to handle local manufacture and marketing of the keyboard.

A new company, **Hytron Ltd**, Park Road, Crowborough, Sussex, has been formed to manufacture and sell data communications and storage equipment. The managing director is J. Hale and marketing director A. Thomas.

Alfred Herbert Ltd, of Coventry, have announced the amalgamation of two of their operating companies, Sigma Instrument Co. Ltd and Herbert-BSA Electrics Ltd, to form a new company called **Herbert Controls and Instruments Ltd**.

**Electrical Remote Control Co. Ltd**, and Raymond Engineering Inc, of Connecticut, have formed a joint company, Raymond Controls Corporation, which will manufacture, import and market Elremco products in the U.S.A. and Latin America.

Racal Electronics Ltd, of Bracknell, Berks, and the **Antenna Products Company** of Texas have announced an agreement whereby Racal has exclusive representation of A.P.C. outside the American continent. A.P.C. are manufacturers of m.f., h.f., v.h.f., and u.h.f. aerials, and specialize in log periodic types.

Racal Electronics Ltd has announced that following discussions with the Ministry of Technology and the Industrial Reorganization Corporation it is selling the business and certain assets of **Airmec-AEI Ltd** (acquired when it took over the Controls & Communications group) to the Plessey Company Ltd.

Dixons, of 3 Soho Square, London, W.1, have been appointed exclusive U.K. distributors for the **Ikegami** range of closed-circuit television equipment.

Salford Electrical Instruments has signed an agreement to market in the U.K. the range of **Petercem micro switches** manufactured by Compagnie Electro-Mécanique, of France.

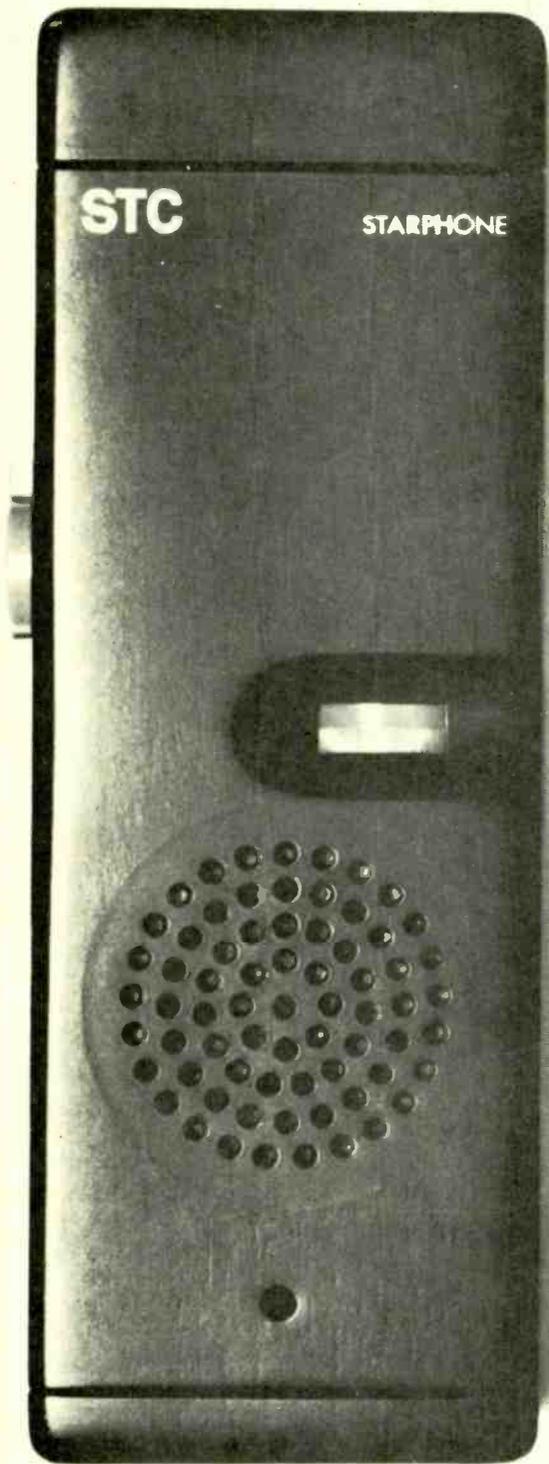
A marketing agreement has been announced between B & K Instruments Ltd and Intecole Systems Ltd, manufacturers of 'MODULOG' data logging equipment. B & K will distribute 'MODULOG' and provide full after-sales service in the U.K. and Eastern Europe.

The sale of **Eddystone Radio's** semi-domestic receivers is now concentrated through Alfred Imhof Ltd, 112-116 New Oxford Street, London W.C.1, who will act as main distributor.

**Amalgamated Wireless (Australasia) Ltd**, have appointed Marconi Instruments as servicing agents in the U.K. for their telecommunications test gear.

London Weekend Television have purchased five RCA vision tape recorders, type TR-70B, as part of their colour expansion. The contract is valued at nearly £1M.

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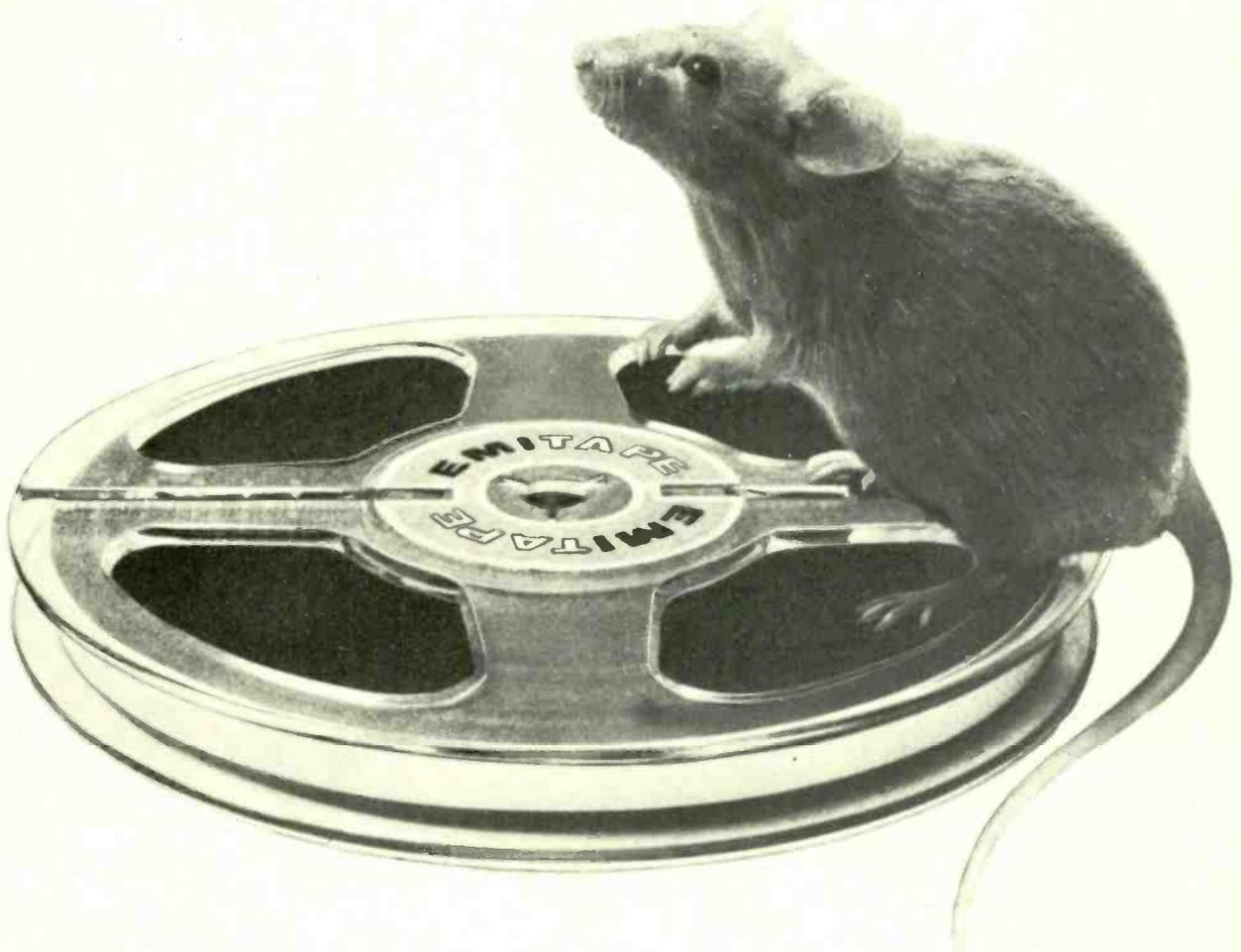
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WW—105 FOR FURTHER DETAILS

# Letter from America

Japanese competition is causing some concern in American Trade Union circles and the presidents of three of the largest unions in the electrical industry recently appealed to the Nixon administration to curb imports of electrical goods. One union leader said "This rapidly rising flood of imports from Japan, Taiwan, Korea, Hong Kong and Mexico has almost eliminated U.S. domestic production in some segments of this industry". Another official stated that "More than 50% of the black-and-white TV sets sold in the U.S. during 1969 will be of foreign manufacture".

The situation is complicated by some U.S. manufacturers taking advantage of the fact that components can be sent "offshore" to be assembled and returned on a Low Value Added duty. The low wages being of course the added value. According to the Tariff Commission, about \$270 million a year of electronic products—plus some \$13 million in scientific instruments—are involved.

One area in which the Japanese are now making considerable inroads is the electronic desk calculator field. In fact, it is estimated they already have 50% of the total sales (currently assessed at 100,000 machines a year). A typical machine is the new Toshiba BC-1212 which is a 12 digit, one memory model costing less than \$500 (£210).

Super high-gain bipolar transistors will become serious rivals to f.e.t.s in the near future. At the moment they are a little more expensive but they do offer some definite advantages such as lower leakage current and wider temperature ranges. National Semiconductor have used them in their new LM108 op. amp.—replacing the f.e.t.s used in earlier types. It is claimed that the input error current equals the f.e.t. up to 50°C but is far superior at 125°. Robert Wedlar, the designer, said the current is so low at 125° that it could not be compared with an f.e.t.—or even a complicated chopper stabilized amplifier costing much more. The performance is limited by leakages in the printed boards, resistors and capacitors rather than the amplifier itself. These super-gain transistors operate at virtually zero voltage so it is necessary to use a bootstrap circuit in the LM108 but the offset voltage is typically less than 1mV. The low current error means that the 108 can be used with configurations not possible with more conventional amplifiers. It can operate from source resistances as high as 10MΩ,

introducing less error than other units with 10kΩ sources. This high resistance allows time delays in analogue circuits of up to one hour with capacitors no larger than 1μF!

RCA have just released a new time-sharing computer (model 61) which is designed for a lease price of about \$50,000 a month—or a cool \$2½ million cash. According to RCA's T. A. Smith, the computer revolution is only just beginning and it is destined to have a greater impact on everyone's life than originally envisaged. Some of the advances in communications expected during the next few years include students operating "teacher" computers, housewives using a special video console to order groceries and automatic car control for commuters. This last named idea is not really so far fetched and much work has already been carried out by various research organizations and highway authorities using embedded control circuits and ancillary equipment for long-distance expressways. A form of automatic control for cars was demonstrated recently by the Mellon Institute. It rejoices in the name Computerised Energy Distribution and Automatic Control, or CEDAC, and it is intended to replace automotive electrical circuitry, improve safety—and cut repair bills into the bargain! Two computers are used one to control 18 functions and the other to diagnose electrical troubles. Integrated circuits are used extensively and a driver-operated master display panel transmits signals to the central computer to perform such functions as operating door locks, windscreen washers, power windows and lighting. Capacity is provided for climate control, anti-skid devices, fuel injection and transmission and ignition sub-systems. A digital display panel can be incorporated which will provide instantaneous readout of speed, oil pressure, fuel level, engine temperature, etc. If any trouble develops, the diagnostic computer will analyse it.

A new plastic developed by Union Carbide would appear to have many advantages over existing materials. It is called Parylene and it is a better insulator than epoxys, silicones or urethanes, has a higher resistance to moisture and thermal expansion is very low. Applications include semiconductor barrier coatings, corrosion protection and encapsulation. One company—Rockwell—has been working with NASA developing techniques for vacuum depositing Parylene on complex circuit assemblies and it is claimed that tests

have been very successful. Not only are electrical parameters unchanged after many hours of stringent tests but the deposited film can conform to very complex shapes.

In a new book entitled "A biography of the Watsons and I.B.M." author William Rodgers says "In all the world, one corporation dominates the future—I.B.M." The *New York Times* book reviewer thinks this is a little extravagant but concedes that I.B.M. does employ 250,000 people (more than half are college graduates) and that current stock value is more than the gold ever held in Fort Knox. According to Rodgers, I.B.M. activities "cover much of the worlds advanced technology in space, on the earth, under the seas and in thousands of industries". Although I.B.M. have a reputation of being a forward looking, enlightened company, I, for one, find the move towards larger and larger conglomerations very disquieting. Many business experts are predicting a greater and greater swing towards an international business oriented world during the next few years. For instance, Dr. Perlmutter, Professor of Industry at the University of Pennsylvania, believes that by 1985 there will be 200 or 300 super giant multi-national firms dominating the world. The National Industries Conference Board estimates that by 1975 some 25% of the gross national product of the free world outside the U.S. will come from branches and subsidiaries of U.S. companies operating abroad. Not enough people know that this is a two-way affair—last year foreign investors put over 2½ billion dollars into U.S. industry via the stock exchanges. This international business accord has been welcomed by some who feel it will help the "one world" concept. Whether people will like living in a computerized world, dominated by super-national corporations is another matter!

A great deal of interest was aroused by the new RCA Selectavision (SV) video cartridge tape recorder when it was demonstrated recently. This uses laser technology and it can be attached to any colour TV set (although the user cannot tape his own programmes). The tape is made of plastic and the recordings are made by an electron beam system. The tape or "colour encoded master" is then developed and converted by a laser to a series of holograms recorded on the tape with photoresist. After chemical treatment a nickel master is made and this is so durable that it can make many thousands of tapes without degradation. The playback equipment consists of a very low power laser tube plus a basic form of TV camera. The laser beam passes through the tape to the pick-up tube which sees the image colours as coded variations. How does the SV compare with the E.V.R. system of C.B.S.? Well, RCA see the most significant difference in the cost as they expect to market the system for less than \$400 (£167). Tape prices are believed to be around \$10 for a 30 minute programme and \$18 for 60 minutes. Some months ago C.B.S. said that the E.V.R. unit would sell for \$800 and tapes would be \$40.

G. W. TILLET.

# Operational Amplifiers

## 10. A triangular, square-wave generator

by G. B. Clayton, B.Sc., A.Inst.P.

The circuit to be described uses an operational integrator supplied with a constant input to generate a precise triangular wave. A schematic diagram illustrating the principle of operation is given in Fig. 8. Two amplifiers are used, one acting as an integrator ( $A_1$ ) and the other ( $A_2$ ) acting as a regenerative com-

parator. Diodes  $D_1, D_2, D_3$  and  $D_4$  determine the direction of current flow into the integrator. When the comparator output is at its positive level ( $V_0^+$ ) diodes  $D_1$  and  $D_4$  are reverse biased, diodes  $D_2$  and  $D_3$  are forward biased and a current  $+E_s/R_3$  flows through  $D_2$  to the summing point of amplifier  $A_1$ . The output voltage of this

amplifier runs down at a rate  $-E_s/R_3C$  volts/sec (Fig. 9(a)). With the comparator output at its negative value ( $V_0^-$ ) a current  $-E_s/R_4$  flows through diode  $D_4$  away from  $A_1$  and  $A_1$  output voltage runs up at a rate  $+E_s/R_4C$  volts/sec (Fig. 9(b)).

The output from the integrator (amplifier  $A_1$ ) is applied to the non-phase-inverting terminal of amplifier  $A_2$  (the comparator) through the resistor  $R_1$ . The phase-inverting input terminal of amplifier  $A_2$  is connected to earth. The comparator makes a transition between states when the voltage between the two input terminals of  $A_2$  goes through zero. When the comparator output is in its positive state  $V_0^+$  the transition occurs when the output from the integrator is

$$e_{o1} = - \left( V_0^- \frac{R_1}{R_2} \right)$$

and when the comparator output is in its negative state the transition occurs when

$$e_{o1} = - \left( V_0^+ \frac{R_1}{R_2} \right)$$

Waveforms are illustrated in Fig. 10. The frequency and the periods  $t_1$  and  $t_2$  are conveniently set by choice of  $R_3, R_4$  and  $C$ .

A practical circuit giving component values is illustrated in Fig. 11. A single integrated circuit having two op. amps formed on the same silicon chip mounted in a single dual-in-line pack was selected for use. There are now several of these dual op. amps commercially available at modest cost; in fact the price of a dual amplifier is very little more than that of a single amplifier and this makes multi amplifier circuits economically attractive.

In the circuit a frequency compensating capacitor of value 4,700 pF is connected to the input lag compensating terminals of the amplifier used as an integrator. No frequency compensation is applied to the amplifier acting as the comparator. Diode clipping, using a 470  $\Omega$  resistor and four silicon diodes, is employed to accurately define the comparator output swing ( $V_0^+$  and  $V_0^-$ ).

The oscillograms (Fig. 12) show the triangular and square waveforms produced by the circuit using various values for  $R_3, R_4$  and  $C$ . If the circuit were to be made the basis of a function generator frequency ranges could be conveniently selected by switching in different values of  $C$  and a fine control of frequency could be obtained by using potentiometers for  $R_3$  and  $R_4$ . Unity mark-space ratio is obtained for equal values of  $R_3$  and  $R_4$ , a variable mark-space ratio for independent variation of  $R_3$  and  $R_4$ .

The circuit functions over a wide frequency range from very low frequencies of order 0.2 Hz to 100 kHz. The 5 k $\Omega$  potentiometer is used as a balance control to cancel integrator drift due to initial amplifier offsets; the adjustment is made at the lowest frequencies. With  $R_3 = R_4$  magnitude, say 2 M $\Omega$ , and  $C = 1 \mu\text{F}$  the balance control is adjusted to give a waveform with unity mark-space ratio. The effects of integrator drift are only really appreciable for the longer timing periods and if very low frequency operation is not required the

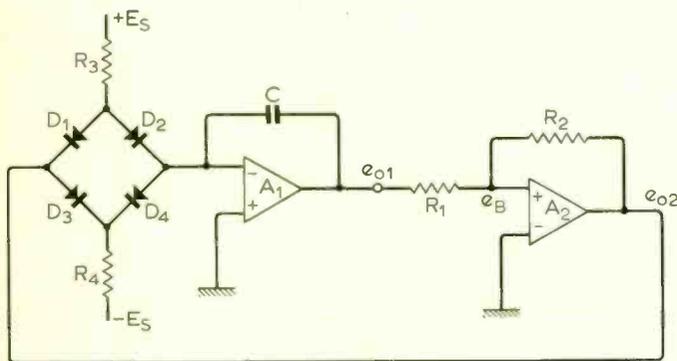
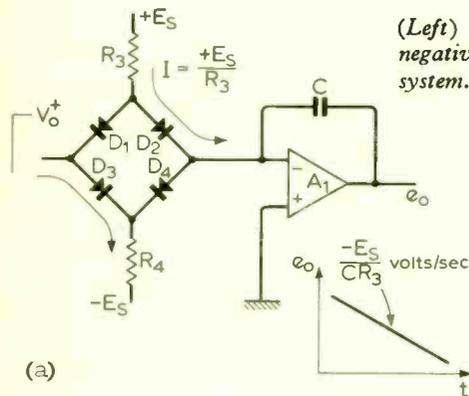


Fig. 8. Schematic for generator of triangular and square waves.

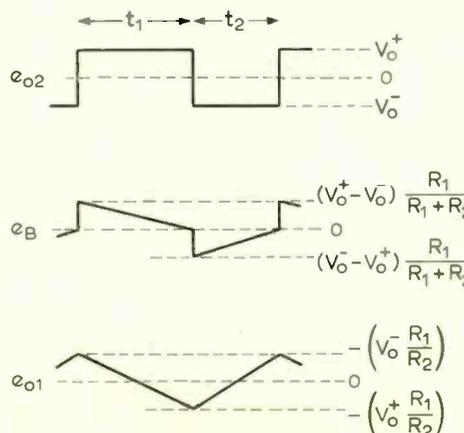


(Left) Fig. 9. Conditions for (a) positive and (b) negative levels of comparator output voltage in the Fig. 8 system.

Fig. 10. Waveforms in the triangular- and square-wave generator.

$$t_1 = (V_0^+ - V_0^-) \frac{R_1}{R_2} \frac{CR_3}{E_s}$$

$$t_2 = (V_0^+ - V_0^-) \frac{R_1}{R_2} \frac{CR_4}{E_s}$$



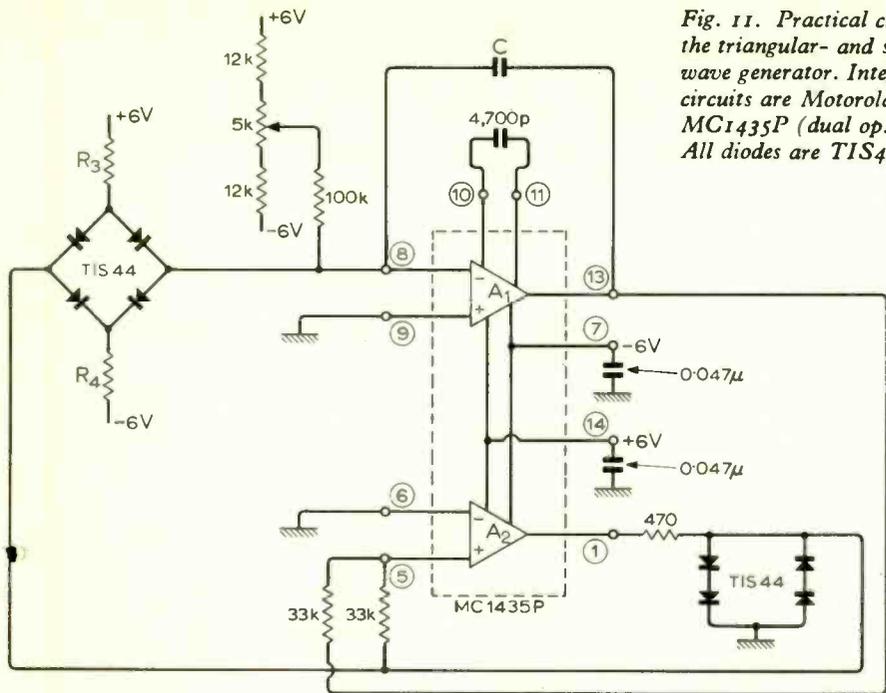
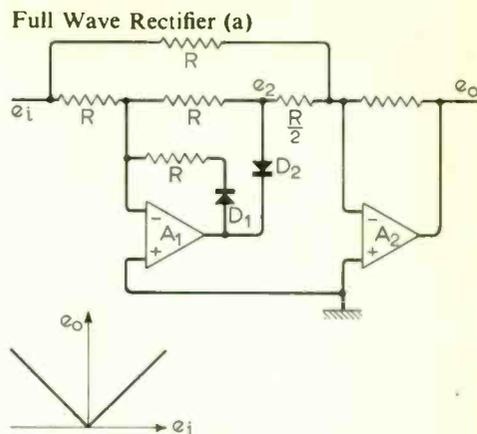
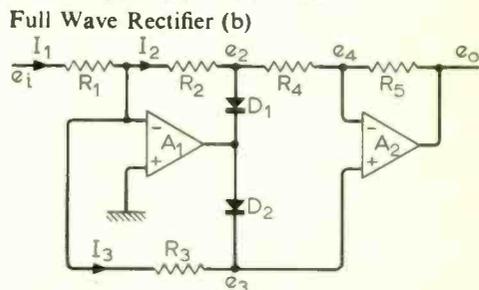


Fig. 11. Practical circuit for the triangular- and square-wave generator. Integrated circuits are Motorola MC1435P (dual op.amp.). All diodes are TIS44.



The circuit shows an arrangement commonly used to obtain full-wave rectification. The first amplifier acts as a half-wave rectifier and the second amplifier as an adder. For negative input signals  $D_2$  is reverse biased and  $e_2 = 0$ ; the output from the second amplifier is thus  $e_o = -e_i$ . For positive input signals  $D_2$  is forward biased and  $e_2 = -e_i$ . The output from the second amplifier (the adder) is thus  $e_o = -(e_i + 2(-e_i)) = e_i$ .



For positive inputs  $D_2$  is reverse biased and the two inverting amplifiers are in cascade

$$\left| \frac{e_o}{e_i} \right| = \frac{R_2 R_5}{R_1 R_4}$$

For negative input signals  $D_1$  is reverse biased and there are then two feedback paths to the summing junction of amplifier  $A_1$ , one from the output of  $A_1$  through  $D_2$  and  $R_3$  and the other from the output of  $A_2$  through  $R_5, R_4$  and  $R_2$ .

With the usual summing point restraints we have  $I_1 = I_2 + I_3$ . This gives

$$\frac{e_i}{R_1} = - \left( \frac{e_o}{R_5 + R_4 + R_2} + \frac{e_3}{R_3} \right)$$

But  $e_3 = e_4 = e_o \frac{R_2 + R_4}{R_5 + R_4 + R_2}$

$$\left| \frac{e_o}{e_i} \right| = - \left( \frac{R_2 + R_4 + R_5}{R_3 + R_2 + R_4} \right) \frac{R_3}{R_1}$$

Using equal value resistors throughout makes

$$\left| \frac{e_o}{e_i} \right|_+ = 1 \quad \text{and} \quad \left| \frac{e_o}{e_i} \right|_- = -1$$

Circuit (b) offers several advantages over (a). The current drain on the driving source is less, for in circuit (a) the input signal drives two amplifiers in parallel. All resistors may be made equal in circuit (b) and equal value resistors are easy to select for high accuracy. Circuit (b) may be adapted to summation by the connection of additional input resistors to the summing point of amplifier  $A_1$ .

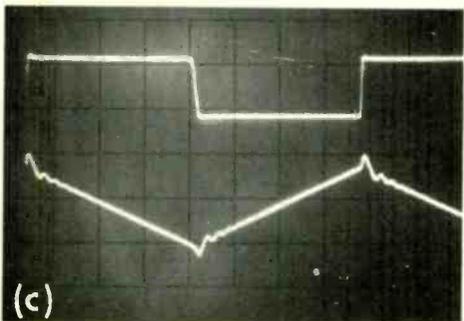
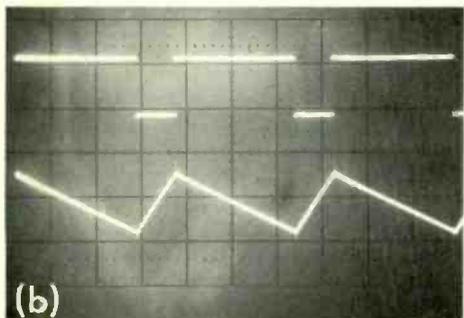
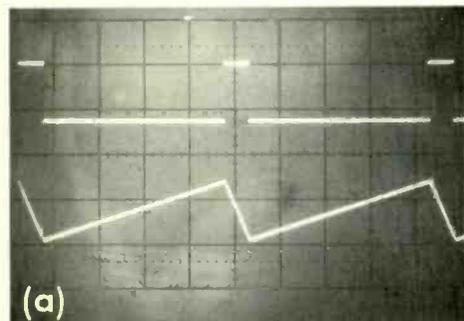


Fig. 12. Waveforms from the triangular- and square-wave generator for different values of  $C, R_3$  and  $R_4$ . In (a)  $C = 1 \mu F, R_3 = 56 k\Omega, R_4 = 680 k\Omega$ ; horizontal scale 50 ms/div. In (b)  $C = 0.01 \mu F, R_3 = 56 k\Omega, R_4 = 18 k\Omega$ ; horizontal scale 0.1 ms/div. In (c)  $C = 220 pF, R_3 = 27 k\Omega, R_4 = 27 k\Omega$ ; horizontal scale 1  $\mu s$ /div. All waveforms, vertical scale 2 V/div.

integrator balance control could well be omitted from the circuit. At the higher frequencies the output triangular wave from the integrator shows marked switching transients (Fig. 12(c)).

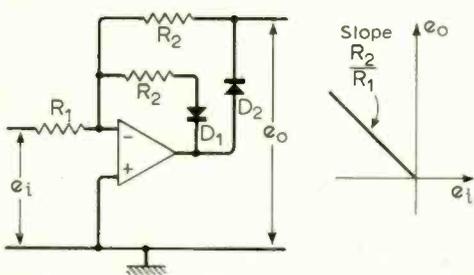
### Precise rectifiers

The following section was regrettably omitted from an earlier issue. With it we conclude Mr. Clayton's series of articles on op. amps.

The forward voltage drop across a solid-state diode can cause errors when the device is used for low-signal levels in a conventional rectification or detection circuit. Op. amps can be combined with diodes and resistors to perform almost ideal rectification.

For positive input signals  $D_1$  is forward biased and  $D_2$  is reverse biased; the output voltage is zero with output impedance  $R_2$ .

#### Half Wave Rectifier



For negative input signals  $D_1$  is reverse biased,  $D_2$  is forward biased and the output voltage is  $-e_i (R_2/R_1)$  with output impedance equal to the closed-loop output impedance of the amplifier. Dependent on the choice of  $R_2/R_1$  the circuit may be used to produce gain as well as rectification. The circuit may be adapted to summation by the connection of appropriate input resistors to the amplifier summing point. In this case the amplifier will give half-wave rectification of the sum of the input signals.

# World of Amateur Radio

## Amateur 70-cm band coveted

British amateurs are reacting sharply to repeated demands by prominent manufacturers of mobile and personal two-way business communications equipment that the mobile u.h.f. band should be extended downwards to 420 MHz, thus threatening the entire amateur 70-cm band which currently extends in the U.K. from 425 to 429 and 432 to 450 MHz. While such proposals are usually accompanied by the rider that provision would have to be made for amateurs, no suggestions have been made as to how this could be done without seriously impairing the usefulness of this important amateur band. When the 70-cm band was released in October 1948, it was then 40 MHz wide, but over the years it has been whittled down to the present 22 MHz.

Amateurs point out that they were making effective use of these allocations for many years before the mobile services made practical use of u.h.f.; indeed, amateur development paved the way for the present increasing use of u.h.f. by the mobile services. Almost all amateur television experimental work is concentrated in this band, which is also highly suitable for investigation of tropospheric propagation and for moon-bouncing.

In Region 1 (including Europe), with a few exceptions, no provision is made in the international allocation table for mobile services in the section 430 to 440 MHz; in Region 2 (including U.S.A.) and Region 3 the entire allocation 420 to 450 MHz is shared by the radiolocation and amateur services.

A pertinent indication of the potential of these frequencies for extended distances is shown by the recent breaking of the world amateur 432-MHz record by a two-way contact over the 1,185-mile path between stations K2CBA, Petersburg, N.Y., and W0DRL, Topeka, Kansas. Similarly, an amateur in Virginia recently became the first to work 20 States on this band. European activity includes frequent contacts between the U.K. and western European countries. The present width of the band is of importance in allowing regional sub-divisions and the voluntary allocation of the top 16 MHz to video transmissions for amateur television.

## Long delay echoes

The renewed interest in long delay ("cosmic") echoes reported in August in this section has

already resulted in the total of useful reports of amateur experiences of this strange phenomenon rising to almost 50. Professor Mike Villard (W6QYT), of Stanford University, is convinced that this is a phenomenon "the origin of which is crying out to be understood". The reports now range in frequency from 810 kHz up to and including 50 and 144 MHz, two frequency bands not normally associated with ionospheric propagation. The period of the echoes ranges from  $\frac{1}{2}$ -second to two reports of "super-long" delays of 5 minutes. The reports are now spaced in latitude from Canada to Peru; in longitude from Libya to the Marshall Islands; in time from 1932 to this summer. Preliminary analysis of the reports suggests that there are two main categories of echoes, one of which may be explainable in terms of retardation at the ionospheric critical frequency. The other category tends to occur at the time of opening or closing of transmission at a given frequency, when conditions are good for long distance propagation, often in times of low magnetic activity. Professor Villard (Stanford Electronics Laboratories, Radioscience Laboratory, Stanford, California) would welcome further reports from British Commonwealth amateurs.

## The Young idea?

Recently a Cardiff youngster, Robert Ellis, passed his Radio Amateurs' Examination and morse test at the age of 13 $\frac{1}{2}$  years, and thus qualified to receive his own licence at the minimum age of 14 years. (For many years, minimum British age for a full licence was 16—as your contributor who acquired an artificial aerial licence, 2BUH, at 14 and G3VA at 16 well recalls.) An F.C.C. survey of new amateur licensees in the United States has shown that over the past 20 years there have been substantial shifts to both older and younger ages for obtaining a first licence. Although the median age of newcomers is now 24.0, compared to 25.9 in 1949, 36% of them are in the age group 16 and below, compared with only 8.5% in 1949. More than half of the newcomers were found to have been introduced to amateur radio through a relative or friend who already held a licence.

During a recent 14 MHz c.w. contest, which involved an exchange of "age" in place of the usual check serial number, the majority of operators were in the late twenties and early

thirties, though an overall spread of from 17 to 60 was noted during a short period of participation.

The latest (1970) issue of the R.S.G.B. Amateur Radio Call Book includes at least a few amateurs who are known to have held the original "three letter" call signs issued before the First World War; pre-1939 call signs represent about 13% of the current licences.

## Royal Signals Society

The Royal Signals Amateur Radio Society—with a current membership of over 600 present and former members of the Royal Signals and the R.S. Territorial and Army Volunteer Reserve—is aiming to increase its membership to over 1000 by the end of 1970, which is the jubilee year of the Corps.

The Society, with members in many parts of the world, operates a headquarters station (G4RS and GB3RCS) at Blandford Camp, Dorset; produces a quarterly journal *Mercury*; operates a number of "nets" on several amateur bands and issues a number of awards. It also operates a QSL Bureau and acts as forum for and link between many wartime members of the Royal Signals, including the many amateurs who served in the various Special Communications Units, as well as those with much more recent experience in Army radio communications. General Secretary is: W.O.1 (F. of S.) J. Cooper (G3DPS), 15 Valley Road, Blandford Camp, Blandford Forum, Dorset.

**In Brief:** Overall winners of the 1969 V.H.F. National Field Day were the Mid-Essex VHF-UHF Contest Group, with the Pennine V.H.F. Group as runners-up. . . . Preparation of the Australis-Oscar V amateur satellite continues with the electronic package undergoing radio-frequency-interference, telemetry sensor calibration, vibration and thermal tests. Amsat (Radio Amateur Satellite Corporation) is seeking launch facilities for this further amateur communications satellite from the U.S. government. . . . Thailand recently withdrew its objections to amateur communication between licensed Thai stations and those in other countries. . . . French amateurs have been instrumental in securing a law which forbids proprietors of apartment buildings opposing the installation of amateur aerials. . . . The Derby society has reported its highest ever membership—654 on the nominal role, with a fully paid-up membership of 221 of whom 107 hold transmitting licences. . . . The Clifton Amateur Radio Society with a clubroom open every Wednesday and Friday at 225 New Cross Road, London S.E.14, has been planning new activities to encourage wider membership (details from R. A. Hinton, 58 Camilla Road, S.E.16). . . . A revised "band plan" for the 70, 144, 432 and 1296 MHz bands, as agreed at the 1969 I.A.R.U. Region 1 meeting at Brussels, comes into force (voluntarily) on 1st January, 1970. . . . 144 MHz contacts have been effected by means of meteor scatter between Bulgaria (LZ1BW) and Holland and Luxembourg; a French amateur, F9FT, in Rheims has contacted SV1AB of Athens on s.s.b. also by means of meteor scatter.

PAT HAWKER, G3VA

# Test Your Knowledge

Series devised by L. Ibbotson\*,

B.Sc., A.Inst.P., M.I.E.E., M.I.E.R.E.

## 19. Electronics Fundamentals

- When a particular bipolar-transistor amplifier is used to amplify a sinusoidal signal the collector current flows for approximately  $\frac{1}{4}$  of the input signal cycle. The mode of operation of the amplifier is:
  - class A
  - class B
  - class AB
  - class C.
- Select, from the types of amplifier circuits described below, one in which voltage phase inversion occurs:
  - triode—common grid
  - pentode—cathode follower
  - bipolar transistor—common collector
  - field-effect transistor—common source.
- The upper "3dB point" of one stage of a multistage aperiodic amplifier occurs at the frequency at which:
  - the reactance of the coupling capacitor is equal to the input resistance of the next stage
  - the susceptance of the coupling capacitor is equal to the total shunt conductance (formed by the output conductance of the stage combined with the input conductance of the next)
  - The total shunt capacitance (the combination of the output capacitance, the stray capacitance between the stages and the input capacitance of the next stage) has a reactance equal to the input resistance of the next stage
  - the susceptance of the total shunt capacitance is equal to the total shunt conductance.
- Considering pentodes, bipolar transistors, junction f.e.t.s and m.o.s.t.s, the "Miller effect" (by which the input capacitance of an amplifying device is many times larger when it is in operation than the "cold" value) is normally significant in voltage amplifiers using:
  - any of the four
  - bipolar transistors only
  - bipolar transistors or junction f.e.t.s but not pentodes or m.o.s.t.s
  - all except pentodes.
- The advantage of coupled tuned circuits for linking r.f. amplifiers in cascade, compared to any other form of coupling is:
  - the amplifying-device gain is greatest
  - the gain frequency characteristic is nearest to the ideal
  - unwanted feedback is reduced
  - the transformer coupling the circuits gives extra amplification.
- The power delivered to its load by a normal power amplifier is supplied
  - entirely by the d.c. supply
  - entirely by the input signal
  - partly by the d.c. supply and partly by the input signal
  - by the active device (valve or transistor).
- A low-frequency power amplifier (using a pentode or transistor, with a fixed supply potential and transformer-coupled load) will, in all cases, deliver its maximum undistorted output power to a load which has a transformed value presented to the device:
  - equal to the device output resistance
  - equal to twice the device output resistance
  - equal to half the device output resistance
  - unrelated to the device output resistance
- The use of push-pull configuration in a power amplifier has a number of advantages when compared to the use of a single-ended configuration (using in each case devices of appropriate power dissipation; the supply voltage, class of operation and power output being the same). Select from below the quoted advantage which does not apply:
  - non-linear distortion in the output may be reduced
  - an unbalanced input to the stage can be used
  - the output transformer is used more efficiently
  - the effect of variations in the supply potential is reduced.
- Complementary-symmetry circuits can be constructed using:
  - any of the normal range of active devices
  - valves only
  - bipolar transistors only
  - bipolar transistors or f.e.t.s.
- A particular amplifying device has a dynamic transfer characteristic (mutual characteristic) of which the slope increases as the output current increases. If it is used in a large-signal amplifier, over a range in which this characteristic can be regarded as parabolic, the harmonic distortion produced will:
  - be negligible
  - consist predominantly of even harmonics
  - consists predominantly of odd harmonics
  - include equal amounts of even and odd harmonics.
- The application of negative feedback to an amplifier always results in:
  - an increase in input impedance
  - an increase in output impedance
  - an increase in signal-to-noise ratio at the output
  - a decrease in the harmonic distortion produced by the amplifier.
- An emitter-follower circuit is generally used to match a high impedance output to a low impedance load. In addition it imposes on the signal:
  - a voltage and a current gain
  - a voltage gain but a current loss
  - a current gain but a voltage loss
  - a loss of both current and voltage
- When an LC sinusoidal oscillator is operating in its steady-state condition, the loop gain at the oscillating frequency must be:
  - unity
  - minus unity
  - greater than unity
  - positive, and less than unity.
- An active device with an a.c. negative resistance characteristic is connected in shunt with a parallel tuned circuit. Oscillations of finite amplitude will occur provided the maximum value of the magnitude of the negative resistance of the device for the particular bias used is:
  - zero
  - greater than the dynamic impedance at resonance of the tuned circuit
  - equal to the dynamic impedance at resonance of the tuned circuit
  - less than the dynamic impedance at resonance of the tuned circuit.
- The open-loop gain of an ideal operational amplifier should be:
  - zero
  - unity
  - 3 dB
  - infinity.
- The most common fault in the operation of directly-coupled amplifiers is:
  - drift
  - variation in the gain
  - a tendency to oscillate
  - excessive noise generation

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

# Personalities

**John M. Grocock, Ph.D.**, recently appointed director of quality control for the European area by the International Telephone and Telegraph Corporation, has been with Standard Telephones and Cables (an I.T.T. associate) since 1958 where for three years he was concerned with transistor design. In 1961 he was appointed quality assurance manager for Transistor Division and later assumed responsibility for quality and reliability at both the Harlow and Footscray semiconductor manufacturing plants. In his new appointment Dr. Grocock will assume overall responsibility for the quality and reliability of all products leaving I.T.T. factories in the European area, including the UK. Prior to joining S.T.C. he spent seven years with the Ministry of Supply after undertaking research at Imperial College for his Ph.D.

**M. H. Easy**, director of development at Decca Radar Ltd, has been awarded the annual trophy of the Radar and Electronics Association for his "outstanding contribution to the radar and electronics industry". Mr. Easy joined the Decca Navigator Company from the Royal Air Force in 1945, transferring to Decca Radar Ltd at the company's inception in 1949. As a Squadron Leader during the war Mr. Easy was responsible for the ground stations of the "OBOE" blind-bombing system which was used so successfully by "Pathfinders".

**Anthony S. Pudner, M.B.E., F.I.E.E., F.I.E.R.E.**, engineer-in-chief of the Cable & Wireless Group for the past four years has been appointed a director. Educated at the Imperial Service College, Windsor, Mr. Pudner, who is 52, joined C. & W. in 1934. His overseas service included two years (1950/2) in Korea in charge of the company's field telegraph unit. He recently became a vice-president of the Institution of Electronic and Radio Engineers. Cable & Wireless have also announced the appointment of **Peter A. McCunn** as a director. He is 46 and has been traffic manager for the past four years.

**J. C. Akerman**, commercial product manager for all semiconductor devices within Mullard's Industrial Electronics Division since 1966 and a director of Associated Semiconductor Manufacturers Ltd, has been appointed head of Mullard's Consumer Electronics Division in succession to **K. O. Rees** who has left the company. **N. Weisbloom** has become commercial product manager for all semiconductor devices in the Industrial Electronics Division. Since 1966 Mr. Weisbloom has held a similar position in the Consumer Electronics Division. The company has also announced the following appointments in the Consumer Electronics Division. **T. Jacobs, B.Sc.**, who has been with Mullard since 1953, has become technical commercial manager of the division. Latterly Mr. Jacobs has been manager of the technical services department of the division. **L. B. Johnson, B.Sc., M.I.E.E.**, becomes commercial product manager for all semiconductor devices in the division. He joined the company in 1942 and was at one time manager of the quality and reliability laboratory at Mullard, Southampton, and latterly was commercial product manager for i.c.s in the Industrial Electronics Division.

**Wilfrid John Fry, M.I.E.R.E.**, has been appointed managing director of the Electronic Instrumentation Group of Bell & Howell Ltd. Mr. Fry, who is 42, joined the company in 1962, having previously spent thirteen years with the Solartron Electronic Group.

**P. J. N. Collaro** has joined E.M.I. as marketing director for the electronics and industrial operations and is responsible for the direction and development of marketing policy for all the companies and divisions within the organization: S.E. Laboratories (Holdings), Precision Electronic Terminations (E.M.I.), Nickols Automatics (E.M.I.), Ardent, Tape Manufacturing Co., E.M.I. Tape, Ferial Organization, and the six divisions of E.M.I. Electronics. Before joining E.M.I. Mr. Collaro was the marketing director for Leasco and

was previously managing director of the European division of K.L.H. Research and Development Corp.

**Welwyn Electric** of Bedlington, Northumberland, has announced the appointment of **G. R. Latham, B.Sc., F.I.E.E.**, as divisional manager of its newly formed Interconnections Division. Mr. Latham has latterly been working for the Plessey Co. where he was employed as engineering manager, microelectronics, at their Swindon factory. Prior to that he was with Ferranti Ltd., for fourteen years. In his new capacity Mr. Latham will be responsible for implementing the agreement recently signed between Welwyn and Sanders Associates Inc. of New Hampshire, U.S.A., under which Welwyn will produce the range of flexible, rigid and multi-layered circuit boards developed by the Flexprint Division of Sanders.

**A. L. Dow, B.Sc.(Hons)**, has joined Coutant Electronics Ltd as a development engineer in the Power Supply Division. Prior to joining Coutant Mr. Dow worked for two years in the Micro-electronics Division of E.M.I. From 1962 to 1967 he undertook a 1-3-1 year sandwich course spending the middle three years at Southampton University studying for his degree in electronic engineering.

**Michael G. Shortland, M.Sc.Tech.**, who is 35, and a graduate of Manchester University where he took first class honours in electrical engineering in 1956 and received his Master's Degree the following year, has been appointed manager of the Control and Automation Division of the Electrical Research Association. In 1963 he joined BISRA (now the Inter Group Laboratories of the British Steel Corporation) from the U.K.A.E.A., Winfrith. At BISRA he first headed the Control Dynamics Section but in 1964 took charge of the newly formed Automatic Control Section. In May 1967 he was additionally appointed chief engineer (automation).

**Kenneth O. Rees**, who recently resigned his directorship with the Mullard Company (which he joined in 1947), has been appointed director of marketing in the Plessey Components Group. Mr. Rees, who is 46, is currently chairman of the British Radio Valve Manufacturers' Association and is the Association's representative to the Conference of the Electronics Industry.

**Jack Hale, B.Sc.(Eng.), M.I.E.E.**, appointed managing director of Hytron Ltd, of Crowborough, Sussex, served his apprenticeship with B.T.H. from 1948-53 and rejoined B.T.H. as project engineer following his service in the R.N.V.R. From 1959-64 Mr. Hale was with PE Consulting Group Ltd, as a management consultant, before joining Feedback Ltd as production

manager. In 1965, he became production director and in 1968, was appointed a director of Feedback Inc., U.S.A. Hytron also announces the appointment of **Arthur Thomas, M.Inst.M.C.**, as marketing director. He was for some time with Muirhead & Co. Ltd, as sales engineer and then spent six years as sales manager of Muirhead Inc., in Canada and the U.S.A. In 1967 he became the European manager of Telautograph Inc. of Los Angeles. **G. P. Gates** has also joined the board as director of development. Mr. Gates was a founder of Hytec Corporation, Los Angeles, consulting engineers and manufacturers of control equipment. He remains a director of Hytec Corporation, although he has moved to England to supervise the development of Hytron's new range of handwriting transmission systems and computer peripherals.

**R. M. A. Jones** has been appointed to the central management of Pye of Cambridge Ltd, as director of planning and administration. He joined Pye in 1933 and became managing director of Pye Group (Radio & Television) Ltd and chief executive of the Consumer Products Division in 1966. Throughout the war he served in the Royal Corps of Signals and was at the time of demobilization Lt.Col. on the staff of the Chief Signals Officer of the 1st Corps. Mr. Jones is also appointed chairman of Pye Group (Radio & Television) Ltd, thus retaining his link with this activity. In succession to Mr. Jones, **J. T. Griffiths**, joint managing director of TV Manufacturing Ltd, has been appointed managing director of Pye Group (Radio & Television) Ltd and chief executive of the Consumer Products Division.

**K. P. Kenny** is appointed marketing manager of the Marine Division of Dymar Electronics Ltd, of Watford. After service at sea and ashore for a major shipping line Mr. Kenny has spent five years with Cossor Electronics Ltd.

## Obituary

**Raymond Dorrington Bangay**, who retired from the Marconi Company in 1957 after over 54 years' service with the company died on October 29th. Born in 1883, he joined Marconi in 1902 and later that year went to America to help with the installation of radio stations. On his return to England in 1907, he started his study on the military uses of wireless, which included the first experiments in air-to-ground communications. From 1921 to 1925 he was chief of designs. Subsequently, he changed his orientation from design to exporting and from 1935 until his retirement was foreign manager.

# New Products

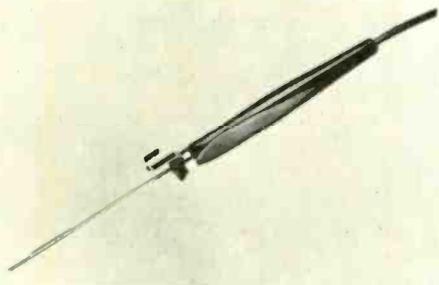
## Sub-miniature Power Supplies

A Belclere sub-miniature encapsulated stabilized power supply is now available from Electronic Component Services (Worcester) Ltd. The new hermetically sealed unit is designed for printed-circuit mounting and has a low ripple voltage. There are four types available, with a maximum ripple voltage of  $500\mu$  V. r.m.s.—P.S. 2009 (output 9V at 40mA), P.S. 2012 (output 12V at 30mA), P.S. 2015 (output 15V at 20mA) and P.S. 2020 (output 20V at 15mA). Overload point is at 5mA above rated output. Voltage drop at rated load is less than 150mV. Output voltages are  $\pm 5\%$ . Dimensions of the supplies are 60mm long by 37mm wide by 25mm high. Typical prices are: 1-9 at £3 5s each or, quantities from 50-99 at £2 9s 6d each. Non-standard types of these power supplies can be made to order. Electronic Component Services (Worcester) Ltd, 63-66 Foregate Street, Worcester.

WW309 for further details

## Lightweight Soldering Iron

A low-voltage lightweight soldering iron, the Tip-Touch is available from Midland Electronics. This 6W iron requires 6V a.c. or d.c. and maximum bit temperature is  $320^{\circ}\text{C}$ . Three sizes



of interchangeable bits are available with diameters of  $\frac{1}{16}$ ,  $\frac{1}{32}$ , and  $\frac{1}{8}$  in. The shaft is stainless steel. Lead length is five feet. Midland Electronics Ltd, Cogenhoe, Northampton.

VW317 for further details

## Portable A.F. Power Meter

A portable battery operated a.f. power meter, type 85, has been designed by Dymar Electronics to provide a wide power measuring range, wide frequency response and high accuracy both of the terminating impedance and measured power. Twelve power ranges in 1, 3, 10 sequence give full-scale readings from  $100\mu$  to W 30W and an



auxiliary dB scale allows direct readings in dBm (0dBm—1mW) from  $-20\text{dBm}$  to  $+45\text{dBm}$ . A feature of the instrument is a temperature compensated "square law" detector which gives true power reading irrespective of waveform. There is a choice of 30 input impedances arranged in three decades from  $1.25\Omega$  to  $1,000\Omega$  each one being accurate to 2% and capable of dissipating 50 watts. The frequency range is 30Hz—30kHz; accuracy is 3% between 100Hz and 10kHz. The integral power supply is monitored by a press-button switch on the front panel. The batteries are two PP1 power packs which give a typical operating time of 800 hours. The U.K. price, including batteries, is £125. Dymar Electronics Ltd, Colonial Way, Radlett Road, Watford, Herts.

WW301 for further details

## 100-watt Broadband Linear Amplifier

A modular solid-state 100-watt broadband linear amplifier which operates in the 2-32MHz range and weighs only 1kg has been developed by E.M.I. Electronics Canada Ltd. Units can be used singly or combined in parallel for power outputs of from 100 watts up to many kilowatts. Power required is  $-24\text{V d.c. } 11\text{A}$ . Each unit is

compatible with the h.f. transmitter used with the "Manpack" system, as well as with transmitters used in mobile, airborne and fixed ground stations. The complete amplifier is contained in a single module measuring approx.  $300 \times 60 \times 50$  mm. Receptacles for power and r.f. input and output are located on the face of the module. The rear panel is used to dissipate heat, and various methods of heat dissipation may be used. These include water or air cooling for large systems and pannel or plate mounting for smaller systems. E.M.I. Electronics Canada Ltd, P.O. Box 1005, Dartmouth N.S., Canada.

WW319 for further details

## Monitor Diode Supply

For monitoring the r.f. output of radar transmitters operating in the 1-12MHz band the English Electric Valve Co. has produced the type BS600 monitor diode supply and indicator unit. Provision is made for monitoring either by a built-in meter which gives a reading proportional to the mean r.f. power input to the diode, or by feeding the demodulated r.f. pulse envelope to an external oscilloscope, in order to read the peak power accurately. Supplies for the diode anode and heater are taken from sockets on the front

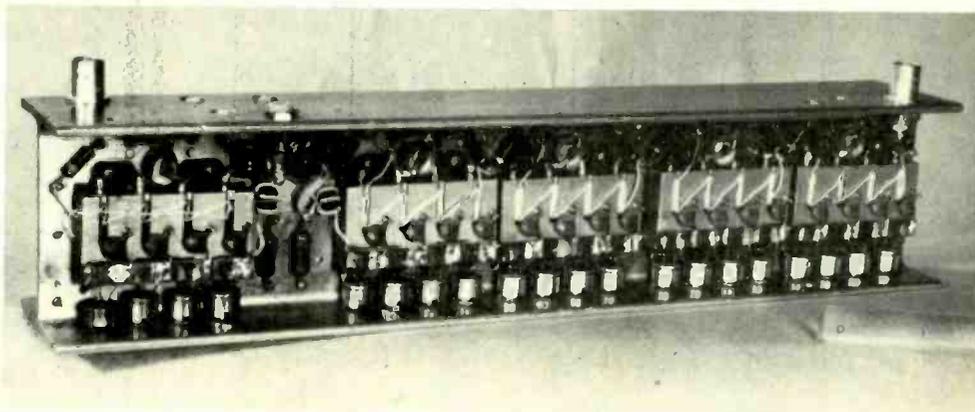


panel of the instrument. A heater-voltage control, also on the front panel, provides for adjustment of the diode heater-voltage for all conditions of r.f. input. The correct diode load-resistance is built into the unit. English Electric Valve Co. Ltd, Chelmsford, Essex.

WW302 for further details

## Circuit Board Faultfinder

A low-cost unit for production-line testing of circuit boards and many types of electrical and electronic sub-assemblies, and known as Testmatic TM60, is being produced by Wayne Kerr. It makes up to 59 measurements in 4 seconds and gives unskilled operators a clear indication of 'O.K.', 'High' or 'Low' together with the location of any defective test point. Programming is quick and easy, the board for this serving also as the test jig. All checks can be pre-set for acceptance within any limits from  $\pm 1\%$  to  $\pm 50\%$ . The basis of the





tests is d.c. voltage checks and any subsidiary signals, circuits or supplies can be fed into the TM60 at the rear of the unit or embodied in the programme board.

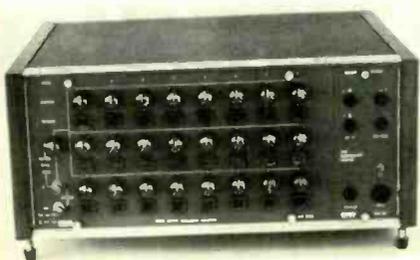
Intermittent faults can be detected by switching the instrument to a continuous repetition of the test programme, with an audible warning device operating when the defect arises. Outputs are provided for operating external alarms, sorting or counting mechanisms. Price is £695. Wayne Kerr Co. Ltd, New Malden, Surrey. WW318 for further details

### Wet Tantalum Capacitors

A range of wet tantalum capacitors is available from General Instrument (UK). The capacitors have low leakage current, long life and small physical size. Capacitance values range from 1.7 to 560.0 $\mu$ F and working voltages from 6 to 125V. The operating temperature range is -55°C to +85°C at the full-rated voltage or +125°C at 65% of nominal voltage. Surge voltage can be 115% of rated voltage. The capacitors will withstand at least 2,000 hours' operation at the rated temperature and d.c. voltage and meet MIL-C-3965 /D and 4F, DEF 5134-A5, AEC and SEN specifications. Three different cylindrical case sizes are used throughout the range of electrical specifications. General Instrument (U.K.) Ltd, Industrial Components Division, Stonefield Way, Victoria Road, South Ruislip, Middx. WW307 for further details

### V.L.F. Frequency Analyser

Aim Electronics have announced a third-octave frequency analyser (TOF 260A) with a frequency range extending from 0.5Hz up to 100kHz and covering any eight octaves in this frequency range. The octaves covered are pre-set to customer requirements. The unit consists of twenty-four filters, each covering one-third of an octave, designed in accordance with B.S.2475:1964 (which recommends centre frequencies and equivalent bandwidths of the filter elements). Each filter may be attenuated by 0-100% by adjustment of a ten-turn calibrated potentiometer. The outputs from all the filters may be selected by adjustment of the attenuators. Typical applications include extraction of third-octave information from unknown waveforms and simulating the characteristic noise



of any low-frequency excitation (e.g. vibrations) by selective filtering of white noise. Price: £600. Aim Electronics, Bar Hill, Cambridge.

WW316 for further details

### Variable Temperature Soldering Iron

The W-TCP-2 variable-temperature soldering pencil from Weller Electric, is a small lightweight 20-watt iron that can be run at any temperature range from 200°F (93°C) to 450°F (233°C). The required temperature is selected on a control unit



which gives a 24-volt feed into the iron from a 230-volt mains input. Price, including the continuously-variable temperature-controlled soldering pencil, the control unit and one tip is £23. Extra tips are 8s each. Weller Electric Ltd, Redkirk Way, Horsham, Sussex.

WW306 for further details

### Plastic Encapsulated A.F. Transistors

Two pairs of plastic encapsulated silicon transistors for use in 20W and 35W complementary audio amplifiers have been introduced by Motorola. The four transistors are encased in a compact Thermopad package (Motorola case 90) for easy mounting and efficient heat transfer. The n-p-n MJE205 and p-n-p MJE105 are 5A transistors for use in complementary audio amplifiers delivering up to 20W. They have a  $V_{ce0}$  of 50V, power dissipation of 65W and high current gain of 25 to 100 at a collector current of 2A. The n-p-n MJE2801 and p-n-p MJE2901 are 10A devices for use in complementary audio amplifiers with outputs of up to 35W. They have a  $V_{ce0}$  of 60V,  $P_d$  of 90W and high current gain of 25 to 100 at a collector current of 3A. Application notes AN433 and AN427 are available, describing respectively a 20W and a 35W amplifier using these transistors. Motorola Semiconductors Ltd, York House, Empire Way, Wembley, Middx. WW335 for further details

### Plug-to-Jack "T" Adaptor

The r.f. components division of Sealectro have introduced a new 75 $\Omega$  sub-miniature "T" adaptor. Designated Conhex 50-185-0019 it is designed for screw-on mating engagement and will permit two cable-mounted plugs to be connected



in series—the third leg accommodating a cable mounted jack. This third leg employs a knurled coupling nut in place of the usual hexagonal arrangement and allows repeated disconnection. The adaptor has a gold plated body and contacts, and Teflon insulators. Sealectro Ltd, Farlington, Portsmouth, Hants.

WW303 for further details

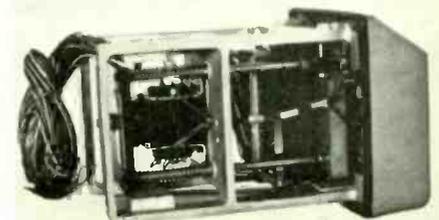
### Encapsulated Power Supplies

Philbrick/Nexus Research offers two encapsulated power supplies with 0.01% regulation for either 115V a.c. or 230V a.c. power lines. Model 2203 has a  $\pm 15V \pm 100mA$  output, the 2204 a  $\pm 15V \pm 50mA$  output. These power supplies have 0.005% load regulation and less than  $\pm 40$  p.p.m./°C temperature coefficient. The unit is short-circuit protected and has automatic overload tracking. The units are capable of output trimming (optional) to  $\pm 15.00$  V or without trimming the units will put out  $\pm 15V \pm 0.03V$ . Model 2203 costs £30 (1-9) and model 2204 £23 (1-9). Philbrick/Nexus Research, 81a North Street, Chichester, Sussex.

WW308 for further details

### Card Programmed Switching Matrix

The Sealectro SCR1010 is a multiple switching device which can be programmed in seconds by the insertion of a pre-punched plastic card. The device contains 100 individually operated single-pole switches which, prior to insertion of a card are at an open setting. Any number of cards may be



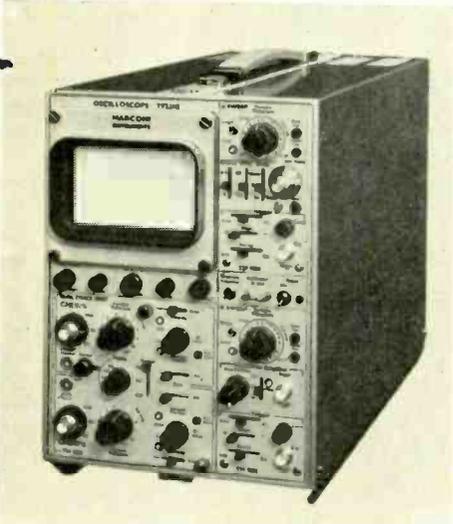
programmed by pre-punching with up to 100 holes, corresponding to the switch positions, and stored ready for use. When a particular programme is chosen, the appropriate card is inserted in a slot in the switching device which then automatically senses the card and closes the switches corresponding to the punched holes. Interlocks prevent operation from an incorrectly punched or misorientated card.

The switches are rated at 250mA 50V d.c., and the complete unit has a guaranteed life in excess of 1,000,000 operations. Programming Division, Sealectro Ltd, Walton Road, Farlington, Portsmouth, Hants. PO6 1TB.

**WW327 for further details**

## Wideband Oscilloscope

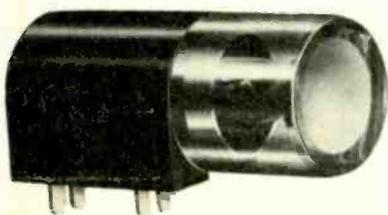
Features of the Marconi TF 2210 wideband oscilloscope include dual timebase, delayed sweep facility, dual trace with internal triggering from either of two identical Y channels and sensitivity of 50mV/cm from d.c. to 100MHz. In conjunction with the two identical timebase generators, the delayed



sweep facility can be used for detailed examination of virtually any part of any waveform. The same waveform can be displayed for examination on a fast delayed sweep or a slow delaying sweep or examined simultaneously in both fast and slow sweep forms on separate traces. By means of a dual trigger delay, a controlled double image can be displayed for comparison of one part of a waveform with another. With long delay times, jitter can be obviated completely by use of gated delay. Combination of the dual timebase facility with the dual trace Y input system allows two different waveforms to be viewed at two sweep speeds. The result is a highly informative display comprising four separate traces. Marconi Instruments Ltd, St. Albans, Hertfordshire. **WW325 for further details**

## Signal Lamp

Designed for mounting directly onto a printed circuit assembly, a recently introduced Bulgin signal lamp has four mounting pins on 0.1 x 0.3in (2.54 x 7.6mm) centres and thus fits proprietary boards having a 0.1 in standard matrix. The



lamp body has a maximum working rating of 30V at 0.5A and accepts two different lens types—domed end or flat end (as shown in accompanying illustration). Both types of lens are a push fit on the body and are available in a choice of five transparent colours, red, amber, green, blue and water clear, and five translucent colours, red, orange, green, blue and white. The lamps have order numbers D965 (transparent) and D966 (translucent) for flat lens, D967 (transparent) and D968 (translucent) for domed lens. A. F. Bulgin & Co. Ltd, Bye-Pass Road, Barking, Essex.

**WW330 for further details**

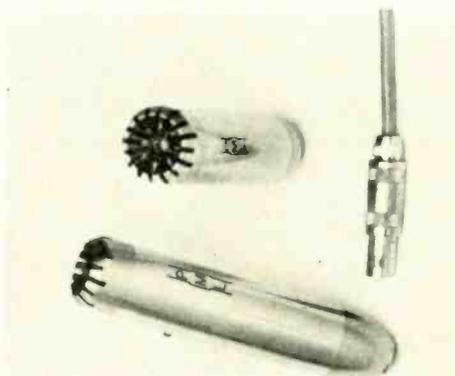
## Miniature V.H.F. Paging Receiver

Weight, including rechargeable cells, of the crystal-controlled Type CO.442 Tele-Tracer v.h.f. pocket receiver is just over 100g (3½ ounces). Four different paging facilities can be supplied: tone only; tone and light; light only; tone and speech. A prefocused lamp of special design enables the light signal to be seen in daylight. Three types of power supply are available: a rechargeable cell which is automatically recharged when the receiver is placed in a charging rack; a throw-away mercury battery cassette which can be recharged whilst detached from the receiver. The receiver conforms with the new G.P.O. regulations for v.h.f. pocket paging systems which come into force in January 1970, and is made by Cass Electronics Ltd, White Hart Yard, Guildford Street, Chertsey, Surrey.

**WW328 for further details**

## Miniature Condenser Microphone

A miniature microphone manufactured in Sweden by the Pearl Microphone Laboratory weighs 40g, is only 75mm long x 18mm diameter and incorporates an f.e.t. amplifier. A supply of 0.5 to 0.8mA at 67.5V is required but because of the wiring



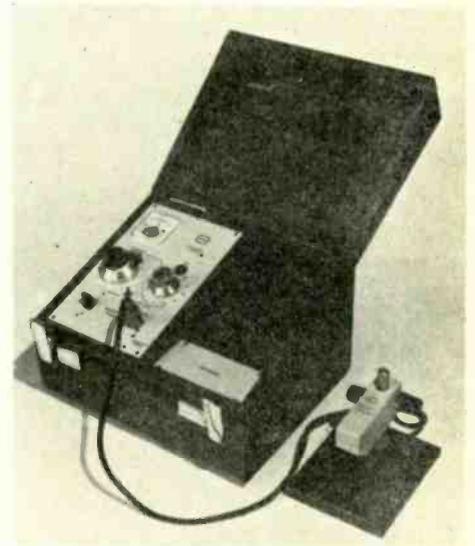
arrangements used only a 2-core flexible cable is required. Frequency response is from 30Hz to 20kHz, dynamic range is 126dB and sensitivity, at 1dyne/cm<sup>2</sup> 100mN/m<sup>2</sup> is -50dB. The case and cartridge are designed so that noise is not produced by the microphone rubbing against clothing. This microphone is available with an omni-directional response

pattern (Type DC-20) or a cardioid pattern (Type DC-21). Both types are supplied with a 20ft cable and a stand adaptor. Jagor Interelectric Ltd, Mercury House, Hanger Green, Ealing, London W.5.

**WW326 for further details**

## Resistivity Bridge

The battery operated Radley MkIII resistivity bridge is designed to measure the resistivity of semiconductor materials in the range 10<sup>-2</sup> to 10<sup>4</sup> ohm-cm. Integrated circuit operational amplifiers are used with a pulse counting phase discriminator for accurate null detection. The null indicator—a centre zero microammeter—is



driven by the phase discriminator operating in a digital mode so that directional proximity of the null is also indicated. Bridge accuracy of ±1% is claimed. A simple four-in-line configuration is used in the probe system for which low cost replaceable contacts are available. Soil resistivity may also be measured by changing the probe head for an array of earth spikes. The bridge costs £245. J. A. Radley (Laboratories) Ltd, 220 Elgar Road, Reading, Berks. **WW331 for further details**

## 100-W Audio Amplifier

A feature of the Centurion audio amplifier is that its power output of 100W r.m.s. across 4Ω may be open- or short-circuited without adverse effect. Four input channels are provided, each with an individual volume control and suit a wide range of signal source levels from 1mV to 20V. The input channels are electronically mixed by separate circuits, and the final output may be adjusted with treble, bass and master

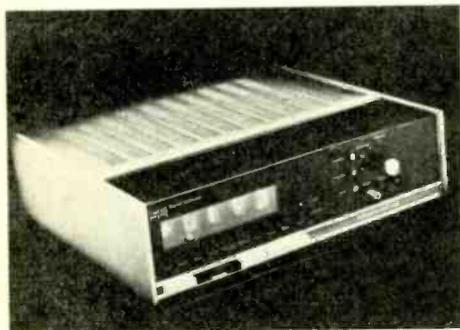


volume controls. Overall frequency response is 20Hz to 20kHz  $\pm 1$ dB. Signal-noise ratio is less than 70dB and harmonic distortion at 1W and 100W is less than 0.1% and 1%, respectively. The Centurion is listed at £99 and is available from Adastra Electronics Ltd, 167 Finchley Road, Swiss Cottage, London N.W.3.

**WW324 for further details**

## Digital Voltmeter

The SM212 digital voltmeter has a full scale indication of  $\pm 9999$  and measures up to 1kV in five steps: 100mV, 1V, 10V, 100V and 1kV. Resolution is  $10\mu\text{V}$  at the 100mV step. The first three steps up to 10V are direct reading and the input impedance is more than  $1000M\Omega$ . The input voltage at the other two steps is attenuated and input



impedance is  $10M\Omega \pm 0.1\%$ . Accuracy on the direct steps is  $\pm 0.01\% \pm 1$  digit, and on the attenuated steps it is  $\pm 0.015\% \pm 1$  digit. Digitization time is 30ms and the display consists of four in-line side view numerical indicator tubes with integral decimal points, and one side view polarity indicator. The SM212 which has a common mode rejection of more than 140dB is available from SE Laboratories (Engineering) Ltd, North Feltham Trading Estate, Feltham, Middlesex.

**WW323 for further details**

## Storage Cathode-ray Tube

The Type E714B direct view storage c.r.t. introduced by E.E.V. is intended for use in oscilloscopes, and incorporates the electrostatic method for flood-gun and writing-gun focus and for deflection. The tube has a robust storage layer and uses an aluminized P31 screen. In the storage mode, typical light output is 175 ft-lamberts. Variable persistence gives a choice of storage time from several minutes to less than one second. With the flood gun switched off and provided no further writing is applied, storage time extends to several days. The

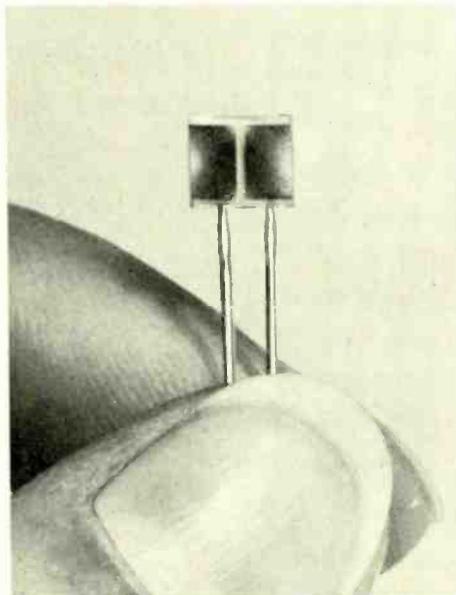


tube has a writing speed in the storage mode of  $0.5\text{cm}/\mu\text{s}$ , a deflection sensitivity of approximately 12V/cm in both axes, at a writing beam voltage of 1.5kV, a typical line width of 0.4mm in the c.r.t. mode. The English Electric Valve Co. Ltd, Chelmsford, Essex.

**WW329 for further details**

## A.C. Microvoltmeter

The Comark a.c. microvoltmeter type 1251 has a maximum sensitivity of  $30\mu\text{V}$  f.s.d. with a resolution of  $0.30\mu\text{V}$  per scale division on a scale length of 120mm with d.c. output. The instrument has 12 fixed calibration ranges covering  $100\mu\text{V}$  f.s.d. to 30V f.s.d. Sensitivity is continuously variable up to a maximum of  $\times 3$  on all ranges. The variable sensitivity control does not affect the calibration of the instrument on fixed ranges. The input impedance is greater than  $5M\Omega$  in parallel with 20pF on the most sensitive ranges, increasing to  $10M\Omega$  in parallel with 20pF on the less sensitive ranges. Response is flat from 10Hz to 20kHz on  $100\mu\text{V}$  range, 10Hz to 50kHz on  $300\mu\text{V}$  range, and 3Hz to 200kHz on the remaining ranges with  $-3\text{dB}$  points at 50, 200 and 500kHz respectively. Accuracy is given as  $\pm 3\%$  of f.s.d. and the instrument, which measures average value, is calibrated to indicate the r.m.s. value of sine waves. A d.c. output, proportional to meter reading, of 1V for f.s.d. at 2mA is provided, permitting the instrument to be used as an a.c./d.c. converter for digital voltmeters, etc. Comark also produces a similar a.c. millivoltmeter type 1241 but this has no

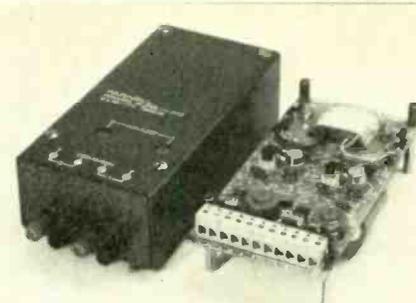


variable sensitivity. It covers the range from 1mV f.s.d. to 300V f.s.d. in 12 ranges with a flat response from 3Hz to 200kHz ( $-3\text{dB}$  1Hz to 500kHz). The normal response time is less than 0.1s extending to approximately 2s for low-frequency measurement. Both instruments are battery powered. Comark Electronics Ltd, Brookside Avenue, Rustington, Littlehampton, Sussex.

**WW304 for further details**

## Op. Amp. Power Supply

Farnell's A15 power supply has two nominal outputs arranged to provide 15V-0-15V at 100mA. Each output can be varied over the range 12V to 17V. Alternatively, the outputs may be connected in series to obtain



24V to 34V. Two separate controls are provided and effect both ganged adjustment and independent variation of one output. Stability during zero to full load variation and  $\pm 10\%$  mains change is better than 2mV. Ripple and noise content is less than 1mV p-p. Protection is afforded by means of cut-back and current limiting circuitry and mains fuse. The unit may be purchased as a printed circuit card at a price of £18 or as a modular sub unit with cover, mains lead and terminals for £20. Farnell Instruments Ltd, Sandbeck Way, Wetherby, Yorkshire.

**WW322 for further details**

## Plastic S.C.R.s

Transiiron Electronic Ltd has introduced a range of low-cost silicon planar s.c.r.s in a particularly rugged TO-92 plastic package. These devices are ideally suited to lamp and solenoid driving, sensing and timing applications and for motor control and other industrial and consumer switching problems. Designated 2N5060-64, there are 30V, 60V, 100V, 150V and 200V types with peak pulse currents up to 40A and extended blocking voltage capability up to 300V. Other versions with tightened or relaxed specifications for gate-trigger current are also available. Moisture resistance is to Military Standard 202C (Method 106B) and the packages are tested for thermal and mechanical stress, including constant acceleration to 40,000g on each axis for 32 hours, vibration shock and simulated fall, and corrosion resistance. Transiiron Electronic Ltd, Gardner Road, Maidenhead, Berks.

**WW320 for further details**

## Signal Generator-Synthesizer

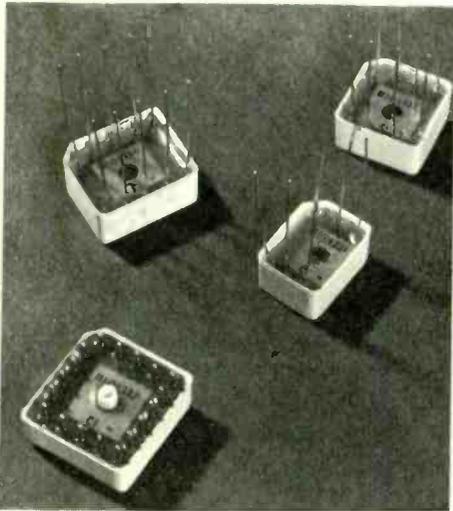
The French Adret Codasyn 201 combines the functions of a signal generator (modulation, attenuation and sweep) with the accuracy of a synthesizer (digital frequency selection and coherent spectrum derived from a crystal controlled oscillator) and is intended for use as an exceptionally accurate and stable coherent frequency source over the range 0.1Hz to 2MHz. The instrument incorporates a very stable crystal oscillator in a proportionally controlled oven followed by a phase locked harmonic generator and digital circuits using what is claimed to be a unique frequency synthesis design. Digital dividers provide a spectrally pure output whose frequency stability is  $\pm 1 \times 10^{-7}/\text{day}$ . Higher stability of  $\pm 2 \times 10^{-9}/\text{day}$  is optional. Output frequency is controlled by eight digital dials with resolution to 0.1Hz. In addition, a calibrated search or interpolation oscillator provides smooth

frequency control between all digital steps up to 100kHz. Resolution and stability of this oscillator permit a meaningful setting of 0.001Hz. A separate calibrated variable oscillator covers the band 0.1Hz to 2MHz without range change. High level output voltage is  $+13\text{dBm} \pm 0.5\text{dB}$  (1V r.m.s.) into  $50\ \Omega$  for c.w. and f.m. modes, or  $+7\text{dBm} \pm 0.5\text{dB}$  (0.5V r.m.s.) into  $50\ \Omega$  for the a.m. mode. Attenuated output is  $-1\text{dBm} \pm 0.5\text{dB}$  (0.2V r.m.s.) into  $50\ \Omega$  for c.w. and f.m., or  $-7\text{dBm} \pm 0.5\text{dB}$  (0.1V r.m.s.) into  $50\ \Omega$  for a.m. Frequency response is within  $\pm 0.5\text{dB}$  over the entire frequency range. The Adret Codasyn 201 is marketed in the U.K. by Racal-Electronics Ltd, Western Road, Bracknell, Berkshire.

**WW321 for further details**

## Ferrite Packages

A range of packages for handling and mounting small and awkward shaped pieces of ferrite has been developed by the Industrial and Electronic Components Division of Plessey. The packages—'Maxi Packs'—can be used where circuit-board area and space are not at a premium. The ferrite circuitry, built by Plessey according to the particular requirement, is

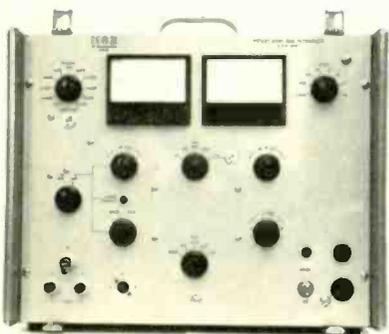


encapsulated in a resin block which is finally enclosed in a plastic box. As the electrical contacts to the component are made via either terminal spills or printed-circuit termination pins, all of which are on one face of the box, mounting in either the upright or inverted positions is easy. They are available in ten sizes. Plessey Co. Ltd, Swindon, Wilts.

**WW312 for further details**

## Transistor and Diode Tester

Model RK66 is another tester in the range supplied by K.S.M. Electronics Ltd, and

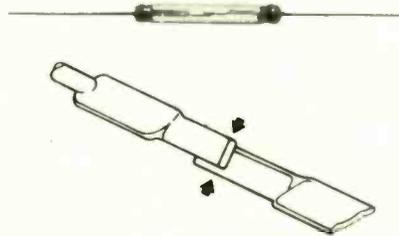


the instrument has the following specification. **Transistor measurements:** leakage current, 1 nA and above; collector current, 1 nA to 2A f.s.d.; collector voltage, 0-12V; base current, 0-150mA; and  $h_{fe}$  (1kHz); 0-1500. **Diode measurements:** forward voltage drop (at 2A) 0-12V d.c.; reverse voltage, 0-1kV d.c. f.s.d.; and reverse current, 10 nA and above. K.S.M. Electronics Ltd, Bradmore Works, Bradmore Green, Brookmans Park, Herts.

**WW332 for further details**

## Novel Reed Switch

A magnetic reed switch manufactured by the Gordos Corporation of the U.S.A., and marketed in the U.K. by B & R Relays, contains blades twisted from their normal planes which open and



close using a sliding or wiping action. This wiping action maintains low contact resistance, and contact bounce is reduced to some 70 $\mu\text{s}$  (compared to a standard time of about 1ms) giving increased life. Contact resistance of 100m $\Omega$  remains relatively stable throughout the life of the switch which is in the region of more than  $10^6$  operations. Maximum operating time is 50 $\mu\text{s}$  and maximum contact rating is 0.5A at 150V d.c. Two models are available, designated MR 1148 and MR 1348. Both have a nominal coil-power requirement of 50mW and identical specifications. The difference is in diameter of the glass container. MR 1148 is 2.67mm and MR 1348 is 3.2mm. Length is the same at 53mm. B & R Relays Ltd, Temple Fields, Harlow, Essex.

**WW310 for further details**

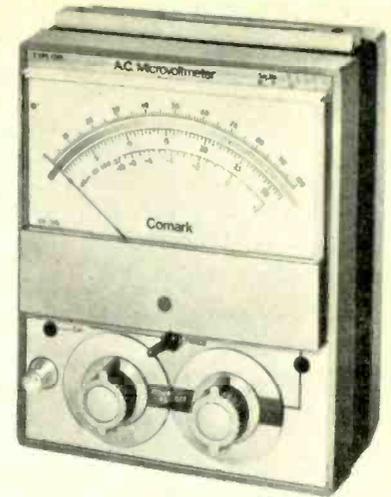
## V.H.F. Tetrodes

Two new, air-cooled, high-power, ceramic-metal tetrodes (types YL1470 and YL1480) are announced by Mullard. They have a high gain (greater than 300) that enables them to be used with solid-state drive circuits that are simpler than those needed with other high-power output valves. With a drive input of 22W the YL1470 gives an output of 6.6kW at frequencies up to 110MHz; up to the same frequency, the YL1480 requires a drive of 40W to produce an output of 12.5kW. Mullard Ltd, Mullard House, Torrington Place, London W.C.1.

**WW305 for further details**

## Sensitive Cadmium Sulphide Cell

A sub-miniature cadmium sulphide photocell is now available from Mullard. Type RPY58, it is made by a new 'monograin' construction technique that gives the cell high sensitivity and virtual freedom from initial zero drift. Other electrical parameters remain within 40% of their original values during life even when the cell is operated at maximum dissipation. The cell is encapsulated in a transparent plastic. The electrodes are very close together—about



40 $\mu\text{m}$ —and have a large area of contact. Hence, the resistance is much less than that of a conventional cadmium sulphide cell, a typical value being 600 $\Omega$  at 50 lux from a light source with a colour temperature of 2700 $^{\circ}\text{C}$ . The RPY58 has a maximum permissible dissipation of 200mW and an ambient temperature operating range extending from  $-40$  to  $+70^{\circ}\text{C}$ . It measures approximately  $6 \times 6 \times 2\text{mm}$  without its flexible leads, which are 37mm long and spaced for standard printed-circuit grids. Mullard Ltd, Mullard House, Torrington Place, London W.C.1.

**WW311 for further details**

## Non-polarized Tantalum Capacitors

A range of non-polarized solid tantalum capacitors is announced by General Instrument (UK). Designated NPMCS, the capacitors range from 0.034 to 160  $\mu\text{F}$  and standard tolerances are  $\pm 20\%$  and  $\pm 10\%$ , but  $\pm 5\%$  types are available. Typical capacitance variation with temperature is  $-4\%$  at  $-55^{\circ}\text{C}$  and  $+85^{\circ}\text{C}$  referred to  $25^{\circ}\text{C}$ . Full rated operating voltage can be applied throughout the temperature range  $-55$  to  $+85^{\circ}\text{C}$  and surge voltage over this range of temperatures can be 130% of rated voltage. These capacitors are basically two (MCS) capacitors connected cathode-to-cathode in a bakelite case. They are particularly suitable for use in circuits where the reverse voltage is too high for polarized types. General Instrument (UK) Ltd, Stonefield Way, Victoria Road, South Ruislip, Middlesex.

**WW314 for further details**

## Power Regulator Module

Emihus Microcomponents have introduced a d.c. power regulator module, measuring approx.  $60 \times 30 \times 25\text{mm}$ , which is adjustable over the range 3.5V to 30V and which will supply a load circuit of 0.6A over this voltage range without any derating. The load current may be extended up to 20A by means of external transistors. Both positive and negative types are available. The regulator is designed to withstand very large variations of input voltage and the stabilization factor is typically 1100:1 at  $V_{out}=10\text{V}$ . The operating temperature range is 0 to  $100^{\circ}\text{C}$  and the total power dissipation of the module in standard form is 6W at  $40^{\circ}\text{C}$ . Temperature coefficient is typically 0.02% $^{\circ}\text{C}$  and recovery time 50ms (for a 250mA change in load current recovering to 50mV). Emihus Microcomponents Ltd, Glenrothes, Fife, Scotland.

**WW315 for further details**

# December Meetings

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

## LONDON

- 1st I.E.E.—Discussion on "Wideband techniques and the local telecommunications network of the future" at 17.30 at Savoy Pl., W.C.2.
- 2nd I.E.E.—"The design of active filters" by Dr. A. G. J. Holt at 18.00 at 9 Bedford Sq., W.C.1.
- 4th I.E.E.—"The commercial exploitation of research and development" by J. C. Duckworth at 17.30 at Savoy Pl., W.C.2.
- 4th I.E.E.—"Computer-based telemetry systems for distribution management" by R. A. F. Smythers at 18.00 at 9 Bedford Sq., W.C.1.
- 5th I.E.E.—Discussion on "Measurements using c.r.t. displays" at 17.30 at Savoy Pl., W.C.2.
- 8th I.E.E./I.Meas. Control—"The Concorde's flying control system" by I. L. Rye at 17.30 at Savoy Pl., W.C.2.
- 10th I.E.E.—"Computer-aided instruction" by Inst. Captain G. Huggett, R.N., at 18.00 at 9 Bedford Sq., W.C.1.
- 10th B.K.S.T.S.—"The acoustics of the Royal Albert Hall" by K. Shearer at 19.30 at the Colour Film Services, Portman Close, Baker St., W.1.
- 11th I.E.E./I.E.E.—Third lecture on "Physiology for engineers" at 18.00 at St. Bartholomew's Medical College, E.C.1.
- 11th I.E.E.—"Passive satellite communications" by R. L. Harris at 18.00 at 9 Bedford Sq., W.C.1.
- 11th R.T.S.—"New large-screen television projector" by I. Lake at 19.00 at I.T.A., 70 Brompton Rd., S.W.3.
- 15th I.E.E.—Discussion on "Gallium arsenide lasers" at 17.30 at Savoy Pl., W.C.2.
- 16th I.E.E./I.E.E.—Discussion on "Non-magnetic digital recording techniques" at 18.00 at 9 Bedford Sq., W.C.1.
- 17th I.E.E.—Discussion on "Electron-optical design techniques" at 14.30 at Savoy Pl., W.C.2.
- 17th I.E.E.—Discussion on "More engineers in management?" at 18.00 at 9 Bedford Sq., W.C.1.
- 18th I.E.E.—Discussion on "Radio interference measurements" at 17.30 at Savoy Pl., W.C.2.

## BATH

- 10th I.E.E.—"Noise in transistor circuits" by P. J. Baxandall at 19.00 at the Technical College.

## BIRMINGHAM

- 11th I.E.E.—"Quasars: the most powerful transmitters in the universe" by Dr. P. J. S. Williams at 19.15 at the University.

## BOURNEMOUTH

- 2nd I.E.E.—"Electromagnetic levitation" by R. B. Owen at 18.30 at the College of Technology.
- 3rd I.E.E.T.E.—R. Aero. Soc.—"Automatic flight control" by A. J. Colwell at 20.00 at the Anglo Swiss Hotel.

## BRISTOL

- 16th I.E.E.T.E.—"Electrics & electronics in heavy industries" by A. R. S. Gough at 19.30 at Queens Bldg., the University, University Walk.

## CAMBRIDGE

- 9th I.E.E.—"Electromagnetic levitation" by H. Bolton at 19.30 at Cambridgeshire College of Arts and Technology.
- 11th I.E.E./I.E.E.—"Circuit optimization by digital computer" by J. S. Reynolds at 20.00 at Engng. Labs, Trumpington St.

## CARDIFF

- 10th I.E.E./I.E.E.—"Electronics in the nation's economy" by I. Maddock at 18.30 at U.W.I.S.T.
- 12th S.E.R.T.—"High-fidelity and public address" by J. Davies at 19.30 at Llandaff Technical College.
- 17th R.T.S.—"Loudspeakers—their history and development" by R. L. West at 19.00 at B.B.C. Llandaff.

## COVENTRY

- 4th I.E.E./I.E.E.T.E.—"Satellite communication" by J. M. Brown at 18.30 at Herbert Art Gallery.

## EDINBURGH

- 9th I.E.E./I.E.E.—"Project planning and control" by J. Brennan at 18.00 at the Carlton Hotel, North Bridge.

## EVESHAM

- 9th I.E.E.—"The Post Office Tower" by S. G. Young at 19.00 at the B.B.C. Club.

## GLASGOW

- 8th I.E.E./I.E.E.—"Project planning and control" by J. Brennan at 18.00 at the University of Strathclyde.
- 19th S.E.R.T.—"Transistors in logical circuits" by G. Roberts at 19.30 at 70 Bothwell St., C.2.

## IPSWICH

- 16th I.E.E.—"Automatic landing of aircraft" by A. W. Jolliffe at 18.30 at Great White Horse Hotel.

## LEEDS

- 2nd I.E.E.—"The management of major electronic projects" by J. W. Sutherland at 18.30 at the University.
- 9th I.E.E.—"Radar data processing techniques with application to air traffic control" by Dr. P. J. C. Child at 19.00 at the University.

## LEICESTER

- 9th R.T.S.—"Decca Navigator" by R. S. Trevelyan at 19.30 at Vaughan College, St. Nicholas Circle.

## LETCHWORTH

- 1st I.E.E.—"Colour television" by P. L. Mothersole at 15.00 at the College of Technology.

## LIVERPOOL

- 10th I.E.E.—"Information theory and code design" by S. B. Wilson at 19.00 at the University.

## MANCHESTER

- 3rd I.E.E.—"Computers and communications" by Prof. R. L. Grimsdale at 18.15 at U.M.I.S.T.
- 4th S.E.R.T.—"Ferguson colour television receiver" by K. Harris at 19.30 at the Renold Bldg., U.M.I.S.T.
- 11th I.E.E.—"Pulse code modulation" by G. H. Bennett at 19.15 at the Renold Bldg., U.M.I.S.T.

## NEWCASTLE-UPON-TYNE

- 10th I.E.E./I.E.E.—"Hybrid integrated circuits" by T. D. Towers at 18.00 at the Polytechnic.

## NOTTINGHAM

- 16th I.E.E.—"Concorde electronics" by H. Hill at 18.30 at the University.

## PORTSMOUTH

- 10th I.E.E.—"Stripline circuits in microwave equipments" by J. M. H. Chambers at 19.00 at Highbury Technical College, Cosham.

## READING

- 11th I.E.E.—"Solid state displays" by L. H. Lea at 19.30 at the University, Whiteknights Park.

## RUGBY

- 2nd I.E.E.—"Application of electronics to aero engine design" by D. R. Foulds at 18.30 at the College of Engineering Technology.

## RUGELEY

- 4th I.E.E.—"Loudspeakers" by Dr. A. R. Bailey at 19.00 at Shrewsbury Arms.

## SHRIVENHAM

- 2nd I.E.E./I.E.E.—"Impact of micro-electronics for circuit design" by C. S. Den Brinker at 18.15 at R.M.C.S.

## SOUTHAMPTON

- 2nd I.E.E.T.E.—"Engineering education & training for the 1970s" by R. Bray at 19.30 at the British Legion Centre, Cumberland Place.

## ST. HELENS

- 18th S.E.R.T.—"Amateur radio operation" by E. H. Lewis at 20.00 at the Technical College.

## TREFOREST

- 2nd I.E.E.—"The electronic wattmeter" by P. C. Joslin at 19.00 at Glamorgan College of Technology.

## WORCESTER

- 10th B.C.S./I.Prod.E.—"Computer aided design" by K. Thompson at 19.30 at the Technical College, Deansway.

## Late November Meetings

### ABERDEEN

- 26th I.E.E.—"Large scale integration—why, where and when?" by D. D. Jones at 19.30 at Robert Gordon's Inst. of Technology.

### BELFAST

- 25th I.E.E.—"Audio frequency hi-fi amplifiers" by I. Hardcastle at 18.30 at the Ashby Inst., Queens University, Stranmillis Rd.

### DUNDEE

- 27th I.E.E.—"Large scale integration—why, where and when?" by D. D. Jones at 19.00 at the University.

### DURHAM

- 26th I.E.E.T.E.—"Modern techniques of air-traffic control" by J. Henderson at 19.30 at the University's Science Labs., South Road.

### FAREHAM

- 27th I.E.E. Grads.—"Brain cell to micro-circuit—pattern recognition" by Dr. I. Aleksander at 19.00 at H.M.S. Collingwood.

### INVERNESS

- 25th I.E.E.—"Large scale integration—why, where and when?" by D. D. Jones at 19.30 at the Technical College.

### LEEDS

- 25th I.E.E.—"Use of satellites in long-distance communication" by H. Stanesby at 18.30 at the University.

### NOTTINGHAM

- 20th R.T.S.—"The design of colour video tape recorders" by W. Silvie at 19.30 at the B.B.C. Studios, Wilson House, Derby Road.

### READING

- 24th I.E.E.—"Hi-fi" by J. Moir at 19.30 at the J. J. Thomson Laboratory, the University, Whiteknights Park.
- 25th I.E.E.—"Automatic test equipment" by O. H. Davie at 19.30 at the J. J. Thomson Laboratory, the University, Whiteknights Park.

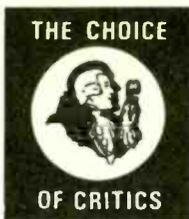
### SOUTHAMPTON

- 25th I.E.E.—Faraday Lectur "People, communications and engineering" by J. H. H. Merriman at 10.30 and 14.30 (students) and 18.30 (public) at the Guildhall.

# Answers to "Test Your Knowledge"—19

## Questions on page 589

1. (c)
2. (d) Valves, bipolar transistors and f.e.t.s are broadly analogous in their use in most basic amplifier circuits. Phase inversion occurs in the device only when the cathode, emitter or source respectively is the common electrode in the circuit.
3. (d) At mid-band frequencies in a properly designed amplifier this shunt capacitance has much too small a susceptance to draw significant current. As the frequency is increased the capacitive current increases, the output voltage falls, and additional phase shift is introduced.
4. (d) In a pentode the screen grid reduces the control-grid/anode capacitance to such an extent that in normal circuits the Miller effect is insignificant.
5. (b) By adjusting the degree of coupling so that "double-humping" just starts to occur the output is almost constant in amplitude over a band of frequencies and drops rapidly outside that band.
6. (a) The input may take power, as in the case of a bipolar transistor amplifier, but this power is dissipated in the transistor.
7. (d) The optimum load causes the output current and voltage to swing up to the "knee" of the most extreme characteristic which may be reached (this will be determined by limitations which depend on the particular device), and down almost to cut-off. It appears that the maximum power transfer theorem is violated here, but this is not so because the input signal amplitude, and hence the value of the Norton equivalent current generator at the output, is not a fixed parameter.
8. (b) The inputs to the two devices must be balanced about the supply common line.
9. (d) Complementary symmetry circuits use devices requiring supply potentials of opposite polarities; i.e., n-p-n and p-n-p bipolar transistors; n-channel and p-channel f.e.t.s.
10. (b)
11. (d) The input impedance, the output impedance and the signal-to-noise ratio each may be increased or decreased depending on the details of the circuit.
12. (c)
13. (a) When the oscillations are building up the loop-gain must be greater than unity, but the output amplitude will stabilize at a value at which non-linearity reduces the gain to unity.
14. (d) The power absorbed by a resistor of value  $R$ , when the voltage across it is  $V$ , is  $V^2/R$ . If  $R$  is negative power is given out by the resistor. So long as the negative shunt resistance is smaller than the positive shunt resistance more power is delivered to the circuit than is absorbed. As oscillations build up non-linearity in the device characteristic reduces the mean a.c. resistance until it is equal in magnitude to the dynamic impedance at resonance of the tuned circuit.
15. (d)
16. (a)



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5A.250V. ~ rating.

P.28 + P.29 Flex-lead two pin model for extension uses, 5A.250V. ~ rating.

P.490 + P.491 2 pole Domina connectors for multiple stacking,  
5A.250V. ~ rating.

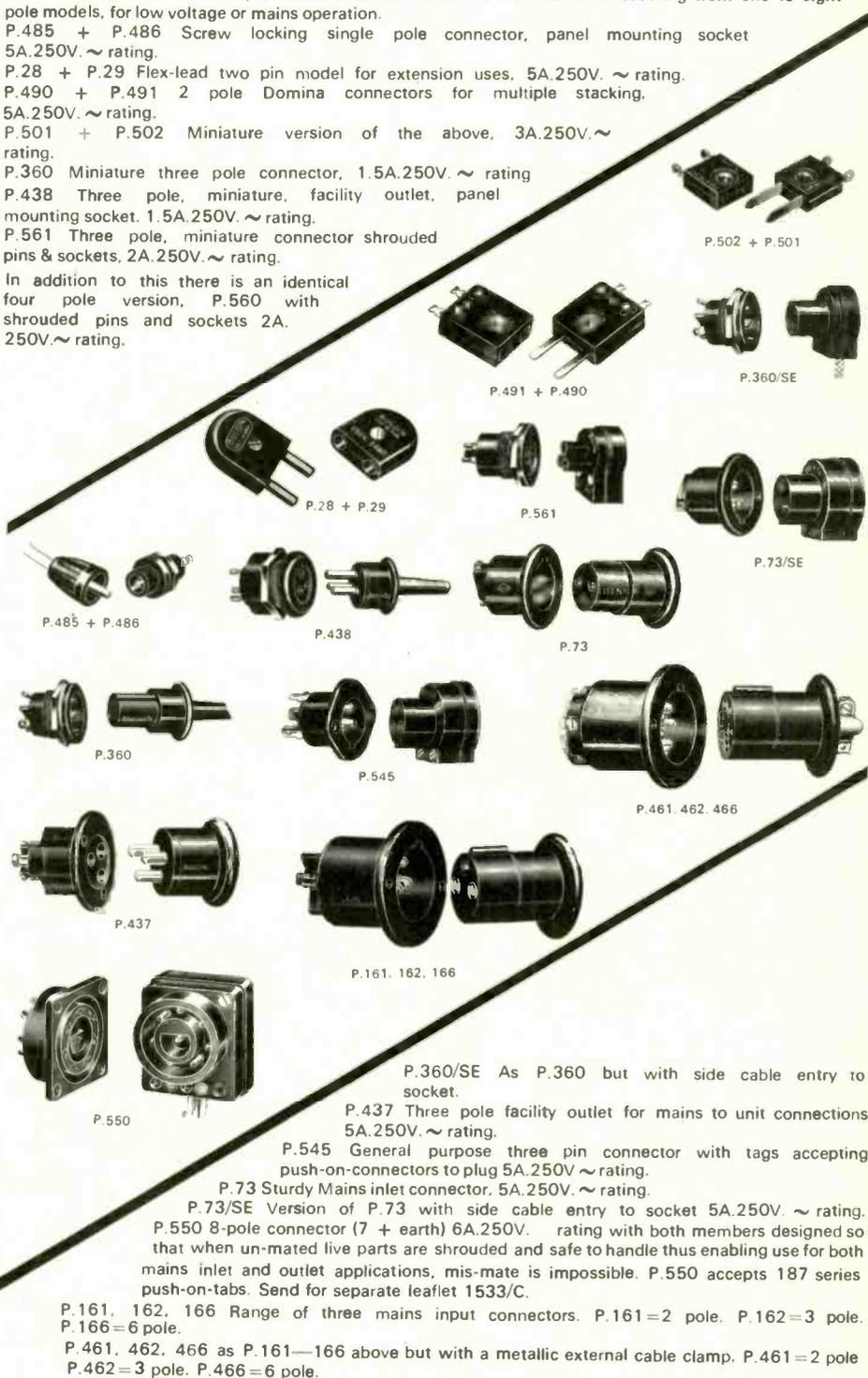
P.501 + P.502 Miniature version of the above, 3A.250V. ~ rating.

P.360 Miniature three pole connector, 1.5A.250V. ~ rating

P.438 Three pole, miniature, facility outlet, panel mounting socket, 1.5A.250V. ~ rating.

P.561 Three pole, miniature connector shrouded pins & sockets, 2A.250V. ~ rating.

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| CROWN AGENTS | U.K.A.E.A.              | D.S.I.R. |

WW—106 FOR FURTHER DETAILS

# Literature Received

## ACTIVE DEVICES

A TTL series 74N Cross Reference Guide, listing 13 manufacturers' devices in cross reference with National's TTL line, is available from Marketing Services Department, National Semiconductor Corporation, 2975 San Ysidro Way, Santa Clara, California 95051 ..... **WW401**

Farnell Instruments Ltd, Sandbeck Way, Wetherby LS22 4DH, Yorkshire, list their digital logic components with prices, in publication F21 ..... **WW402**

"Gunn effect devices and their applications", an 8-page article originally published in *Mullard Technical Communication*, is now available as a reprint. I.E.D./Valve Sales, Mullard Ltd., Torrington Place, London W.C.1. **WW422**

## HARDWARE

A descriptive sheet is available from Jidenco Ltd, Vale Road, Windsor, Berks, on their reflow solder machine, model J.P.2, suitable for the attachment and removal of flat pack i.cs to and from p.c. boards ..... **WW419**

## INSTRUMENTS

Dana Electronics Ltd, Bilton Way, Dallow Road, Luton, Beds, have produced the following publications:

- Series 7000 Digiphase Synthesizer—very accurate frequencies to 11MHz in 1Hz increments ..... **WW403**
- Amplifier data sheets 789-791 ..... **WW404**
- Series 2600 data amplifiers ..... **WW405**
- Digital voltmeters ..... **WW406**

Type 422 precision v.l.f.-l.f. signal generator, having a frequency range of 0.005Hz-50kHz, frequency accuracy of  $\pm 2$  parts in  $10^3$ , and sine, square and triangular wave outputs is described in a leaflet from Airmec Instruments Ltd, High Wycombe, Bucks ..... **WW407**

Two leaflets have been received from Telequipment Ltd, 313 Chase Road, Southgate, London N.14:

- Oscilloscopes ..... **WW408**
- S54A Single-beam Solid-state Oscilloscope ..... **WW409**

An 8-page technical manual on electronic tachometers, which describes their application to flow rate, r.p.m. and linear speed measurement, is available from Dynalco Corporation, 4107 N.E. 6th Avenue, Ft. Lauderdale, Florida 33308, U.S.A. .... **WW410**

The Wayne Kerr Co. Ltd, New Malden, Surrey, have published a catalogue of their range of electronic measuring instruments ..... **WW411**

Tektronix Inc. has published a 40-page catalogue on oscilloscopes and associated instruments which is available from Tektronix U.K. Ltd, Beaverton House, Harpenden, Herts ..... **WW412**

Two short-form catalogues are available from Bell & Howell Ltd, Lennox Road, Basingstoke, Hants:

- Tape & Graph Recording ..... **WW413**
- Transducer products ..... **WW414**

A short catalogue discussing Brüel & Kjaer electronic measuring equipment is available from B&K Laboratories Ltd, Cross Lances Road, Hounslow, Middx ..... **WW415**

B & K Instruments Ltd, 59 Union Street, London S.E.1, have produced a folder containing details of instruments made by Krohn-hite Corporation, Brush Cle vite, Chronetics, Benrus, Jerrold and Radiometer ..... **WW416**

A short-form catalogue describing their range of electronic measuring instruments is available from Avo Ltd, Avocet House, Dover, Kent .... **WW417**

S.E. Laboratories (Engineering) Ltd, North Feltham Trading Estate, Feltham, Middx, have produced a folder of leaflets and catalogues describing their various products ..... **WW418**

## GENERAL INFORMATION

No.38 (August/September 1969) of the house magazine "News from Rohde & Schwarz" is available from Rohde & Schwarz, 8000 Munchen 80, Muhldorfstrasse 15 ..... **WW420**

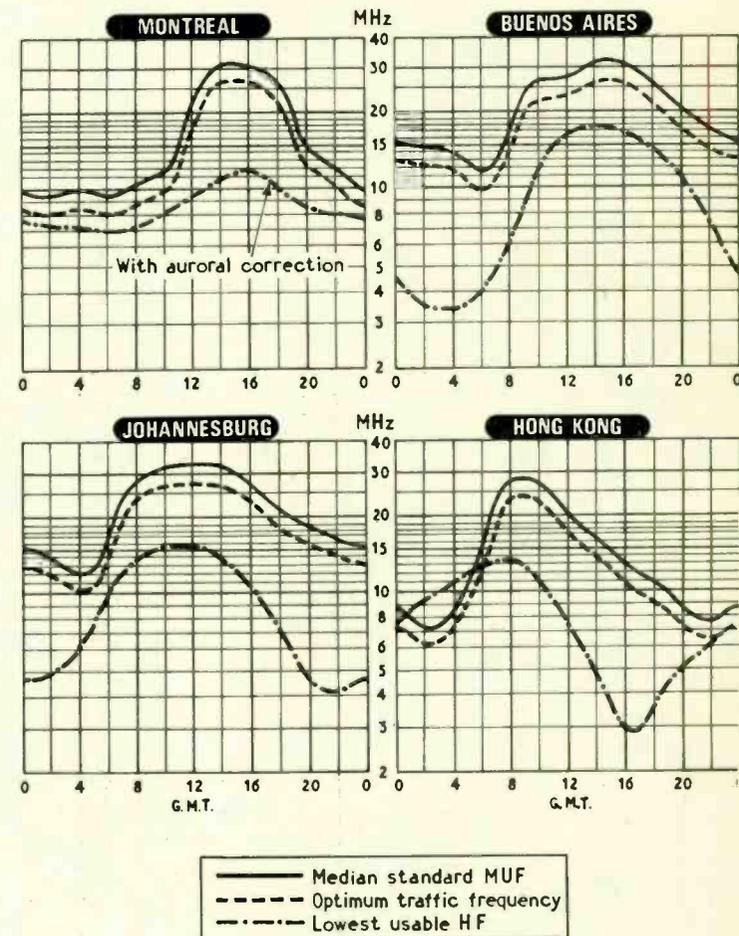
The British Standards Institution, 2 Park Street, London W1Y 4AA, has produced PD64 36: "A guide to the BS9000 scheme", price 12s.

The handbook "Printed Wiring & Printed Circuit Techniques", revised by the Electronic Engineering Association, is available from *Design Electronics*, Dorset House, Stamford Street, London S.E.1. Price 40s, post free.

A 16-page "guidance manual" on how to optimize circuit designs for their most economical production as hybrid i.cs has been produced by Newmarket Transistors Ltd, Exning Road, Newmarket, Suffolk ..... **WW421**

Those readers looking for an introduction to logic circuits will not go far wrong with "It's the Logic that Counts" which is a book published by Marconi Instruments Ltd, Marketing Services Department, St. Albans, Herts. Costing £2 the book uses the "programmed learning" approach.

## H.F. Predictions—December

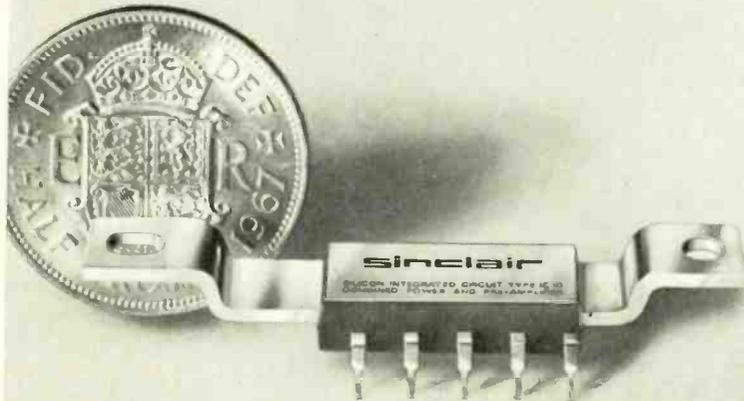


Sunspot numbers for recent months show the expected start of a steady decline in solar activity which will continue until 1975. F2 layer daytime MUFs for routes predominantly in the northern hemisphere are at their peak in December, F1 and E layer MUFs, however, are at their lowest and have little or no effect on circuit operation. Night-time F-layer MUFs on the other hand are also lowest during winter months which, coupled with declining solar activity, seriously reduces the usable spectrum.

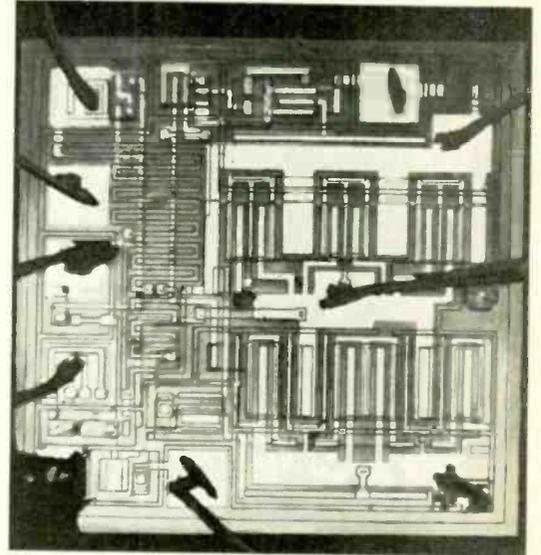
Fade-outs and disturbances should continue as at present, that is relatively frequent but of low intensity.

The northern auroral zone passes through Alaska, Hudson Bay, Iceland and northern Norway; radio paths crossing this zone are subject to period of high attenuation lasting several days.

# SINCLAIR IC-10



## MONOLITHIC INTEGRATED CIRCUIT AMPLIFIER AND PRE-AMP



*A 13 transistor circuit measuring only one twentieth of an inch square by one hundredth of an inch thick!*

## the world's most advanced high fidelity amplifier

The Sinclair IC-10 is the world's first monolithic integrated circuit high fidelity power amplifier and pre-amplifier. The circuit itself, a chip of silicon only a twentieth of an inch square by one hundredth of an inch thick, has 5 watts R.M.S. output (10w. peak). It contains 13 transistors (including two power types), 2 diodes, 1 zenor diode and 18 resistors, formed simultaneously in the silicon by a series of diffusions. The chip is encapsulated in a solid plastic package which holds the metal heat sink and connecting pins. This exciting device is not only more rugged and reliable than any previous amplifier, it also has considerable performance advantages. The most important are complete freedom from thermal runaway due to the close thermal coupling between the output transistors and the bias diodes and very low level of distortion.

The IC-10 is primarily intended as a full performance high fidelity power and pre-amplifier, for which application it only requires the addition of the usual tone and volume controls and a battery or mains power supply. However, it is so designed that it may be used simply in many other applications including car radios, electronic organs, servo amplifiers (it is d.c. coupled throughout), etc. Once proven, the circuits can be produced with complete uniformity which enables us to give a 5-year guarantee on each IC-10, knowing that every unit will work as perfectly as the original and do so for a lifetime.

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### ■ SPECIFICATIONS

|                            |  |
|----------------------------|--|
| Output:                    | 10 Watts peak. 5 Watts R.M.S. continuous |
| Frequency response:        | 5 Hz to 100 KHz $\pm$ 1dB                |
| Total harmonic distortion: | Less than 1% at full output.             |
| Load impedance:            | 3 to 15 ohms.                            |
| Power gain:                | 110dB (100,000,000,000 times) total.     |
| Supply voltage:            | 8 to 18 volts.                           |
| Size:                      | 1 x 0.4 x 0.2 inches.                    |
| Sensitivity:               | 5mV.                                     |
| Input impedance:           | Adjustable externally up to 2.5 M ohms.  |

### ■ CIRCUIT DESCRIPTION

The first three transistors are used in the pre-amp and the remaining 10 in the power amplifier. Class AB output is used with closely controlled quiescent current which is independent of temperature. Generous negative feedback is used round both sections and the amplifier is completely free from cross-over distortion at all supply voltages, making battery operation eminently satisfactory.

### ■ APPLICATIONS

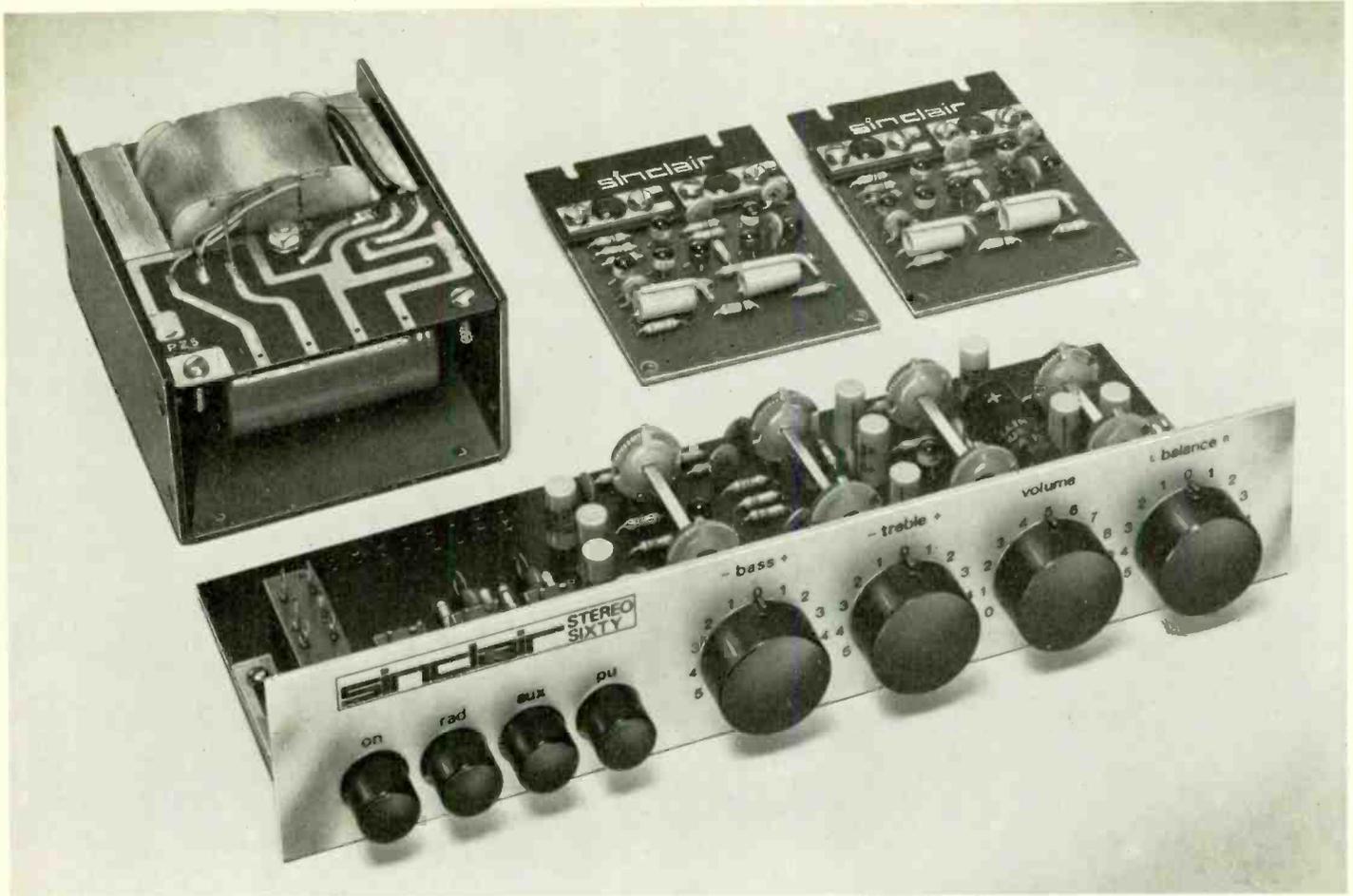
Each IC-10 is sold with a very comprehensive manual giving circuit and wiring diagrams for a large number of applications in addition to high fidelity. These include stabilised power supplies, oscillators, etc. The pre-amp section can be used as an R.F. or I.F. amplifier without any additional transistors.

SINCLAIR

# IC-10

with IC-10 manual  
and 5-year guarantee  
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# 59' 6



## Project 60 an exciting alternative

The buyer of an amplifier today has a remarkably wide variety to choose from. It is unlikely that a purchaser would have real difficulty in finding a unit that met all his requirements, although the price might not be as low as could be wished. The only snags are that one's needs can change and that the technically correct amplifier may be physically inconvenient. If you are confident that there is an amplifier available, of the right size and price, which will meet all your needs for the foreseeable future, then that is your best buy. If not, however, we can offer you another possibility which we believe to be an exciting alternative approach. That alternative is **Project 60**.

Project 60 is a range of modules which connect together simply to form a complete stereo amplifier with really excellent performance. So good, in fact, that only 2 or 3 amplifiers in the world can compare with it in overall performance.

The modules are: 1. The Z-30 high gain power amplifier, which is an immensely flexible unit in its own right. 2. The Stereo 60 preamplifier and control unit. 3. The PZ.5 and PZ.6 power supplies. A complete system comprises two Z-30's, one Stereo-60 and a PZ-5 or PZ-6. The power supplies differ in that the PZ-6 is stabilised whilst the PZ-5 is not. This means that the former should be used where the highest possible

continuous sine wave rating is required. In a normal domestic application there will not be a significant difference between using either power unit unless loudspeakers of very low efficiency are being used.

All you need to assemble your system is a screwdriver and a soldering iron. No technical skill or knowledge whatsoever is required and, in the unlikely event of you hitting a problem, our customer service and advice department will put the matter right promptly and willingly.

Perhaps the greatest beauty of the system is that it is not only flexible now but will remain so in the future. We shall shortly be introducing additional modules which will include a comprehensive filter unit, a stereo F.M. tuner and an even more powerful amplifier for very large systems. These and all other modules we introduce will be compatible with those shown here and may be added to your system at any time.

Project 60 modules have been carefully designed to fit into virtually every known type of plinth or cabinet and templates provided enable you to position them. Only holes have to be drilled into the wood of the plinth and any slight slips here will be covered completely by the aluminium front panel of the Stereo 60. The Project 60 manual gives all the instructions you can possibly want clearly and concisely.

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# Z-30 TWENTY WATT R.M.S. (40 WATT PEAK) POWER AMPLIFIER

The Z-30 is a complete power amplifier of very advanced design employing 9 silicon epitaxial planar transistors. Total harmonic distortion is incredibly low being only 0.02% at full output and all lower outputs. As far as we know, no other high fidelity amplifier made can match this specification, no matter what the price. Thus you can be utterly certain that your Project 60 system will do full justice to your other equipment however good it may be. The Z-30 is unique in that it will operate perfectly, without adjustment, from any power supply from 8 to 35 volts. It also has sufficient gain to operate directly from a crystal pickup. So in addition to its use in a high fidelity system you can use a Z-30 to advantage in your car or a battery operated gramophone for your children, for example. These, and many other applications of the Z-30, are covered in the Project 60 manual.

## SPECIFICATIONS

Power output—15 watts R.M.S. (30 watts peak) into 8 ohms using a 35 volt supply; 20 watts R.M.S. (40 watts peak) into 3 ohms using a 30 volt supply.

Output—Class AB.

Frequency response: 30 to 300,000 Hz  $\pm$  1dB.

Signal to noise ratio: better than 70dB unweighted.

Distortion: 0.02% total harmonic distortion at full output into 8 ohms and at all lower output levels.

Size:  $3\frac{1}{2} \times 2\frac{1}{2} \times \frac{1}{2}$  inches.

Input sensitivity: 250mV Into 100 Kohms.

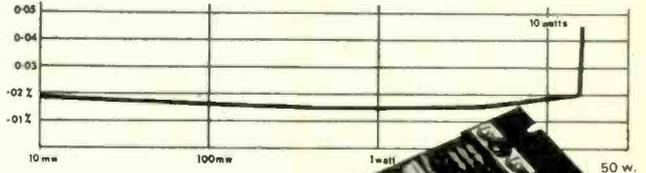
Damping Factor: > 500.

Loudspeaker impedances 3 to 15 ohms.

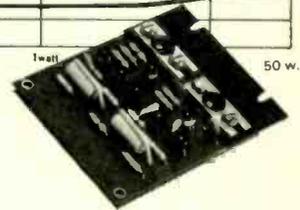
Power requirements: 8 to 35 V.d.c.

## APPLICATIONS

High fidelity amplifier; car radio amplifier; record player fed direct from pick-up; intercom; electronic music and instruments; P.A., laboratory work, etc. Full details of these and many other applications are given in the manual supplied with your Z.30.



Power versus distortion curve of Sinclair Z.30.



**Z.30**

Ready built, tested and guaranteed, with Z.30 manual.

**89/6**

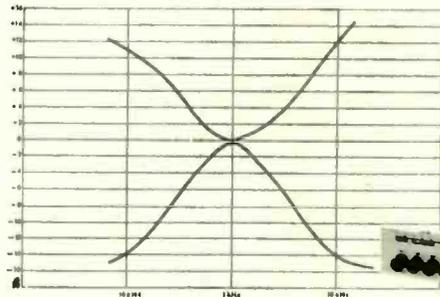
# STEREO SIXTY PREAMPLIFIER AND CONTROL UNIT

The Stereo 60 is a stereo preamplifier and 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 and great attention has been paid to achieving a really high signal-to-noise ratio and excellent tracking between the two channels. Input selection is by means of push buttons and accurate equalisation is provided for all the usual inputs. The tone controls are also very carefully designed and tested.

## SPECIFICATIONS

- Input sensitivities—Radio—up to 3mV; Magnetic Pickup—3mV Correct within  $\pm$  1dB on R.I.A.A. curve. Ceramic Pickup—up to 3mV; Auxiliary—up to 3mV.
- Output—1 volt.
- Signal-to-noise ratio—better than 70dB.
- Channel matching—within 1dB.
- Tone Controls—TREBLE +15 to -15dB, at 10 KHz; BASS +15 to -15dB at 100 Hz.

- Power consumption 5mA.
- Power requirement—PZ.5 or PZ.6.
- Finish—brushed aluminium front panel with black knobs.
- Mounting—on cabinet front by spindle bushes and adjustable brackets.



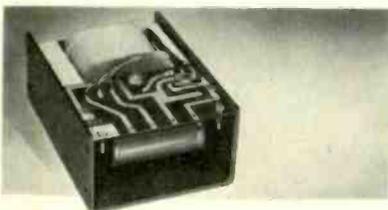
Treble and bass control curves



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**PZ-6** 35 volts stabilised—ideal for driving two Z-30's and a Stereo 60 when very low efficiency speakers are employed.

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If at any time within 3 months of purchasing Project 60 modules 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.

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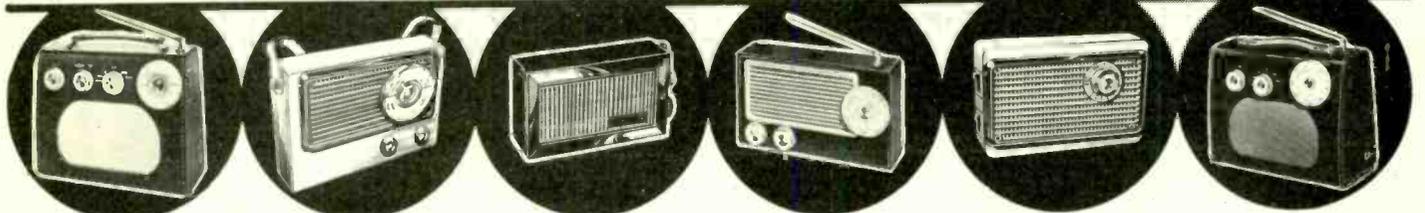
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| U15     | 30 NPN Silicon Planar Transistors TO-5 sim. 2N697   | 10/-  |
| U16     | 10 3-Amp Silicon Rectifiers Stud Type up to 1000 PIV  | 10/-  |
| U17     | 30 Germanium PNP AF Transistors TO-5 like ACY 17-22   | 10/-  |
| U18     | 8 6-Amp Silicon Rectifiers BYZ13 Type up to 600 PIV   | 10/-  |
| U19     | 30 Silicon NPN Transistors like BC108   | 10/-  |
| U20     | 12 1.3amp Silicon Rectifiers Top-Hat up to 1,000 PIV  | 10/-  |
| U21     | 30 A.F. Germanium alloy Transistors 2G300 Series & OC71                                       | 10/-  |
| U22     | 10 1-amp Glass Min. Silicon Rectifiers High Volts   | 10/-  |
| U23     | 30 Mad'A's like MAT Series PNP Transistors  | 10/-  |
| U24     | 20 Germanium 1-amp Rectifiers GJM up to 300 PIV   | 10/-  |
| U25     | 25 300Mc/s NPN Silicon Transistors 2N708, B8V27   | 10/-  |
| U26     | 30 Fast Switching Silicon Diodes like IN914 Micro-min.  | 10/-  |
| U28     | Experimenters' Assortment of Integrated Circuits, untested Gates, Flip-Flops, Registers, etc. | 20/-  |
| U29     | 10 1 amp SCR's TO-5 can up to 600 PIV CR81/25-600   | 20/-  |
| U30     | 15 Plastic Silicon Planar Trans. NPN 2N2924-2N2926  | 10/-  |
| U31     | 20 Sil. Planar NPN Trans. low noise Amp 2N3707  | 10/-  |
| U32     | 25 Zener diodes 400mW D07 case mixed Volts, 3-18  | 10/-  |
| U33     | 15 Plastic case 1 amp Silicon rectifiers 1N4000 series  | 10/-  |
| U34     | 30 Sil. PNP alloy Trans. TO-5 BCV26, 28302/4  | 10/-  |
| U35     | 25 Sil. Planar Trans. PNP TO-18 2N2906  | 10/-  |
| U36     | 25 Sil. Planar NPN Trans. TO-5 BFY50/51/52  | 10/-  |
| U37     | 30 Sil. alloy Trans. 80-2 PNP, OC200 28322  | 10/-  |
| U38     | 20 Fast Switching Sil. Trans. NPN, 400Mc/s 2N3011   | 10/-  |
| U39     | 30 RF Germ. PNP Trans. 2N1303/5 TO-5  | 10/-  |
| U40     | 10 Dual Trans. 8 lead TO-5 2N2060   | 10/-  |
| U41     | 30 RF Germ. Trans. TO-1 OC45 NKT72  | 10/-  |
| U42     | 10 VHP Germ. PNP Trans. TO-1 NKT667 AP117   | 10/-  |

Code Nos. mentioned above are given as a guide to the type of device in the Pak. The devices themselves are normally unmarked.

## BI-PAK SEMICONDUCTORS (DEPT. WW.)

### TESTED SCR'S

|         |      |      |           |
|---------|------|------|-----------|
| PIV 1 A | 7A   | 16A  | 30A       |
| 25      | 7/8  | 7/8  | 30/-      |
| 50      | 8/8  | 8/8  | 10/8 35/- |
| 100     | 8/8  | 10/8 | 15/- 45/- |
| 200     | 12/6 | 15/- | 20/- 55/- |
| 300     | 15/6 | 20/- | 25/-      |
| 400     | 17/6 | 25/- | 35/- 80/- |
| 500     | 30/6 | 40/- | 45/- 85/- |
| 600     | 40/- | 45/- | 50/-      |

### SIL. RECTS TESTED

|              |      |           |
|--------------|------|-----------|
| PIV 750mA 3A | 10A  | 30A       |
| 50 1/-       | 2/0  | 4/3 9/6   |
| 100 1/3      | 3/3  | 4/6 15/-  |
| 200 1/8      | 4/4  | 4/9 20/-  |
| 300 2/3      | 4/6  | 6/8 32/-  |
| 400 2/6      | 5/6  | 7/6 25/-  |
| 500 3/6      | 6/6  | 8/6 30/-  |
| 600 3/3      | 6/6  | 9/6 37/-  |
| 800 3/6      | 7/6  | 11/6 40/- |
| 1000 5/-     | 9/3  | 12/6 50/- |
| 1200 8/6     | 11/6 | 15/-      |

### FULL RANGE OF ZENER DIODES

VOLTAGE RANGE 2-18V. 400mW (DO-7 Case) 2/6 ea. 1-5W (Top-Hat) 3/6 ea. 10W (80-10 Stud.) 5/- ea. All fully tested 5% tol. and marked. State voltage required.

### BRAND NEW TEXAS GERM. TRANSISTORS Coded and Guaranteed

| Pak No. | EQVT            |
|---------|-----------------|
| T1      | 8 2G371A OC71   |
| T2      | 8 2G374 OC75    |
| T3      | 8 2G374A OC81D  |
| T4      | 8 2G381A OC81   |
| T5      | 8 2G382T OC82   |
| T6      | 8 2G344A OC44   |
| T7      | 8 2G345A OC45   |
| T8      | 8 2G378 OC78    |
| T9      | 8 2G399A 2N1302 |
| T10     | 8 2G417 AF117   |

All 10/- each

2N2060 NPN SIL. DUAL TRANS. CODE D1699 TEXAS. Our price 5/- ea. 120 VCR NIXIE DRIVER TRANSISTOR. 8in. BRX21 & C407. 2N1893 FULLY TESTED AND CODED ND120. 1.24 3/6 each. TO-5 N.P.N. 25 up 3/- ea.

### OTHER MONOLITHIC DEVICES

BP424. Zero voltage switch. 8/8 each. This device is a monolithic I.C. that acts a combined threshold detector and trigger circuit for controlling a triac. It is designed to pulse the gate of a thyristor at the point of zero supply voltage, and therefore eliminate radio frequency interference when used with resistive loads.

D13D1 Silicon Unilateral switch 10/- each. A Silicon Planar, monolithic integrated circuit having thyristor electrical characteristics, but with an anode gate and a built-in "Zener" diode between gate and cathode. Full data and application circuit available on request.

CA3020 RCA (U.S.A.) LINEAR INTEGRATED CIRCUITS Audio Power Amplifier. 30/- each.

FREE One 10/- Pack of your own choice free with orders valued £4 or over.

PLEASE NOTE. To avoid any further increased Postal Charges to our Customers and enable us to keep our "By Return Postal Service" which is second to none, we have streamlined our Despatch Order Department and we now request you to send all your orders together with your remittance, direct to our Warehouse and Despatch Department, postal address: BI-PAK SEMICONDUCTORS, Despatch Dept., P.O. Box 6, WARE, HERTS. Postage and packing still 1/- per order. Minimum order 10/-.

### INTEGRATED CIRCUITS

BI-PAK MONOLITHIC DIGITAL CIRCUITS (10 lead TO-5) BP305A, 8-Input AND gate, 9/8 each. BP314A, 7-Input NOR gate, 9/8 each. BP315A, Dual 3-Input NOR GATE, 9/8 each. BP316A, Dual 2-Input NOR gate (expandable), 9/8 each. BP320A, J-K-Binary element, 11/8 each. BP332A, Dual 3-Input OR gate, 9/8 each.

BI-PAK MONOLITHIC AMPLIFIERS (TO-5 8 lead)

BP709C, Operational amplifier, 15/- each. BP701G, Operational amplifier (with Zener output), 12/8 each. BP702C, Operational amplifier (with direct output), 12/8 each. BP501, Wide band amplifier, 18/- each. BP521, Logarithmic wide band amp., 14/- each. BP210C, General purpose amplifier (TO-5 8 lead), (voltage or current amp.), 12/8 each.

FAIRCHILD (U.S.A.) RTUL MICROLOGIC INTEGRATED CIRCUITS Epoxy case, TO-5 lead temp. range L<sup>o</sup>C to 55<sup>o</sup>C.

UL900, Buffer, 10/8 each. UL914, Dual two-input gate, 10/8 each. UL923 J-K-flip-flop, 14/- each. Complete data and circuits available in booklet form priced 1/6.

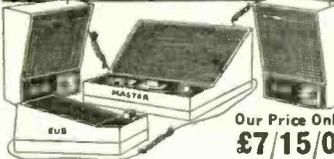
### MULLARD I.C. AMPLIFIERS

TAA243, Operational amplifier, 70/- each. TAA263, Linear AF amplifier, 18/8 each. TAA293, General purpose amplifier, 21/- each.

### QUALITY-TESTED PAKS

|   |      |
|---|------|
| 6 Matched Trans. OC44/45/81/81D                 | 10/- |
| 20 Red Spot AF Trans. PNP                       | 10/- |
| 16 White Spot RF Trans. PNP                     | 10/- |
| 5 Silicon Rects. 3 A 100-400 PIV                | 10/- |
| 2 10 A Silicon Rects. 100 PIV                   | 10/- |
| 2 OC1140 Trans. NPN Switching                   | 10/- |
| 1 12 A SCR 100 PIV                              | 10/- |
| 3 Sil. Trans. 28303 PNP                         | 10/- |
| 4 Zener Diodes 250mW 3-12V                      | 10/- |
| 3 200 Mc/s Sil. Trans. NPN B8V26/27             | 10/- |
| 3 Zener Diodes 1W 33V 5% Tol.                   | 10/- |
| 2 Low Noise Trans. OC42 Eqvt.                   | 10/- |
| 2 Power Transistors 1 OC26 1 OC35               | 10/- |
| 5 Silicon Rects. 400 PIV 250mA                  | 10/- |
| 4 OC75 Transistors                              | 10/- |
| 1 Power Trans. OC20 100V                        | 10/- |
| 1 OA202 Sil. Diodes Sub-min.                    | 10/- |
| 2 Low Noise Trans. NPN 2N2929/30                | 10/- |
| 1 Sil. Trans. NPN VCB 100 250mA                 | 10/- |
| 8 OA81 Diodes                                   | 10/- |
| 4 OC72 Transistors                              | 10/- |
| 4 OC77 Transistors                              | 10/- |
| 4 Sil. Rects. 400 PIV 500mA                     | 10/- |
| 5 GET884 Trans. Eqvt. OC44                      | 10/- |
| 5 GET883 Trans. Eqvt. OC45                      | 10/- |
| 2 2N708 Sil. Trans. 300 Mc/s. NPN               | 10/- |
| 3 QT31 LF Low Noise Germ. Trans. PNP            | 10/- |
| 6 1N914 Sil. Diodes 75 PIV 75mA                 | 10/- |
| 8 OA95 Germ. Diodes Sub-min. IN69               | 10/- |
| 3 NPN Germ. Trans. NKT773 Eqvt. AC130           | 10/- |
| 2 OC22 Power Trans. Germ.                       | 10/- |
| 2 OC26 Power Trans. Germ.                       | 10/- |
| 4 AC128 Trans. PNP High Gain                    | 10/- |
| 4 AC127/128 Comp. pair PNP/NPN                  | 10/- |
| 3 2N1307 PNP Switching Trans.                   | 10/- |
| 7 GC82B Germ. Diodes Eqvt. OA71                 | 10/- |
| 3 AF116 Type Trans.                             | 10/- |
| 12 Assorted Germ. Diodes Marked.                | 10/- |
| 4 AC126 Germ. PNP Trans.                        | 10/- |
| 4 Silicon Rects. 100 PIV 750mA                  | 10/- |
| 3 AF117 Trans.                                  | 10/- |
| 7 OC81 Type Trans.                              | 10/- |
| 3 OC711 Trans.                                  | 10/- |
| 5 2N2928 Sil. Epoxy Trans.                      | 10/- |
| 7 OC71 Type Trans.                              | 10/- |
| 2 28701 Sil. Trans. Texas                       | 10/- |
| 3 12 Volt Zener 400mW                           | 10/- |
| 2 10 A 600 PIV Sil. Rects. IN458R               | 10/- |
| 3 BC108 Sil. Trans. NPN High Gain Trans.        | 10/- |
| 1 2N910 NPN Sil. Trans. VCB100                  | 10/- |
| 2 100 PIV Sil. Rect. 1.5 A R5330 AF             | 10/- |
| 3 B8V95A Sil. Trans. NPN 200 Mc/s               | 10/- |
| 3 OC200 Sil. Trans.                             | 15/- |
| 8 Sil. Power Diodes BYZ13                       | 15/- |
| 1 Sil. Power Trans. NPN 100mc/s. TK201A         | 15/- |
| 6 Zener Diodes 3-15V Sub-min.                   | 15/- |
| 1 2N1132 PNP Epitaxial Planar Sil.              | 15/- |
| 3 2N697 Epitaxial Planar Trans. Sil.            | 15/- |
| 4 Germ. Power Trans. Eqvt. OC16                 | 15/- |
| 1 Unijunction Trans. 2N2646                     | 15/- |
| 2 Sil. Trans. 200 Mc/s. 60Vcb ZT83/84           | 15/- |
| 1 Tunnel Diode A6Y11 1050 Mc/s.                 | 15/- |
| 2 2N2712 Sil. Epoxy Planar HFE225               | 15/- |
| 8 BY 100 Type Sil. Rects.                       | 20/- |
| 25 Sil. and Germ. Trans. Mixed, all marked, New | 30/- |

## 4-STATION INTERCOM



Our Price Only £7/15/0

Solve your communication problems with this new 4-Station Transistor Intercom system (1 master and 3 subs), in de luxe plastic cabinets for desk or wall mounting. Call/talk/listen from Master to Subs and Subs to Master. Operates on one 9 v. battery. On/off switch. Volume control. Ideally suitable to modernise Office, Factory, Workshop, Warehouse, Hospital, Shop, etc., for instant inter-departmental contacts. Complete with 3 connecting wires, each 66ft. and other accessories. Nothing else to buy. P. & P. 7/6 in U.K.

## INTERCOM/BABY ALARM



OUR PRICE ONLY 3 gns.

Same as 4-Station Intercom for two-way instant conversation from MASTER to SUB and SUB to MASTER. Ideal as Baby Alarm and Door Phone. Complete with 66ft. connecting wire. Battery 2/6. P. & P. 4/6.

## 7-STATION INTERCOM

(1 MASTER & 6 SUB-STATIONS) in strong metal cabinets. Fully transistorised. 3 1/2 in. Speakers. Call on Master identified by tone and Pilot lamp. Ideally suitable for Office, Hotel, Hospital and Factory. Price 27 gns. P. & P. 14/6 in U.K.

## Transistor TELEPHONE AMPLIFIER



59/6

Why not increase efficiency of Office, Shop and Warehouse with this incredible De-Luxe Portable Transistor TELEPHONE AMPLIFIER which enables you to take down long telephone messages or converse without holding the handset. A useful office aid. A must for every telephone user. Useful for hard of hearing persons. On/off switch. Volume Control. Operates on one 9 v. battery which lasts for months. Ready to operate. P. & P. 3/6 in U.K. Add 1/6 for Battery.

Full price refunded if returned in 7 days. WEST LONDON DIRECT SUPPLIES (W.W.), 169 Kensington High Street, London, W.8



**2½kW FAN HEATER**

Three position switching to suit changes in the weather. Switch up for full heater (2½kW), switch down for half heat (1½kW), switch central blower cold for summer cooling—adjustable thermostat acts as auto control and safety cut-out. Complete kit £3.15.0. Post and ins. 7/6. Made-up model £4.15.0. Post and ins. 7/6.

**FLUORESCENT CONTROL KITS**

Each kit comprises seven items—Choke, 2 tube ends, starter, starter holder and 2 tube clips, with wiring instructions. Suitable for normal fluorescent tubes or the new "Grolux" tubes for fish tanks and indoor plants. Chokes are super-silent, mostly rain filled. Kit A—15-20 w. 19/6. Kit B—30-40 w. 19/6. Kit C—80 w. 19/6. Kit E—65 w. 19/6. Kit MF1 is for 6in., 9in. and 12in. miniature tubes. 19/6. Postage on Kits A and B 4/6 for one or two kits then 4/6 for each two kits ordered. Kits C, D and E 4/6 on first kit then 3/6 for each kit ordered. Kit MF1 3/6 on first kit then 3/6 on each two kits ordered.

**BECKASTAT**

This is an instant thermostat, simply plug your appliance into it and its lead into wall plug. Adjustable setting for normal air temperatures. 13A loading. Will save its cost in a season. 19/6. Post and ins. 2/9



**REED SWITCHES**

Glass encased, switches operated by external magnet—gold welded contacts. We can now offer 3 types: **Miniature.** 1in. long x approximately 1/16in. diameter. Will make and break up to 1A up to 300 volts. Price 2/6 each. 24/- dozen. **Standard.** 2in. long x 3/16in. diameter. This will break currents of up to 1A, voltages up to 250 volts. Price 2/- each. 15/- per dozen. **Flat.** Flat type, 2in. long, just over 1/16in. thick, approximately 1/4in. wide. The Standard Type flattened out, so that it can be fitted into a square solenoid, or a larger quantity may be packed into a square solenoid. Rating 1 amp 200 volts. Price 6/- each. 5/- per dozen. Small ceramic magnets to operate these reed switches 1/3 each. 12/- dozen.

**ISA FOOT SWITCH**

Suitable for Sewing Machine Motor, Drilling Machine or in fact to switch any job where both hands are to be left free. Rated at 15 amps, 250 volts. Price 22/6.



**3 DIGIT COUNTER**

For Tape Recorder or other application. Re-settable by depressing button. Price 8/6.



**TRANSDUCER**

Made by Acos, reference No. 1.D.1001. For measuring vibration, etc., to be used in conjunction with "G" Meter. Regular price £5. Our price 49/6. Brand new and unused.



**ISOLATION SWITCH**

20 Amp D.P. 250 Volts. Ideal to control Water Heater or any other appliance. Neon indicator shows when current is on. 4/6 48/- per dozen.



**LIGHT CELL**

Almost zero resistance in sunlight increases to 10 K. Ohms in dark or dull light. Epoxy resin sealed. Size approx. 1in. dia. by 1/2in. thick. Rated at 500 MW. wire ended. 8/6 with circuit.



**FLEX BARGAINS**

**Screened 3 Core Flex.** Each core 14/0076 Copper PVC insulated and coloured, the 3 cores laid together and metal braided overall. Price £3.15.0 per 100 yds. coil  
**15A 3 Core Non-kink Flex.** 70/0076 insulated coloured cores, protected by tough rubber sheath, then black cotton braided with white tracer. A normal domestic flex as fitted to 3kW fires. Regular price 3/6 per yd. 50 yd. coil £4.10.0, or cut to your length 2/6 per yard.  
**10A 3 Core Non-kink Flex.** As above but cores are 28/0076 Copper. Normal price 2/6 per yd. 100 yd. coil £7.10.0, or cut to your length 1/6 per yd.  
**6A 2 Core Flex.** As above, but 2 cores each 23/0076 as used for Vacuum Cleaners, Electric Blankets, etc. 33/6 100 yd. coil.

**3-CORE WATERPROOF FLEX**

6A, 23/0076 circular PVC covered as fitted to electric drills and most portable appliances, ideal extension lead. Regular price 1/6 per yd., our price 79/6 for 100 yd. coil. Post 6/6. **Elliot Sealed Contact Reed Relay.** Three circuits closed by 3 volt or 100MA. 9/6 each.

**Slim Tubular Microphone.** For hand holding or frontal suspension—lever switch—high impedance with lead and plugs for cassette tape recorder but suitable for most amps. 19/6.  
**500MA Moving Coil Meter.** 2in. flush mounting round meter ex-Government but unused and perfect. 17/6.



**6, 12 OR 24 VOLT SOLENOID**

For energizing Reed Switches, etc., size approx. 1in. long by 1in. diameter. Hole through Solenoid approx. 1/16in. 8/6 each.

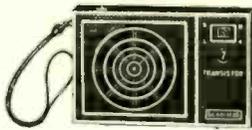


**5A 3-PIN SWITCHED SOCKETS**

An excellent opportunity to make that bench d/s board you have needed or to stock up for future jobs. This month we offer 6 British made (Herafit) bakelite flush mounting shuttered switch sockets for only 10/- plus 3/6 post and insurance. (20 boxes post free.)

**'GLADIATOR' 2 WAVEBAND TRANSISTOR RADIO**

7 transistor, 2 wave band (medium & long) pocket radio with carrying handle and ear-plug. These radios use a ferrite slab aerial and a conventional superhet circuit with built-in moving coil speaker. Completely built up, ready to play. Offered at less than importer's price due to bankrupt purchase. A remarkable bargain. 39/6 plus 3/6 post and insurance.



**MINIATURE EXTRACTOR FAN**

Beautifully made by famous German Company. PAPST System. 230/240 A.C. Mains operated, size 3 1/2in. x 3 1/2in. x 2in. Made for instrument cooling but ideal to incorporate in a cooker hood, etc. 65/- P. & p. 2/9.

**BUY TIME SLOT METERS**

If you hire out equipment such as TV sets by the hour then these slot meters are what you require. We have 3 types. 6d. an hour, 1/- an hour and 1/6 an hour. Brand new. Made by the famous Weston Company. Price £3.18.6. post and ins. 6/6



**HORSTMANN 'TIME & SET' SWITCH**

(A 30 Amp Switch). Just the thing if you want to come home to a warm house without it costing you a fortune. You can delay the switch on time of your electric fires, etc., up to 14 hours from setting time or you can use the switch to give a boost on period of up to 3 hours. Equally suitable to control processing. Regular price probably around £5. Special snip price 29/6. Post and ins. 4/6.



**DISTRIBUTION PANELS**

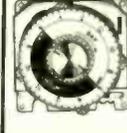
Just what you need for work bench or lab. 4 x 13 amp sockets in metal box to take standard 13 amp fused plugs. Supplied complete with 6 feet of heavy cable and 13 amp plug. Similar panels advertised at £5. Our price 39/6, plus 3/6 post and insurance.



**THIS MONTH'S SNIP**

**24 HOUR TIME SWITCH**

Mains operated. Adjustable Contacts give on/off per 24 hours. Contacts rated 20 amps, repeating mechanism so ideal for shop window control, or to switch hall lights (anti-burglar precaution) while you are on holiday. Made by the famous Smiths Company. This month only 39/6 complete with perspex cover, new and unused, plus 3/6 postage and insurance, a real snip which should not be missed.



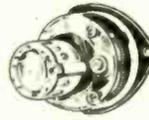
**DOUBLE ENDED MAINS MOTOR**

On feet with holes for screw-down fixing. To drive models, oven, blower heater, etc. 10/- each, plus 3/6 post and insurance. 6 or more post free.



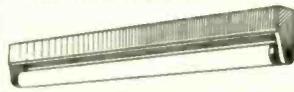
**INSTRUMENT MOTOR WITH GEAR BOX**

Made by the famous Smiths Company. This motor has an 8-gear train in perspex gear box. Approximate dimensions, motor 1 1/2in. x 1 1/2in. diameter, gear box 2 1/2in. diameter. Although only 2 watt motor this is really powerful and impossible to stop by hand. Mains operated and available with the final speeds 1 rpm, 4 rpm, 30 rpm, 60 rpm and 1 rev. per hour. 35/- **SIMILAR MOTOR,** but approximately half the size and mains operated, final shaft, 2 revs. per min. Price 17/6.



**ATLAS SLIMLINE FLUORESCENTS**

**THE TWENTYLITE**



(unit). Measures 2ft. long. Is ideal Kitchen, Bedroom, Hallway, Porch, Loft, etc. Don't miss this amazing offer. 39/6 with tube. Assembled ready to install. 4 ft. twin model 59/6. Post and ins. 6/6 extra.

A Fluorescent lighting unit made by the famous Atlas company, with super silent polyester filled choke and radio suppressed starter. The tube springs in and out and the whole unit is beautifully made and finished white enamel. Amazingly economical. If left on all the time costs only one penny per day (uses 1 mile this amazing offer. 39/6 with tube. Assembled ready to install. 4 ft. twin model 59/6. Post and ins. 6/6 extra.

**1 WATT AMPLIFIER & PRE-AMP**

5 transistors—highly efficient made for use with tape-head G4 but equally suitable for microphone or pick up. Limited quantity 29/6. Full circuit diag. also shows tape controls 5/-.



**VARYLITE**

Will dim incandescent lighting up to 600 watt from full brilliance to off. Fitted on M.K. flush plate, same size and fixing as standard wall switch may be fitted in place of this, or mount on surface. Price complete in heavy plastic box with control knob £3.19.6.

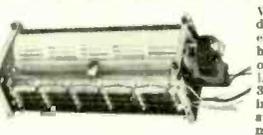


**HI FI BARGAIN**

**FULL F1 12 INCH LOUDSPEAKER.** This is undoubtedly one of the finest loudspeakers that we have ever offered, produced by one of the country's most famous makers. It has a die-cast metal frame and is strongly recommended for Hi-Fi and Rhythm Guitar and public address. Flux Density 11,000 gauss—Total Flux 44,000 Maxwell—Power Handling 15 watts R.M.S.—Cone Moulded fibre—Freq. response 30-10,000 c.p.s.—speedy 3 or 15 ohms—Main resonance 60 c.p.s.—Chassis Diam. 12in.—12 over mounting lugs—Baffle hole 11in. Diam.—Mounting holes 4, holes—1in. diam. on pitch circle, 11in. diam.—Overall height 5 1/2in. A £6 speaker offered for only £39.6 plus 7/6 p. & p. Don't miss this offer. 15in. 30 watt £7.19.6. 18in. 100 watt £24.10.0.



**TANGENTIAL HEATER UNIT**



Winter is coming but act today and you won't dismay. This heater unit is the very latest type, most efficient, and quiet running. It is fitted in a blower and blower heaters costing £15 and more. We have a few only. Units complete, wired ready to fit into cases, i.e. motor, transformer, 3 kW. heater switching 1, 2 and into any metal line case or cabinet. Only need on/off switch. 79/6. Postage and insurance 6/6. Don't miss this.

**MINIATURE WAFER SWITCHES**



3 pole, 2 way—4 pole, 2 way—3 pole, 3 way—4 pole, 3 way—2 pole, 4 way—3 pole, 4 way—2 pole, 6 way—1 pole, 12 way. All at 3/6 each, 38/- dozen, your assortment.

**WATERPROOF HEATING ELEMENT**

26 yards length 70W. Self-regulating temperature control. 10/- post free.

**AC FAN**

Small but very powerful mains motor with 54 in. blades. Ideal for cooling equipment or as extractor. Silent but very efficient. 17/6, post 4/6. Mounts from back or front with 4BA screws.



**DRILL CONTROLLER**

Electronically changes speed from approximately 10 revs. to maximum. Full power at all speeds by finger-tip control. Kit includes all parts, cables, everything and full instructions 18/6, plus 2/6 post and insurance. Made up model also available 37/6 plus 2/6 p. & p.

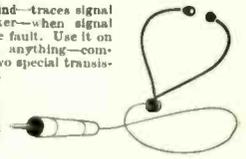


**MAINS MOTOR**

Precision made—as used in record decks and tape recorders—ideal also for extractor fans, blower, heater, etc. New and perfect. Snip at 8/6. Postage 3/- for first one then 1/- for each one ordered. 12 and over post free.

**RADIO STETHOSCOPE**

Easiest way to fault find—traces signal from aerial to speaker—when signal stops you've found the fault. Use it on Radio, TV, amplifier, anything—complete kit comprises two special transistors and all parts including probe tube and crystal earpiece 26/6—twin stenolet instead of earpiece 7/6 extra—post and insurance 2/9.

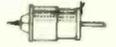


**MAINS TRANSISTOR POWER PACK**

Designed to operate transistor sets and amplifiers. Adjustable output 6v., 9v., 12 volts for up to 500mA (class B working). Takes the place of any of the following batteries: PP1, PP3, PP4, PP6, PP7, PP9, and others. Kit comprises: mains transformer, rectifier, smoothing and load resistor, condensers and instructions. Real snip at only 18/6, plus 3/6 postage.

**PHILIPS TRIMMER**

0-30pf an old design but one which has never been bettered. 1/- each. 10/- doz. £4.0.0 per 100.



**MOTOR WITH GEARBOX**

Very powerful 7 r.p.m., operates from standard A.C. mains. 29/6, plus 3/6 P. & P.



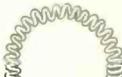
**230 VOLT SOLENOID**

1/2in. stroke. Size 2 1/2in. x 2in. x 1 1/2in. 14/6, postage 2/9.



**SPRING COIL LEADS**

As fitted to telephones. 4 core 2/6 each, 3 core 2/- each.



**PP3 BATTERY ELIMINATOR**

Run your small transistor radio from the mains—full wave circuit. Made up ready to wire into your set and adjustable high or low current. 8/6 each.



**INSTRUMENT BUZZER**

6-12 volts, adjustable tone, a very neat metal cased U.S.A. made unit approx. 1 1/2in. x 1in. x 1/2in. thick. 6/6 each.

**PANEL LAMPS**

In neat plastic cases, available in several voltages as follows: 4v., 6v., 12v., 24v., 36v., 48v., 60v., 110v., 220v., 380v. Note all below 110v. are fitted with lamps. 110v. and above are neon. Price 3/- each, 30/- dozen.



**APPLIANCE THERMOSTAT**

This is a skeleton Type control intended for building into oven, for baking, curing, pottery, etc. 2 models, one preset for screwdriver control. The other has a shaft for knob control. Approximate operating temperature. Note only high temperature insulation used in these stats. Price 12/6 each.

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**MULLARD 5-10.** Mono. Basic kit (requires pre-amp). Input Sensitivity—40 mV; Response 20Hz-15KHz + 1dB; Output 10 watts R.M.S. at 3 or 15 ohms. **KIT £10.10.0; BUILT £13.0.0** (Carr. either, 7/6).

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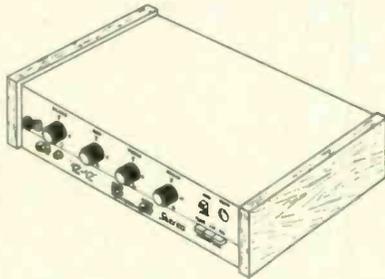
**2+2 STEREO PRE-AMP** similar to Mullard 2-valve pre-amp, but doubled with gang controls and balance. **BUILT £13.19.6** (Carr. 7/6).

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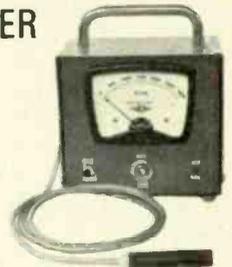
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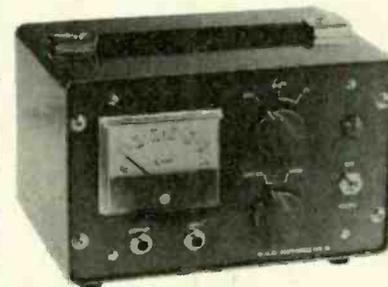


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# Lasky's

## TMK METER KITS ANOTHER LASKY'S EXCLUSIVE

These two new meter kits by TMK offer the professional, electronics hobbyist and student the unique opportunity of building a really first class precision multimeter at a worthwhile saving in cost. The Impact resistant bakelite cabinets are supplied with the meter scale and movement mounted in position; the model 200 also has the rotary range selector in position. The highest quality in components and 1% tolerance resistors are used throughout. Both offer professional standards of accuracy. Supplied complete in every detail with full constructional, circuit and operating instructions.

### MODEL 200

20,000 O.P.V. Multimeter. Features 24 measurement ranges with mirror scale. Large 3 x 2in. meter, full scale accuracy. DCV and current:  $\pm 2\%$ . ACV:  $\pm 3\%$ , resistance  $\pm 3\%$ . Special 0.6V DC range for transistor circuit measurements.

**SPECIFICATION:**

- DCV: 0-0.6-6-30-120-600-1,200V at 20K/OPV.
- ACV: 0-6-30-120-600-1,200V at 10K/OPV.
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- Resistance: 0-10K-100K-1M 10M/ohms (58-580-5.8K-58K at mid-scale).
- Capacitance: 0-0.02-0.2  $\mu$ F (AC 5V range).
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**SPECIFICATION:**

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  - ACV: 0-3-10-50-250-1,000V at 2.5K/OPV 0-1.5-5-25-125-500V at 5K/OPV.
  - DC  $\mu$ A: 0-25  $\mu$ A at 125mA; 0-50  $\mu$ A at 250mA
  - DC mA: 0-2.5-25-250mA at 125mV; 0-5-50-500mA at 250mV.
  - DC Amps: 0-5A at 125mV; 0-10A at 250mV.
  - Resistance: 0-10M/ohms (13, 65, 650, 6.5K and 65K/ohms at centre scale).
  - Output Capacitor (0.1  $\mu$ F, 400V) in series with ACV ranges.
  - Decibels: -20 to +81.5dB in 10 ranges.
- Operates on two 1.5V (U7 type) batteries. Black bakelite cabinet, size 5 1/2 x 6 1/2 x 2 1/2in. Strong resilient plastic handle. Complete with test leads.



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ALSO AVAILABLE READY-BUILT AND TESTED £12.10.0. Post 5/-

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**FULLY BUILT AND TESTED**

A highly accurate Multimeter using a 10  $\mu$ A. Meter hand calibrated to a DC accuracy of  $\pm 3\%$  of full scale. Special features: ultra large meter scale, 6 1/2 x 3 1/2in., incorporating an entirely new type of range selection panel which gives instant identification without taking your eyes from the meter. An audible buzzer is provided for easy short testing. SPEC. DCV ranges: 0-5, 2.5, 10, 50, 250, 500, 1,000V at 100K/OPV. ACV ranges: 3, 10, 50, 250, 500, 1,000V at 5K/OPV. DC current: 0-10, 100 A, 0-10, 100mA, 0-2.5, 10Amps. Resistance: 0-1K, 10K, 100K, 10M, 100M/ohms. Decibels: -10 to +49.4dB. Continuity test/Audible buzzer. Operates on 1x1.5V U2 and 1x1.5V 8.154 type batts. Cabinet size 7 1/2 x 6 1/2 x 2 1/2in. Weight 4lb.

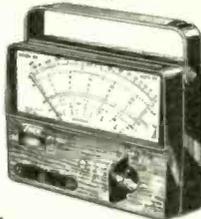


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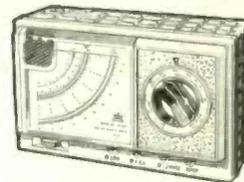
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**POCKET MULTIMETER**

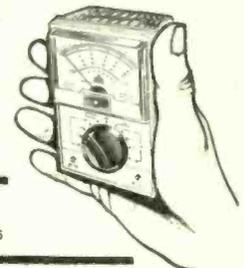
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ALSO AVAILABLE C-1052 3 KOPV METER £5.19.6

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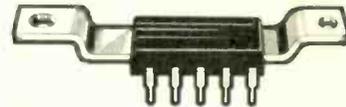
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SPECIFICATION: Ratings at 25°C: Output power typically 3W from 250mV input. Frequency response 20Hz to 80KHz +3dB. Max. operating voltage 21V. Min. operating load 7.5 ohms. Pre-amp input imp. 2M/ohms. Pre-amp D.C. input current 50mA. THE IC-403 IS AVAILABLE FROM STOCK EXCLUSIVELY FROM LASKY'S—COMPLETE WITH INSTRUCTION DATA AND SUGGESTED CIRCUIT APPLICATIONS. FREE INSTRUCTION DATA LEAFLET ON REQUEST. JUST SEND S.A.E.

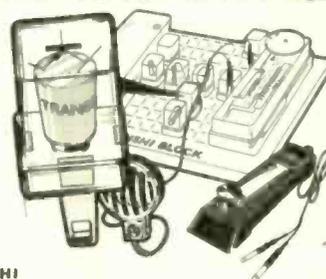


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**BOARD KIT** comes complete with 80-page manual of circuits and data. THESE ARE JUST A FEW OF THE CIRCUITS YOU CAN BUILD IN MINUTES: VARIOUS RADIO RECEIVERS, AMPLIFIERS, MORSE CODE PRACTICE DEVICE, SIGNAL INJECTOR, SIGNAL TRACER, WIRELESS MICROPHONE, ETC. **DENSHI BOARD KIT SR-1A** comprises: Base board; tuner block; 4 resistors; choke coil transformer; 2SA transistor for RF; 2 diodes; 3 capacitors; battery block; Morse key; antenna lead; crystal earphone; various bridge and connecting pieces and 80 page manual. This kit permits the building of 16 basic circuits.

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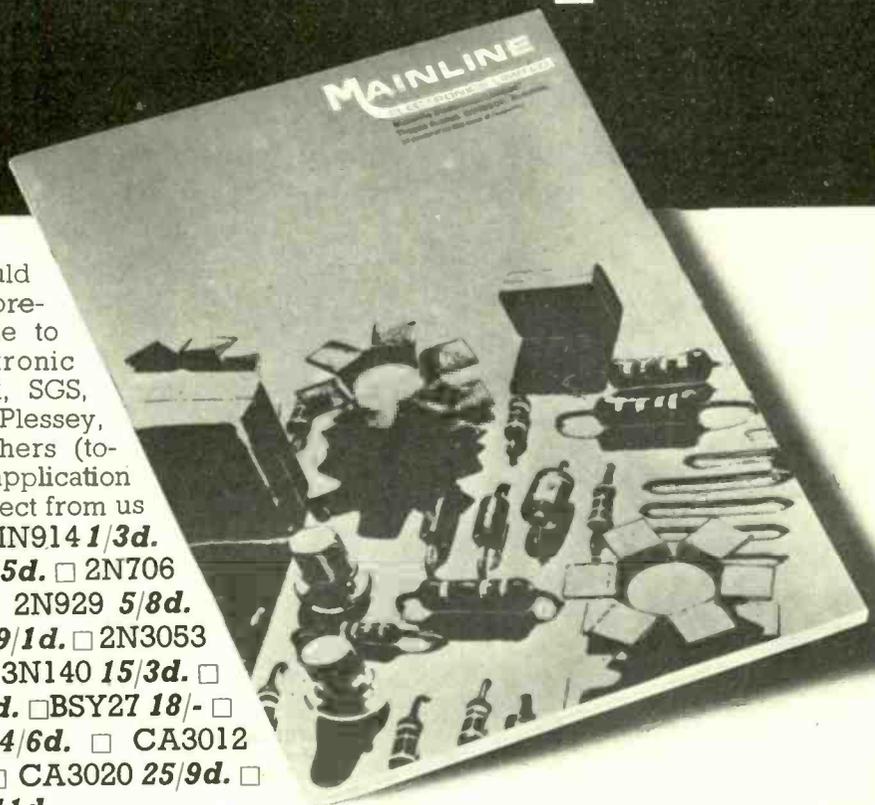
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The Duetto is a good quality amplifier, attractively styled and finished. It gives superb reproduction previously associated with amplifiers costing far more.

**SPECIFICATION:**

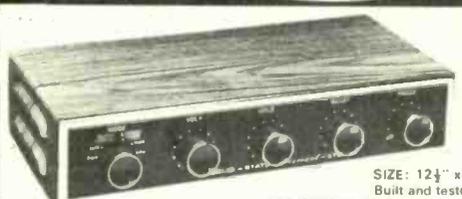
R.M.S. power output: 3 watts per channel into 10 ohms speakers  
**INPUT SENSITIVITY:** Suitable for medium or high output crystal cartridges and tuners. Cross-talk better than 30dB at 1 Kc/s.

**CONTROLS:** 4-position selector switch (2 pos. mono and 2 pos. stereo) dual ganged volume-control.

**TONE CONTROL:** Treble lift and cut. Separate on off switch. A preset balance control.



*The Classic*  
**TEAK FINISHED CASE**  
 8 1/2 GNS.  
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**INTEGRATED HIGH FIDELITY TRANSISTOR STEREO AMPLIFIER**  
 13 1/2 GNS. + 7/6 p. & p.

SIZE: 12 1/2" x 6" x 2 1/2" In teak-finished case Built and tested.

**SPECIFICATION**

**OUTPUT:** 10 watts per channel into 3 to 4 ohms speakers (20 watts) monoral.  
**INPUT:** 6-position rotary selector switch (3 pos. mono and 3 pos. stereo). P.U. Tuner. Tape and Tape Rec. out Sensitivities: All Inputs 100 mV into 1.8M ohm.  
**FREQUENCY RESPONSE:** 40Hz-20KHz ± 2DB.  
**TONE CONTROLS:** Separate bass and treble controls. TREBLE 13dB lift and cut (at 15KHz)  
**BASS:** 15dB lift and 25dB cut (at 50Hz).  
**VOLUME CONTROLS:** Separate for each channel. AC MAINS INPUT: 200-240v. 50-60Hz.  
**Viscount Mark II** for use with magnetic pick ups specification as above. Fully equalised for magnetic pick ups. Suitable for cartridges with minimum output of 4mV/cm/sec. at 1kc. Input Impedance 47k. 15 gns plus 7/6 p.&p.



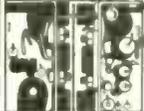
**THE RELIANT MK.II**  
**Solid State General Purpose Amplifier**  
 In teak-finished case  
 6 1/2 GNS.  
 + 7/6 p. & p.

**SPECIFICATION**

**OUTPUT:** 10 watts into a 3 ohms speaker.  
**INPUTS:** (1) for mike (10 m.v.). Input (2) for gram. radio (250 m.v.) individual bass and treble control.  
**TRANSISTORS:** 4 silicone and three germanium.

**MAINS INPUT:** 220/250 volts.  
**SIZE:** 10 1/2" x 4 1/2" x 2 1/2".  
**MIKE TO SUIT (CRYSTAL):** 12/6d. 1/6d. p. & p.  
**8" x 5" speaker 14/8d. + 3/- p. & p.**  
**Mk. 1 5 1/2 gns. + 7/6d. p. & p. less Teak-finished case.**

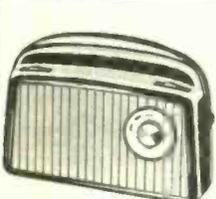
**X101 10w. SOLID-STATE HI-FI AMP**



**With Integral Pre-amp.**  
 Specifications: Power Output (into 3 ohms speaker) 10 watts. Sensitivity (for rated output): 1mV into 3K ohms (0.33 microamp) Total Distortion (at 1 KHz): At 5 watts 0.35%. At rated output 1.5%. Frequency Response: Minus 3 dB points 20 Hz and 40 KHz. Speaker: 3-4 ohms. (3-15 ohms may be used). Supply voltage: 24v D.C. at 800 mA. (6-24v may be used).

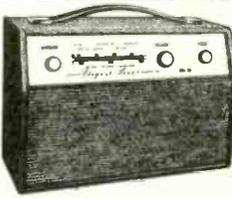
69/6 plus 2/6 p. & p.

**CONTROL ASSEMBLY:** (including resistors and capacitors). 1. Volume: Price 5/-. 2. Treble: Price 5/-. 3. Comprehensive bass and treble: Price 10/-. The above 3 items can be purchased for use with the X101. **POWER SUPPLIES FOR X101:** P101 M (mono) 35/- p. & p. 4/6; P101 (stereo) 42/6 p. & p. 4/6.



**THE DORSET**  
 (600mW Output)  
**£5.5.0**  
 plus 7/6 p. & p.  
 Circuit 2/6. FREE WITH PARTS  
**MAINS POWER PACK KIT:**  
 9/6 extra.

7-transistor fully tunable M.W.-L.W. superhet portable—with baby alarm facility. Set of parts. The latest modulated and pre-alignment techniques makes this simple to build. Sizes: 12" x 8" x 3"



**ELEGANT SEVEN MK. III**  
 (350mW Output)  
**£4.9.6**  
 plus 7/6 p. & p.  
 Circuit 2/6. FREE WITH PARTS  
**MAINS POWER PACK KIT:**  
 9/6 extra.

7-transistor fully tunable M.W.-L.W. superhet portable. Set of parts. Complete with all components, including ready etched and drilled printed circuit board—back printed for foolproof construction.

**50 WATT AMPLIFIER**



AC MAINS 200-250V  
**27 gns.**  
 plus 20/- p. & p.

An extremely reliable general purpose valve Amplifier—with six electronically mixed inputs. Suitable for use with: mics, guitars, gram, tuner, organ, etc. Separate bass and treble controls. Output impedance 3, 8 and 15 ohms.

**CYLDON 2 TRANSISTOR U.H.F. TUNER**

Brand new. Complete with circuit diagram.  
**£2.10 + 1/- p. & p.**

**STEREO PRE-AMPLIFIER**

Inputs—8 position rotary switch (3 position mono, 3 position stereo). Tuner 150 mV into 880k. Magnetic pick-up fully equalised and suitable for magnetic cartridges with minimum output of 4mV/cm/sec. Load 47k. Ceramic pickup 150 mV into 880k. Sensitivities taken for 200mV output. Controls—separate volume controls for each channel. Twin ganged bass. 12dB lift and 15dB cut at 80Hz. Twin ganged treble. 10dB lift and 15dB cut at 10KHz. Voltage required 23-30v DC at 5mA. Size 12 1/2" x 3 1/2" x 2 1/2". In teak finished case, complete with front panel and knobs. Built and tested £7.7.0 plus 5/- p. & p.

**SPECIAL OFFER**

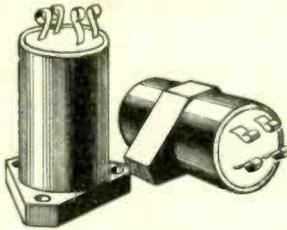
Complete stereo systems comprising BALFOUR 4 speed auto player with stereo head 2 DUO speaker systems size 12 x 6 1/2 x 5 1/2. Plinth (less cover) and the DUETTO stereo amplifier. All above items

**19 GNS.** plus 20/- p. & p.

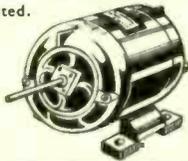
# Electro-Tech Sales

## MINIATURE "LATCHMASTER" RELAY

6, 12, or 24v. D.C. operation. One make one break, contacts rated 5 amps at 30 volts. Once current is applied, relay remains latched until input polarity is reversed. Manufactured for high acceleration requirements by Sperry Gyroscope Co. Size: Length  $\frac{7}{8}$ ", dia.  $\frac{9}{16}$ " (including mount). Actual size as illustrated. Please state vertical or horizontal mount and voltage. £3.10.0 each. P. & P. free.



New "Croydon" 1/50th HP, cont. rating 240v. A.C. motor, 1500 RPM, foot mounted. Size:  $3\frac{3}{8}$ " high x 5" long + spindle length  $1\frac{1}{8}$ " x  $\frac{1}{8}$ " dia. A really beautiful motor at less than half maker's original price. £6.10.0 each. P. & P. 5/-.



K.L.G. Sealed Terminals. Type TLSI AA, overall length  $1\frac{1}{16}$ ", box of 100, 25s. Type TLSI BB, overall length 1", box of 100, 35s. P. & P. Free.



Berco Rotary "Regavolt," variable voltage transformers input 240v. 50/60 cps., output 120-0-120v. at 6 amps. Not new, but in 1st class condition. Few only. £9.10.0. P. & C. 10/-.

Motor Driven Variable Voltage Transformers by Ohmite (U.S.A.). Input 120/240v., 50/60 c.p.s. Output 0-240v. at 480 v.a. A reversible 115v. a.c. geared motor drives the contact sweep arm in the direction required. There is a micro switch mounted at each end of the track which is cam-operated and intended to be connected as a safety-stop. First class condition. £8.15.0. Carriage 15/-.

Mallory Tubular Capacitor, with mounting clip. 1,000 mfd. 45 V.D.C. Size  $2\frac{1}{2}$ " long by  $1\frac{1}{2}$ " dia. 7/6 each. P. & P. 1/6.

S.T.C. Midget Relay Type 4190 GC. (new). 2 changeovers, 12v. 40 m.a. coil (170 ohms). 10/6 each. P. & P. 1/6.

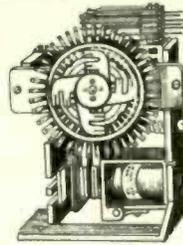
Jackson Air-Spaced Trimmers Type C803. Pre-set locking type, ceramic end-plate, 2-hole fixing. 3-10 p.f., 2/6. 4-20 p.f., 2/6. 4-60 p.f., 4/- 5-100 p.f., 4/- (Minimum order any 4 pieces.) P. & P. 1/6.

Advance Constant Voltage Transformer (new). Input 190-260v. Output volts 12 R.M.S. at 50 v.a. £4.19.6. Carriage 10/-.

We have a large quantity of Mullard Pot Cores, certain types only, also a very large quantity of Denco Neosid iron-dust cores. These items are suitable for industrial users and we would be pleased to give details upon request. Also in stock very large quantity of Torroid rings. Samples upon request.

## ROTARY STEPPING RELAY RT304

48v. coil (28 ohm). The relay has 48 basic segments shorted in step by the 4 sweep contacts to 4 pole-plates (banks of 12). There are 2 secondary switches: (1) one c/o H/Duty contact set which changes over and back with each step; (2) two H/Duty changeovers which changeover on each 12th step and return on the following pulse. Size: Base  $3\frac{1}{2}$ " x  $1\frac{1}{2}$ " x  $4\frac{1}{2}$ " high. New in maker's packing, limited supply, also few only, as above, but 110v. (1,290 ohm coil), £6.10.0 each. P. & P. free.



NEW HYSTERESIS MOTORS BY WALTER JONES. Type 14050/12, 240v. 50 c/s 1500 RPM cont. rating, output 2.0 oz./in. Size: Length (less spindle)  $3\frac{1}{2}$ ". Width  $2\frac{1}{2}$ " x  $2\frac{1}{2}$ ". Spindle  $1$ " x  $3/16$ ". Weight 3 lb. Maker's price in region of £22.10.0. Our price £7.15.0 each. P. & P. 5/-.



Robust M.E.S. Dual-circuit Panel Lamp by Thorne, adjustable length with press-to-test dome. 1" fixing hole. Available red, green, amber. 10/6 each. P. & P. free.



Isolation Transformers. 1 to 1. 250v. Input. 250v. centre tapped out, at 2 K.V.A., mounted in metal case measuring  $8\frac{1}{2}$ " x  $8\frac{1}{2}$ " x 11" high. Weight 65lb. £18.10.0. P. & C. 25/-.

Mullard Geiger Muller Tubes Type MX115 (new). Max. threshold voltage 370. Min. plateau length (volts) 100. Active length 45mm. Wall thickness 375 M.G./sq. cm. Two-pin base. £3.10.0. Post free.

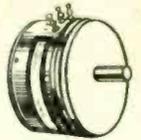
Dubilier Nitrogol Capacitors. 24 mfd. at 350 V.D.C. Size (approx.)  $4\frac{1}{2}$ " high x  $3\frac{1}{2}$ " x  $2\frac{1}{2}$ ". 10/- each. P. & P. 2/6.

Muirhead S.M. Drive Type B902C. 3" dia. (not calibrated). 180 deg. sweep. 10/- each. P. & P. 1/6.

American "Powerstat" Variable Voltage Transformer by Superior Electric Co. Input 120v. 50/60 c.p.s. Output 0-120v. at 2-25 amps.  $\frac{1}{8}$ " spindle with alternative pre-set locking device. Size (approx.) 3" dia. x 2" long. First class condition. £2.15.0. P. & P. 5/-.

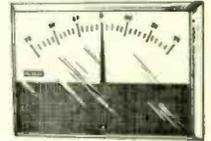
## Precision Motor-driven Potentiometer

By "Precision Line" (U.S.A.). Continuous track with 2 platinum contact wipers set at 90° C.W. resistance 300 ohm only,  $\pm 5\%$  LIN  $\pm 0.5\%$ , ball bearing spindle column. Size: dia.  $1\frac{13}{32}$ ", height  $1\frac{1}{32}$ ", spindle length  $1\frac{1}{32}$ " by  $\frac{1}{8}$ " dia. These potentiometers were purchased by the importer at a cost of approx. £25 each. Our price £6.15.0 each. P. & P. free.



## New 75-0-75 Micro-ammeter by Sifam.

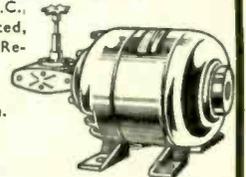
750 ohm movement, clear reading, 5uA divisions x  $\frac{1}{2}$ "; plastic front, projection  $\frac{1}{2}$ " (tapering forward). Size:  $4\frac{1}{2}$ " x  $3\frac{1}{2}$ ". 57/6 each. P. & P. 2/6.



MINIATURE 500-0-500 Micro-Ammeter.  $1\frac{3}{16}$ " Diam. scale. Through-Panel mounting. 45/- P. & P. free.

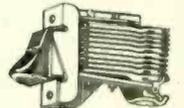
## "Parvalux" Reversible 100 RPM Geared Motor

Type S.D.14, 230/250v. A.C., 22 lb./in. Standard foot mounted, variable angle final drive. Removable 3-tooth chain sprocket on  $3/16$ " spindle. 1st class condition. £7.10.0 each. P. & P. 10/-.



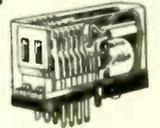
## New beautifully-made 3 change-over Key-Switch.

Neat action, either locking or spring-return, as required determined by reversing fixing-plate. Attractive plastic prestle. Available red, green, grey, cream. Limited number only. 17/6 each. P. & P. 1/6.



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6v. 50Ω 2 c/o, 14/6  
24v. 470Ω 4 c/o, 15/6  
48v. 2780Ω 4 c/o, 15/6  
48v. 1,260Ω 6 c/o, 18/6  
P. & P. free.



## New "Magnetic Devices"

solenoid 240v. A.C. Type 42117, 1 to 3 lb. pull, frame size  $1\frac{1}{2}$ " x  $1\frac{1}{2}$ " x 1". 20/- each. P. & P. free.



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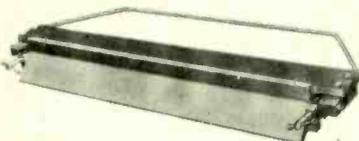
English Electric  $\frac{1}{2}$  h.p. Motors. 240v. single-phase, standard foot mounted, 1,425 r.p.m., continuous rating. £4.15.0. Carriage 20/-.

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| AF127  | 4/-  | BF167 | 6/6  | MAT120  | 5/6  | NKT452  | 13/4 | OC201 | 10/-  | 2N711  | 7/6   | 2N4284  | 3/-  |
| AF139  | 8/-  | BF173 | 6/2  | MAT121  | 5/6  | NKT453  | 12/3 | OC202 | 18/10 | 2N711A | 7/6   | 2N4285  | 3/-  |

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| AFZ11 | 14/-  | BF181     | 7/-   | MPF103 | 9/-   | NKT677   | 5/-  | OC206    | 10/6 | 2N743  | 5/-  | 2N4289 | 3/-  |
| AFZ12 | 11/9  | BF184     | 7/6   | MPF104 | 9/-   | NKT703   | 8/-  | OC207    | 7/6  | 2N744  | 5/6  | 2N4290 | 3/-  |
| AS526 | 4/5   | BFX13     | 4/10  | MPF105 | 9/-   | NKT7713  | 7/6  | OR112    | 9/6  | 2N753  | 5/-  | 2N4291 | 3/-  |
| AS527 | 4/5   | BFX29     | 6/6   | MP3138 | 6/-   | NKT7773  | 6/-  | ORP60    | 8/-  | 2N863  | 12/- | 2N4292 | 3/-  |
| AS528 | 4/5   | BFX44     | 6/5   | MJ480  | 21/-  | NKT7774  | 5/4  | ORP61    | 8/-  | 2N865  | 7/6  | 2N4303 | 15/- |
| AS529 | 6/-   | BFX87     | 6/-   | MJ481  | 27/-  | NKT0013  | 12/6 | ORP63    | 9/-  | 2N914  | 4/3  | 2N4871 | 6/9  |
| ASZ21 | 11/-  | BFY50     | 4/6   | MJ491  | 30/3  | NKT10419 | 13/- | ORP93    | 24/- | 2N918  | 15/- | 25002  | 15/- |
| ATZ10 | 40/-  | BFY51     | 3/9   | NKT121 | 10/11 | NKT10519 | 12/6 | OC309    | 12/- | 2N929  | 5/6  | 25004  | 23/- |
| AUY10 | 39/6  | BFY52     | 4/6   | NKT122 | 7/9   | NKT10339 | 10/3 | P346A    | 6/-  | 2N930  | 6/6  | 25017  | 15/- |
| AFY19 | 16/10 | BFY53     | 3/2   | NKT123 | 6/2   | NKT10429 | 11/3 | RAS310AF | 6/-  | 2N1131 | 9/6  | 25018  | 12/6 |
| BA110 | 6/-   | BSX20     | 3/4   | NKT124 | 9/8   | NKT20329 | 12/6 | RAS508AF | 15/- | 2N1132 | 7/6  | 25020  | 15/- |
| BA111 | 6/-   | BSX21     | 8/-   | NKT125 | 6/2   | NKT16229 | 11/- | ST2      | 9/9  | 2N1143 | 26/2 | 25024  | 25/- |
| BA112 | 18/-  | BSY27     | 4/-   | NKT127 | 5/8   | OA5      | 3/8  | ST140    | 3/-  | 2N1177 | 14/6 | 25034  | 15/6 |
| BA115 | 2/8   | BSY95A    | 3/4   | NKT128 | 6/-   | OA10     | 6/-  | ST141    | 5/-  | 2N1302 | 4/6  | 25102  | 10/- |
| BA130 | 3/-   | BTX39     | 120/- | NKT129 | 5/10  | OA47     | 1/6  | T1544    | 1/7  | 2N1303 | 4/6  | 25104  | 12/6 |
| BAY31 | 2/-   | 600R      | 120/- | NKT141 | 6/11  | OA70     | 1/6  | T1543    | 6/9  | 2N1304 | 5/-  | 25301  | 7/7  |
| BAY38 | 3/-   | BTX40     | 120/- | NKT142 | 5/10  | OA73     | 1/6  | U23AAA   | 5/-  | 2N1305 | 5/-  | 25302  | 6/-  |
| BC107 | 2/9   | 600R      | 120/- | NKT143 | 5/4   | OA79     | 1/6  | V405A    | 9/3  | 2N1306 | 6/6  | 25304  | 15/- |
| BC108 | 2/9   | BTY87     | 31/-  | NKT144 | 8/-   | OA81     | 1/6  | XA102    | 6/-  | 2N1307 | 6/6  | 25320  | 12/6 |
| BC109 | 2/9   | 150R      | 31/-  | NKT145 | 3/4   | OA85     | 1/6  | XA702    | 15/- | 2N1308 | 8/-  | 25322  | 8/-  |
| BC113 | 5/-   | BTY91     | 47/-  | NKT161 | 5/8   | OA90     | 1/6  | ZT2      | 19/- | 2N1309 | 8/-  | 25302  | 9/9  |
| BC114 | 7/5   | 300R      | 47/-  | NKT162 | 5/8   | OA91     | 1/6  | ZT86     | 27/6 | 2N1507 | 4/8  | 25702  | 12/- |
| BC115 | 7/11  | BY100     | 3/-   | NKT163 | 5/4   | OA95     | 1/6  | ZT2270   | 19/6 | 2N1613 | 6/6  | 25711  | 23/3 |
| BC116 | 9/-   | BY125     | 3/-   | NKT164 | 5/4   | OA200    | 2/-  | IN23A    | 20/- | 2N1496 | 34/6 | 25712  | 30/3 |
| BC118 | 5/-   | BYX10     | 3/-   | NKT165 | 5/8   | OA202    | 2/-  | IN87A    | 4/-  | 2N171  | 7/6  | 25713  | 30/3 |
| BC125 | 12/-  | BYX36/150 | 2/6   | NKT211 | 6/-   | OA210    | 6/4  | IN60     | 4/-  | 2N2147 | 17/6 | 40361  | 13/3 |
| BC126 | 12/-  | BYX36/300 | 2/10  | NKT212 | 6/-   | OA211    | 9/-  | IN64     | 4/-  | 2N2148 | 12/6 | 40362  | 16/3 |
| BC134 | 9/-   | BYX36/600 | 3/8   | NKT213 | 6/-   | OC19     | 5/-  | IN82A    | 9/6  | 2N2160 | 14/6 | ZT72   | 19/- |
| BC136 | 7/11  | BYX36/600 | 3/10  | NKT214 | 6/-   | OC27     | 33/4 | IN87A    | 4/-  | 2N2161 | 14/6 | ZT76   | 27/6 |
| BC137 | 8/6   | BYY21     | 25/-  | NKT215 | 4/-   | OC22     | 13/- | IN191    | 5/-  | 2N2243 | 23/7 | ZT76   | 27/6 |
| BC138 | 12/-  | BYY23     | 26/3  | NKT216 | 10/5  | OC23     | 15/- | 1544     | 1/6  | 2N2368 | 6/6  | ZT2270 | 19/6 |

When enquiring for types not listed please enclose a STAMPED ADDRESSED ENVELOPE

## COMPONENTS

**RESISTORS** | or | Watt's. **LOW NOISE CARBON FILM**. 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82 ohms and decades (x10, x100, x1,000, x10,000) 1 Meg etc. to 8.2 Megohms (10% tolerance). PRICES: 1-25 4d, 26-99 3d, 100+2d (your selection) and (or) Watt mixed).

**SKELETON PRESET POTS**. 20% Tol. Linear. Low noise. Available in sub-miniature or standard size, horizontal or vertical. 100, 250, 500, 1k, 2.5k, 5k, 10k, 25k, 50k, 100k, 250k, 500k, 1 Meg, 2.5 Meg, 5 Meg. NEW PRICE: 1/- each or any selection of 12 pieces 10/-

**ELECTROLYTIC CAPACITORS (Mullard)**. -10% to +50% tol. Subminiature (all values in µF).

|      |      |     |      |     |     |     |
|------|------|-----|------|-----|-----|-----|
| 4V   | 8    | 32  | 64   | 125 | 250 | 400 |
| 6.4V | 6.4  | 25  | 50   | 100 | 200 | 320 |
| 10V  | 4    | 16  | 32   | 64  | 125 | 200 |
| 16V  | 2.5  | 10  | 20   | 40  | 80  | 125 |
| 25V  | 1.6  | 6.4 | 12.5 | 25  | 50  | 80  |
| 40V  | 1    | 4   | 8    | 16  | 32  | 50  |
| 64V  | 0.64 | 2.5 | 5    | 10  | 20  | 32  |

Price 1/6 1/3 1/2 1/- 1/1 1/2

**MIN. POLYESTER CAPACITORS**. Printed circuit type 250 Vdc working. 0.01, 0.015, 0.022, 7d each, 0.033, 0.047, 8d each; 0.068, 0.10, 9d each

**VEROBOARD 0.15" Matrix FLUX COATED** 2 1/2 x 3 1/2, 3 1/2 x 5 1/2, 3 1/2 x 3 1/2, 3 1/2 x 5 1/2, 5 1/2 x 18 1/2. BARGAIN PACK of 36 square inches all good size pieces only 10/- pack.

**VEROBOARD 0.1" Matrix, 3 1/2 x 2 1/2, 3 1/2, 3 1/2**. **VEROPINS** for 0.15", 36 pieces 3/-.

**VEROCUTTER 9/-** (including free sample pieces).



**S-DeCs** Single "DeC" with accessories and project manual... 29/6  
"2-DeC" kit contains two "DeCs" component tray accessories, instruction book, all packed in attractive plastic box... 69/6  
"4-DeC" kit contains four "DeCs", accessories, manual, etc... 117/6

**BOOKS FROM STOCK**  
General Electric Transistor Manual, 660 pages of data and circuits... 29/6  
RCA Transistor Manual, 554 pages, includes SCR circuits... 28/-  
Designers' Guide to British Transistors. Excellent data book lists over 1,000 common types plus Computer-selected substitution chart... 25/-  
(ADD 2/6 POST & PACKING FOR ALL BOOKS)

**NEONS**  
Signal neons for many types of circuit, type "N" Price 1/6 each or 16/- dozen.

**HEATSINKS**. Suitable for 2 x OC35, etc. As used in commercial equipment. Type 10D... 6/-

**ALUMINIUM CHASSIS**  
6 x 4 x 2 1/2" with reinforced corners 6/9 each (P & P 1/6). Ally panel to fit 1/6. Paxolin panel to fit 2/-. Many other types in stock up to 12 x 8 x 2 1/2" (see catalogue).

**ZENER DIODES**. 400mW 10% Tolerance. Complete range preferred values 3 volt to 30 volt, each... 3/6

**SOLAR CELLS**  
B2M 0.2-0.4 volts @ 2mA Selenium type... 12/6  
B3M 0.2-0.4 volts @ 1-2mA Selenium type... 15/-  
S1M 0.3-0.4 volts @ 10-16mA Silicon... 19/-  
S4M 0.3-0.4 volts @ 25-40mA Silicon... 33/6

2N3819 Texas FET 8/-  
25 + 6/9 100 + 5/9

2N4871 MOTOROLA Unijunction 6/9  
25 + 5/9 100 + 4/9

2N3055 115 WATT POWER 15/-  
25 + 13/- 100 + 11/-

56CAY Gallium Arsenide Infra-Red emitter 29/6 each. (Incl. data)

BC107/8/9 Planars 2/9

TAA263 MULLARD LINEAR IC 17/6

SC41D GE Triac 400piv 6amp 37/6

**LOGIC**  
These are new Prices.  
uL900 9/9 9/- 8/-  
uL914 9/9 9/- 8/-  
uL923 13/- 12/- 11/-  
Five Page Data and Circuits article 2/6  
Larger quantity prices (100+ and 1,000+) on application.  
Plastic Spreaders 1/6

**SILICON RECTIFIERS**

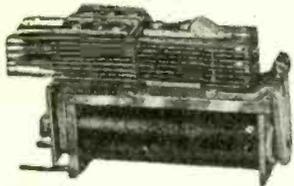
| PIV  | 200mA | 750mA | 2 Amp | 10 Amp |
|------|-------|-------|-------|--------|
| 50   | 6d    | 1/-   | 2/3   | -      |
| 100  | 9d    | 1/6   | 2/3   | 4/6    |
| 200  | 1/3   | 2/-   | 2/9   | 5/-    |
| 400  | -     | 2/6   | 4/-   | 8/-    |
| 600  | -     | 3/-   | 4/6   | 9/6    |
| 800  | -     | 3/9   | 5/-   | 11/3   |
| 1000 | -     | 6/-   | 6/6   | 14/-   |

BF180 MULLARD UHF AMPLIFIER 6/-  
25 + 4/11 100 + 4/3

**THYRISTORS-SCRs**

| PIV | 1A |
|-----|----|
|-----|----|

# Wilkinsons FOR RELAYS



**P.O. TYPE 3000 AND 600**  
**BUILT TO YOUR REQUIREMENTS—QUICK DELIVERY**  
**COMPETITIVE PRICES—VARIOUS CONTACTS**  
**DUST COVERS—QUOTATIONS BY RETURN**  
**LARGE STOCKS HELD OF MINIATURE SEALED RELAYS**



**EQUIPMENT WIRE P.V.C.** covered 80/- per 1,000 yds. 7/0076, 1/024, 14/0048 type 1 and 2, all colours. 14/0076 type 11 Red and Natural £15 per 1,000 yds. 140,000 yds. available.

**MINIATURE SILVER ZINC ACCUMULATOR.** 1.5 volt, 1.5 ampere. Size 2x1.13x0.63in. Weight 1 1/2 oz. Ideal for model work, 12/6 each. 120/- doz., post 1/6.  
**STROBOSCOPE FORK.** 125 cycles. P.O. No. 5, 30/- each, post 2/6.

**LEDEX ROTARY SOLENOIDS AND CIRCUIT SELECTORS.** SIZE 5s. 4 pole, 11 way and off 110/-, 4 pole, 12 way 110/-, 24 pole, 11 way and off 210/-, 54 pole On/Off 150/-.

**N.S.F. SOLENOIDS** type 3E 115.2 ohms 48v. D.C. 17/6 ea. **CERAMIC AND PAXOLIN WAFER SWITCHES** available from stock at keen prices, send for list. 24 way Double Pole Wax Wafer Switches 12/6 each, post 2/6.

**P.O. STANDARD RACKS** 6ft. U channel sides drilled for 19in. panels heavy angle base, 150/-, cpe 20/-, Desk Units for Racks 30/-, cpe 7/6.

**MINIATURE BUZZERS.** 12v. with tone adjuster. 7/6  
**PLASTIC-FILM CONDENSERS TMC 5125017LM** 0.9-0.1 mfd. 500v. also 1 mfd. 150v. TCC 20/- each.

**AIR BLOWERS.** 200/250 volt. A.C. cylindrical 7in.—7in. suitable for intake or extraction. 1/50th h.p. £10. 1/15th h.p. £11. 1/10th h.p. £14.

**ELCOM STUD SWITCHES.** 12 pole 2 way or 3 way types on 3 Banks, break before make action. 50/- each.

**GEARED MOTORS.** 1 r.p.m. or 3 r.p.m. 4 watts very powerful, reversible 24v. A.C. 35/-, post 2/6, can be operated from 230v. with our 20/- Transformer. Post 5/-.

**VACUUM GAUGES.** 2in. scaled, 0/30 inches of mercury, 20/- each, post 2/6.

**STANDARD LEVER KEYS, 3 POSITION**  
 4C lock/4C lock 17/6 each. Stop/6C 15/6 each.  
 2C 2M non-lock/ 2C 2M non-lock 14/6 each.  
 4C non-lock/6C lock 20/- each.

**ONE HOLE FIXING.** Stop/4 C.O. non-locking 2 position 10/6. 6 C.O. lock/2 C.O. lock 3 position 17/6.  
**TRANSFORMER.** 200/240v., tapped 6.3v., 8.3v., 10.3v. at 17 amps 5kv. wkg., 70/-, post 6/-.

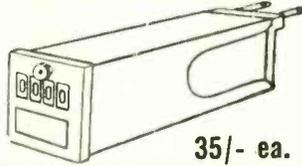
**LAMP HOUSES** with pair of 6in. lenses mounted in a 9in. square case. Ideal spotlight 70/- each, post 10/-.

**BATTERY CHARGERS** at special price made by Westinghouse, worth £35. Input 200/250v. A.C. output 6v. 15 amps D.C. with ammeter, fuses; regulated by a 4-position switch and sliding resistance. **OUR PRICE 170/-**. Cge. 15/-.

**MINIATURE DIGITAL DISPLAY SERIES 661** Counting Insts. Ltd., an assembly of five units each displaying 11 messages in numbers with decimal point, and letters £25 complete, send for details.

**HIGH SPEED COUNTERS**

3 1/2 x 1in., 10 counts per second with 4 figures. The following D.C. voltages are available, 6v., 12v., 24v., 50v. or 100v.



35/- ea.

**SUB-MINIATURE** Microswitch Honeywell S.P.D.T. type 11 SMI TN 13 size 1in. x 1/2in. x 1/2in. 6/6 each, or mounted in fives for 22/6 post free.

**JACK PLUGS.** 2 Point with screw-on cover, 2/6, post 9d.  
**PO 201** on headphone cord 3/-, post 1/6.

**PLUG-IN RELAYS.** Londex 4 change-over HD contacts 28v. D.C. or 240v. A.C. with base and cover, 35/- each.

**RELAYS,** 24 volt D.C., 4 make, 4 break heavy duty contacts with dust cover, 12/6 each, quantities available.

**UNISELECTOR DIGIT SWITCHES** 8 level 12 outlets 3 bridging 5 non-bridging 50 volts. £8/10/-.

**STABILIZED POWER UNITS RACAL.** Inst. type PU 156C, A.C. Input 200/250v. D.C. output positive HT 200/300v. stabilized Load current 250 mA negative HT 150v. stabilized 15 mA. £45.

**ROOM THERMOSTAT.** Adjustable between 45 and 75 deg. Far., 250v. 10 amp. A.C. ideal for greenhouses, 35/- Post 4/6.

**L. WILKINSON (CROYDON) LTD.**  
**LONGLEY HOUSE LONGLEY RD. CROYDON SURREY**

Phone: 01-684-0236

Grams: WILCO CROYDON

**TERMINAL BLOCKS.** 2 way 5C/430 or 3 way 5C/432 50/- per 100 or £20 per 1,000. (As illustrated).

**ROBUST AIRCRAFT PUSH.** 5C/B98 of bakelite barrel type construction, with 1 1/2in. square hole fixing top with actual push below the level of a lin. bakelite circle to prevent it being used accidentally. Samples 5/- each large quantities available.

**MAGNETIC COUNTERS.** Veeder Root with zero reset. 800 counts per minute, counting to 999,999, 110 or 125 volts A.C. or 110 volts D.C. 65/- each, post 3/-.

**VACUUM CONDENSERS,** 25 pf., 32 kV, 27/6, post 3/-.

**METERS GUARANTEED.** Complete list available.

Microamps 0/500 2in. MC... 25/-

Microamps 0/500 2 1/2in. MC... 37/6

Milliamps 0/50 2 1/2in. MC... 35/-

Milliamps 0/500 3 1/2in. MC... 54/-

Amps 50-0-50 2in. MC... 17/6

Amps 0/5 2in. MC... 42/6

Volts 5/0-5 2 1/2in. MC... 25/-

Volts 0/20 2in. MC... 42/6

Volts 0-40 2in. MC... 42/6

Volts 0/10 A.C. 3 1/2in. MCR... 70/-

**MICROAMPS 0/50** scaled in Rongens 2 1/2in. MC 48/-.

**PORTABLE VOLTMETERS** 0/250 Moving Iron A.C./D.C., 6in. scale, in polished wood case, £7/10/-.

**ONE HOLE FIXING SWITCHES**  
**DOUBLE POLE ON/OFF**  
 3 amp 250 volt A.C. 1 1/2in. x 1 1/2in. x 1 1/2in.  
 30/- per dozen, 200/- per 100. Post 3/- per dozen, 6/- per 100.



**MASTER CONTACTOR.** Precision made. Contacts making and breaking twice per second in sound proof case, thermostat controlled heating. 12 or 24v. 18/6, post 6/-.

**VISCO NOL-CATHODRAY CONDENSERS.** .001 mfd. 10 kV, 5/-; .002 mfd. 15 kV, 9/-; .02 mfd. 10 kV, 10/-; .025 mfd. 2.5 kV, 5/-; .05 mfd. 5 kV, 9/-; 0.1 mfd 4 kV, 9/-; 6 kV, 17/6; 0.5 mfd. 2.5 kV, 17/6; 1 mfd. 2 kV, 17/6.

**RESISTORS,** wire wound or carbon, potentiometers, condensers, quantities ex-stock at low prices.

**BRIDGE MEGGER** series 1. With resistance box 1,000 volts, range 0/100 megohms-infinity, usual price £189, our price £60.

## NO EXCUSES! NO DELAYS! FROM STOCK! VARIABLE VOLTAGE TRANSFORMERS

**INPUT 230 v. A.C. 50/60**  
**OUTPUT VARIABLE 0/260 v. A.C.**

**BRAND NEW.** Keenest prices in the country. All Types (and spares) from 1/2 to 50 amp. available from stock.

|                             |          |
|-----------------------------|----------|
| 0-260 v. at 1 amp. ....     | £5 10 0  |
| 0-260 v. at 2.5 amps. ....  | £6 15 0  |
| 0-260 v. at 5 amps. ....    | £9 15 0  |
| 0-260 v. at 8 amps. ....    | £14 10 0 |
| 0-260 v. at 10 amps. ....   | £18 10 0 |
| 0-260 v. at 12 amps. ....   | £21 0 0  |
| 0-260 v. at 15 amps. ....   | £25 0 0  |
| 0-260 v. at 20 amps. ....   | £37 0 0  |
| 0-260 v. at 37.5 amps. .... | £72 0 0  |
| 0-260 v. at 50 amps. ....   | £92 0 0  |

**20 DIFFERENT TYPES AVAILABLE FOR IMMEDIATE DELIVERY.**

**Double Wound Variable Transformers**

Fully isolated, low tension Secondary winding. Input 230 v. A.C. **OUTPUT CONTINUOUSLY VARIABLE 0-36 v. A.C.**

0-36 v. at 5 amp. £9.12.6—  
 £. & p. 8/6

0-36 v. at 20 amp. £21.0.0—  
 15/- p. & c.

These fully shrouded Transformers, designed to our specifications, are ideally suited for Educational, Industrial and Laboratory use.

**INSULATION TESTERS (NEW)**

Test to I.E.E. Spec. Rugged metal construction, suitable for bench or field work, constant speed clutch. Size L. Bin. V. 4in., H. 6in. Weight 6lb.

**500 VOLTS, 500 megohms.**  
 Price £28 carriage paid.

**1,000 VOLTS, 1,000 megohms,**  
 £34 carriage paid.

**5Amp. AC/DC VARIABLE VOLTAGE OUTPUT UNIT**

Input 230 v. A.C. Output 0-260 v. A.C. Output 0-240 v. D.C. Fitted large scale ammeter and voltmeter. Neon indicator, fully fused. Strong attractive metal case 15in. x 8 1/2in. x 6in. Weight 24 lb. Infinitely variable, smooth stepless voltage variation over range. Price £38 plus 30/- p. & c. Similar in appearance to illustration below.

**OPEN TYPES**  
 Designed for Panel Mounting.  
 Input 230 v. A.C. 50/60 Output variable.  
 0-260 v.  
 1/2 amp ..... £3 10 0  
 1 amp ..... £5 10 0  
 2 1/2 amp ..... £6 12 6  
 P. & P. 7/6

1 AMP. 1 AMP.

**VAN DE GRAAF ELECTROSTATIC GENERATOR**

fitted with motor drive for 230 v. A.C. giving a potential of approx. 50,000 volts. Supplied absolutely complete including accessories for carrying out a number of interesting experiments, and full instructions. This instrument is completely safe, and ideally suited for School demonstrations. Price £7/7/-, plus 4/- P. & P. L't. on req.

**CONSTANT VOLTAGE TRANSFORMER**

Input 185-250 v. A.C. Output constant at 230 v. A.C. Capacity 250 watt. Attractive metal case. Fitted red signal lamp. Rubber feet. Weight 17lbs. Price £11/10/-, P. & P. 10/-.

**LATEST TYPE SOLIO STATE VARIABLE CONTROLLER**

Ideal for lighting and heating circuits, compact panel mounting. Built in fuse protection. CONTINUOUSLY VARIABLE.  
 Input 230v AC output 25-230v AC  
 5 amp model £8. 7. 6  
 10 amp model £13. 5. 0

**SPEEDIVAC HIGH VOLTAGE HIGH FREQUENCY GENERATOR**

Input 100/110 volts or 200/250 volts AC/DC Output 19kV variable. Ideal for testing insulation, vacuum, leakage path, gas discharge lamps, neon etc. A useful ozone and HF supply. Manufactured by Edwards High Vacuum Ltd. Brand new in maker's polished wooden carrying case. Offered at fraction of maker's price. £10.0.0 plus 7/6 p. & p.

**36 volt 30 amp. A.C. or D.C. Variable L.T. Supply Unit**

**INPUT** 220/240 v. A.C.  
**OUTPUT** CONTINUOUSLY VARIABLE 0-36 v.

Fully isolated. Fitted in robust metal case with Voltmeter, Ammeter, Panel Indicator and chrome handles. Input and Output fully fused. Ideally suited for Lab. or Industrial use. £55 plus 40/- p. & c.

# SERVICE TRADING COMPANY

# SERVICE TRADING CO

Postage and Carriage shown below are inland only. For Overseas please ask for quotation. We do not issue a catalogue or list.

## LIGHT SENSITIVE SWITCHES

Kit and parts including ORP.12 Cadmium Sulphide Photocell. Relay Transistor and Circuit. Now supplied with new Siemens High Speed Relay for 6 or 12 volt operations. Price 25/-, plus 2/6 P. & P. ORP. 12 and Circuit 10/ post paid.



## 220/240 A.C. MAINS MODEL

incorporates mains transformer rectifier and special relay with 2 X 5 amp. mains c/o contacts. Price inc. circuit 47/6, plus 3/6 P. & P.

## LIGHT SOURCE AND PHOTO CELL MOUNTING

Precision engineered light source with adjustable lens assembly and ventilated lamp housing to take MBC bulb. Separate photo cell mounting assembly for ORP.12 or similar cell with optic window. Both units are single hole fixing. Price per pair £2/15/0 plus 3/6 P. & P.



## INSULATED TERMINALS

Available in black, red, white, yellow, blue and green. New 17/- per doz. P. & P. 2/-.



## SANGAMO WESTON

Ex W.D. Dual range voltmeter. 0-5 and 0-100 v. D.C. FSD 1 mA. In carrying case with tests prods and leads. 32/6. P. & P. 3/6.



## RADIO ALTIMETER

This precision instrument is based on a 24 v. D.C. LOW INERTIA (Integrating) Motor. The Motor drives two precision pots through close tolerance gear-trains, including slipping clutch. Offered at fraction of manufacturer's price: 32/6, plus 6/- P. & P.



## LATEST TYPE SELENIUM BRIDGE RECTIFIERS

30 volt 3 amp., 11/-, plus 2/6 P. & P.  
30 volt 5 amp., 16/-, plus 2/6 P. & P.

## AUTO TRANSFORMERS.

Step up, step down. 110-200-220-240 v. Fully shrouded. New. 300 watt type £3/10/- each. P. & P. 4/6. 500 watt type £4/12/6 each. P. & P. 6/6. 1,000 watt type £5/15/- each. P. & P. 7/6.

## COPPER LAMINATE PRINTED CIRCUIT BOARD.

Large sheet 15 1/2 x 5 1/2 in. 3 for 10/- post paid. (3 minimum order).

## SEMI-AUTOMATIC "BUG" SUPER SPEED MORSE KEY

7 adjustments, precision tooled, speed adjustable 10 w.p.m. to as high as desired. Weight 2 1/2 lb. £4/12/6 post paid.



## NEW MODEL HIGH FREQUENCY TRANSISTORISED MORSE OSCILLATOR

Adjustable tone control. Fitted with moving coil speaker, also earpiece for personal monitoring. Complete with morse key. 45/- plus 3/6d. p. & p.

## NICKEL CADMIUM BATTERY

1.2 v. 35 AH. Size 8 1/2 high x 3 x 1 1/2. 30/- each, plus 4/- P. & P.  
Sintered Cadmium Type 1.2 v. 7AH. Size: height 3 1/2 in., width 2 1/2 in. x 1 1/2 in. Weight: approx. 13 ozs. Ex-R.A.F. Tested 12/6. P. & P. 2/6.

## DRY REED SWITCHES

2 X lamp Dry Reeds (makes contacts) mounted in 870 ohm 9-18v coil. Size 3in. x 3 1/2in. x 1/2in. New. Price 8/6 per pair. Post Paid.  
6 of the above mentioned units (12 Reeds, 6 coils) fitted in metal box. Size 4in. x 3 1/2in. x 1 1/2in. Mfg. by Elliott Bros. New 45/- each. Post Paid.

## Telephone Dials (New) 14/6d. Post Paid.

## 250 v. A.C. SOLENOID

Heavy duty type. Approx. 3lb. pull. 17/6 plus 2/6 P. & P.

## 12 v. D.C. SOLENOID

approx. 1lb. pull. 10/6, P. & P. 1/6.

## 50 v. D.C. SOLENOID

approx. 1lb. pull. 10/6, P. & P. 1/6.

## 50 v. D.C. SOLENOID

approx. 2lb. pull. 12/6, P. & P. 1/6.



## PRECISION INTERVAL TIMER

From 0-30 seconds (repetitive). Jewelled balanced movement. Lever re-set. Operates 230 v. A.C. 5 amp. c/o micro-switch. Ex. equipment; tested. 17/6, plus 2/6 P. & P.



## CONDENSERS

New at a fraction of maker's price.  
2,500 mfd. 100 v. 12/6      4,000 mfd. 25 v. 10/-  
10,000 mfd. 35 v. 15/-      4,000 mfd. 50 v. 15/-

# POWER RHEOSTATS

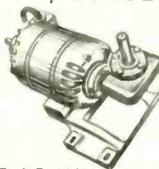
(NEW) Ceramic construction, winding embedded in Vitreous Enamel, heavy duty brush assembly designed for continuous duty. AVAILABLE FROM STOCK IN THE FOLLOWING II VALUES: 100 WATT 1 ohm 10a., 5 ohm 4.7a., 10 ohm 3a., 25 ohm 2a., 50 ohm 1.4a., 100 ohm 1a., 250 ohm 7a., 500 ohm 45a., 1k ohm 280mA., 1.5k ohm 230mA., 2.5k ohm 2a., 5k ohm 140mA., Diameter 3 1/2 in. Shaft length 3 in. dia. 1 1/2 in., 27/6. P. & P. 1/6.  
500 WATT 1/5/10/25/50/100/250/500/1,000/1,500/2,500 ohm. All at 21/-, P. & P. 1/6.  
25 WATT 10/25/50/100/250/500/1,000/1,500/2,500 ohm. All at 14/6, P. & P. 1/6.  
Black Silver Skirted knob calibrated in Nos. 1-9. 1 1/2 in. dia. brass bush. Ideal for above Rheostats, 3/6 each.

# STROBE! STROBE! STROBE!

\* THREE EASY TO BUILD KITS USING XENON WHITE LIGHT FLASH TUBES. SOLID STATE TIMING + TRIGGERING CIRCUITS. PROVISION FOR EXTERNAL TRIGGERING. 230-250V. A.C. OPERATION.  
\* The Strobe is one of the most useful and interesting instruments in the laboratory or workshop. It is invaluable for the study of movement and checking of speeds. Many uses can be found in the psychiatric and photographic fields, also in the entertainment business. It is used a great deal in the motor industry and is a real tool as well as an interesting scientific device.  
\* EXPERIMENTERS "ECONOMY" KIT including Veroboard S.C.R. Unijunction. Xenon Tube + instructions £5.5.0 plus 5/- P. & P.  
\* NEW INDUSTRIAL KIT Ideally suitable for schools, laboratories etc. Roller tin printed circuit. New trigger coil, plastic thyristor £8.0 p.p. Price 9 gns. 7/6 P. & P.  
\* HY-LIGHT STROBE This strobe has been designed for use in large rooms, halls and the photographic field. It has 4 times the light output at 30 f.p.s. and utilizes a silica tube for longer life expectancy, printed circuit for easy assembly, also a special trigger coil and output capacitor. Light output approx 4 joules. Price £10.17.6. P. & P. 7/6.  
\* 7 INCH POLISHED REFLECTOR. Ideally suited for above Strobe Kits. Price 10/6 & 2/6 p. & p. or post paid with kits.  
\*\*\*\*\*

## PARVALUX TYPE SD19 230/250 VOLT AC REVERSIBLE GEARED MOTORS

30 r.p.m. 40 lb. ins. Position of drive spindle adjustable to 3 different angles. Mounted on substantial cast aluminium base. Ex-equipment. Tested and in first-class running order. A really powerful motor offered at a fraction of maker's price. 6 gns. P. & P. 10/-.



## BODINE TYPE N.C.1 GEARED MOTOR

(Type 1) 71 r.p.m. torque 10 lb. in. Reversible 1/70th h.p. 50 cycle. 38 amp.  
(Type 2) 28 r.p.m. torque 20 lb. in. reversible 1/80th h.p. 50 cycle .28 amp.  
The above two precision made U.S.A. motors are offered in 'as new' condition. Input voltage of motor 115v A.C. Supplied complete with transformer for 230/240v A.C. input  
Price, either type £2.17.6 plus 6/6 P. & P. or less transformer £2.2.6 plus 4/6. P. & P.  
These motors are ideal for rotating aerials, drawing curtains, display stands, vending machines etc.



## LARGE DIGIT 12-18 v. D.C. MAGNETIC COUNTER

4in. drum, calibrated 0-9. Figures 1 1/2 in. high 3/4 in. wide. Set of 1m, 1b, 1c/o contacts operated by drum cam. The units which can be used in multiples are ideally suited for batch or lap recording or for the many purposes where large easily read numerals are required. Price 18/6, P. & P. 2/6.



## VEEDER ROOT COUNTER

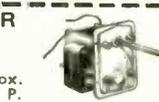
230 v. A.C. 50 cycle 5 figure counter (non resetable). 18/6, P. & P. 1/6.



## 230 v. GEARED MOTOR (as illustrated)

6 R.P.M. or 10 R.P.M.

230 v. A.C. non-reversible, approx. 1.7lb.in. Price 45/-, plus 3/6 P. & P.



## MINIATURE UNISELECTOR

3 banks of 11 positions, plus homing bank. 40 ohm coil. 24-36 v. D.C. operation. Carefully removed from equipment and tested. 22/6, plus 2/6 P. & P.

## UNISELECTOR SWITCHES NEW

4 BANK 25 WAY FULL WIPER  
25 ohm coil, 24 v. D.C. operation. £5.17.6, plus 2/6 P. & P.

6 BANK 25 WAY FULL WIPER  
25 ohm coil, 24 v. D.C. operation. £6.10.0, plus 2/6 P. & P.

8-BANK 25-WAY FULL WIPER  
24 v. D.C. operation, £7/12/6, plus 4/- P. & P.



# RELAYS

BULK PURCHASE ENABLES US TO OFFER THE FOLLOWING NEW SIEMENS PLESSEY, etc. MINIATURE RELAYS AT A HIGHLY COMPETITIVE PRICE

| COIL | WORKING D.C. VOLT | CONTACTS              | PRICE |
|------|-------------------|-----------------------|-------|
| 170  | 9-12              | 4 c/o H.D.            | 14/6  |
| 170  | 9-12              | 3 c/o + 1 H.D. c/o    | 12/6  |
| 280  | 6-12              | 2 c/o incl. base      | 14/6  |
| 700  | 12-24             | 2 c/o Incl. base      | 12/6  |
| 700  | 16-24             | 4 c/o incl. base      | 15/6  |
| 700  | 16-24             | 4M 2B incl. base      | 12/6  |
| 1250 | 20-40             | 2 c/o H.D. Incl. base | 12/6  |
| 2500 | 30-50             | 2 c/o H.D. Incl. base | 12/6  |
| 9000 | 40-70             | 2 c/o incl. base      | 10/-  |

H.D. = Heavy Duty      POST PAID

## MINIATURE RELAYS

9-12 volt D.C. operation. 2 c/o 500 M.A. contacts. Size only 1in. X 1 1/2 in. Price 11/6 Post paid.  
30-36 v. D.C. operation. 2 c/o 500 M.A. contacts. 3,200 ohm coil. Size only 1 X 1 1/2 in. 8/6 post paid.

## 230 VOLT AC RELAYS

230 volt AC Coil. Three c/o 5 amp. contacts. 17/6 Post Paid. (illustrated)  
LONDEX four c/o 3 amp contacts. 18/6, incl. base. Post Paid.



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2 1/2 in. dia. All at 21/- each.

## A.C. VOLTMETERS 0-25 v., 0-50 v., 0-150 v. M.1

2 1/2 in. Flush round all at 21/- each. P. & P. extra.

0-300 v. A.C. Rect. M-Coil 2 1/2 in. 29/-  
0-300 v. A.C. Rect. M-Coil 3 1/2 in. Type W23 55/-

## SANWA MULTI RANGE TESTERS

NEW MODEL UD-50 MULTI TESTER, 20,000 O.P.V. MIRROR SCALED WITH OVERLOAD PROTECTION. Ranges: D.C. volts: 100mV, 0.5 v., 5 v., 250 v., 1,000 v. A.C. volts: 2.5 v., 10 v., 50 v., 250 v., 1,000 v. D.C. current: 5mA, 0.5 mA., 5 mA., 50 mA., 250 mA. Size: 5 1/2 x 3 1/2 x 1 1/2 in. Complete with batteries £7.5.0 Post paid and test prods.



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Functional Versatile Educational

This multi-purpose Auto Transformer, with large centre aperture, can be used as a Double wound current Transformer, Auto Transformer, H.T. or L.T. Transformer, by simply hand winding the required number of turns through the centre opening. E.g. Using the RT.100 V.A. Model the output could be wound to give: 6V @ 121a., 4V @ 25a., 2V @ 50a., etc.  
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RT.300VA 2.27 turns per volt, £4 4 0 + 5/6 p. and p.  
RT. 1KV.A. 1.82 turns per volt, £6 10 0 + 6/6 p. and p.



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Two removable coils are tapped at 0, 110, 220 volts, and 6, 12, 36 volts respectively. A composite apparatus designed for class demonstration. Electro magnetic induction, jumping ring, induction lamp, relationship between field intensity and ampere turns, induction melting, are just a few of the possible experiments. New modified model. £14/10/- P. & P. 10/-.



## L.T. TRANSFORMERS

| All primaries 220-240 volts. | Type No.          | Sec. Taps   | Price   | Carr. |
|------------------------------|-------------------|-------------|---------|-------|
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| 2                            | 30, 40, 50 v.     | at 5 amps.  | £6 5 0  | 6/6   |
| 3                            | 10, 17, 18 v.     | at 10 amps. | £4 10 0 | 4/6   |
| 4                            | 6, 12 v.          | at 20 amps. | £5 17 6 | 6/6   |
| 5                            | 17, 18, 20 v.     | at 20 amps. | £6 12 6 | 6/6   |
| 6                            | 6, 12, 20 v.      | at 20 amps. | £7 5 0  | 7/6   |
| 7                            | 24 v.             | at 10 amps. | £4 15 0 | 5/6   |
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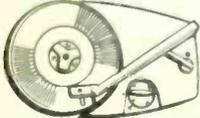


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To get the best out of your MAGNAVOX DECK, you need a MARTIN RECORDAKIT. This comprises a special high quality 5 valve amplifier and pre-amplifier which comes to you assembled on it's printed circuit board - in fact everything for making a superb Tape Recorder. You need no experience or technical skill to bring this about. THE INSTRUCTIONS MANUAL MAKES BUILDING EASY, AND SUCCESS IS ASSURED. Kit comprises: Deck, Amplifier, Cabinet and speaker, with microphone, 7" 1200 ft. tape, and spare spool. ASK FOR BROCHURE 6. TODAY'S VALUE £60. PRICE 39 gns. p.p. 22/6. NOTHING ELSE TO BUY

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Deck plays 33, 45, 78, R.P.M. records. 9 volt operated, with mono cartridge. BRAND NEW... as illustrated.



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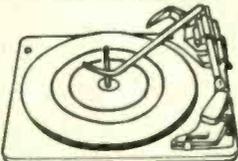


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Portable Transistor Unit-Ideal for Intercoms, Baby Alarms, Tels phone, Record Players or Guitar Practice. 9 Volt 5 transistors with volume control. Output 3 ohms. Ideas for use with STAAR RECORD DECK. PRICE 45/- p.p. 2/6.

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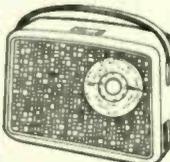


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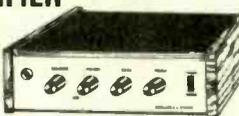
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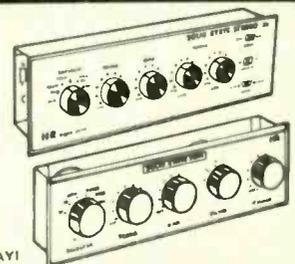
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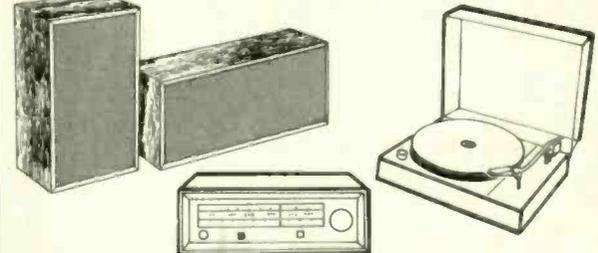
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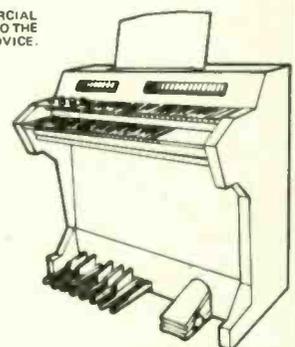
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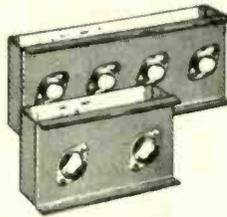
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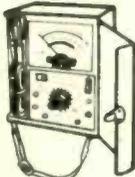
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All transistor grid dip meter, absorption wavemeter and osc. detector. Frequency range 440kc/s to 280Mc/s in 6 coils. Uses 3 transistors plus diode with 500µA meter. Internal battery.  
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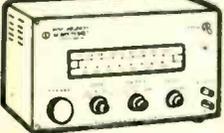
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| MODEL                | £  | s  | d. | No. |
|----------------------|----|----|----|-----|
| 29a RF. Gen.         | 21 | 0  | 0  | 35  |
| 29x Xtal RF Gen.     | 29 | 10 | 0  | 35  |
| 30 Audio Generator   | 19 | 10 | 0  | 24  |
| 31 R.F. Generator    | 12 | 10 | 0  | 25  |
| 32 C.R. Bridge       | 10 | 10 | 0  | 26  |
| 33 Inductance Bridge | 20 | 0  | 0  | 29  |

### \* DELUXE SINE-SQUARE WAVE RC AUDIO GENERATOR

Weinbridge RC Audio oscillator featuring four overlapping scales covering 18c/s to 200 Kc/s. Output waveforms are sine, square and complex. Mirrored scale with smooth geared tuning control. Output 5 volts RMS or 10 volts P-P. Sine wave response 1/2dB. Distortion under 1% at 1Kc/s. Stability 1%. Accuracy 1.2%. O/P impedance under 3kΩ. Variable Attenuator. Mains operated. With Handbook.  
**ORC 27A Price £28 10 0 pp.10/-**



### \* DC STABILISED POWER SUPPLY

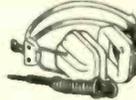
Switched DC Stabilised Outputs UP TO 1AMP. 3-6-9 & 12 VOLTS. Indicator lamp for each voltage. Fully fused mains operated. Negligible ripple. Regulation 1%.  
**SE101A Price £8 15 0**



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Complete capacity for checking all transistors npn and pnp for alpha, beta and German. Also diodes - complete with leads and instructions. **ZQM-2, Price £5.19.6, p.p. 3/6.**

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Featuring soft Padded Headsets, wide frequency response. Adjustable Headbands. Fitted Jack plugs.



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Inputs for PU/Tuner, Battery Model Mains Operated High Quality  
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Features low price for such an instrument. Large 6in full view scaled meter. 28 ranges. D.C. volts: 0/1/5/15/50/150/500/1500. A.C. volts: 0/1/5/15/50/150/500 r.m.s.; 0/1/4/14/40/140/400/1400/4000 p.p. Resistance: R x 10-100 - 1k - 10k - 100k - 1M - 10M. Range 0.2 ohm to 1000MΩ.  
**MODEL TE65 £17.10.0 p.p. 7/6**  
HV Probe 50/-  
R.F. Probe 42/6



### \* FIELD STRENGTH METER

5-Ranges 1-250 mc/s. Fitted 200µA meter. Earphone output. Calibrated tuning scales.  
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**EXPERIMENTER'S MODULE**  
Terrific offer of brand new 5TC time delay electronic units. Adjustable 3-15 secs. 9-12V operated. Supplied complete with suggested uses circuits. 5TC Module Price 35/-

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The Detector Unit consists essentially of a highly sensitive 931A photo-electric cell combined with a firing circuit. Incorporates a single cold cathode electronic relay, capacitors and resistors designed to fail to safety if external wiring is open or short circuited. Encapsulated in a resin which fully insulates the unit electrically and provides a high degree of mechanical and thermal shockproofing. Original price £74. OUR PRICE, BRAND NEW £6 each, with data sheet.  
**SIZE 4 x 3 x 2 1/2 in.**  
Limited quantity available



### \* 20,000 OHMS PER VOLT MULTIMETER

Popular model but with extra scale range. 20,000 ohms per volt. 0/5/25/50/250/500/2500V d.c.; 0/1/10/50/100/500/1000V a.c.; 0/50µA, 0/2/1/250mA. Resistance 0-6kΩ and 6MΩ. Also dB scales or capacitance.  
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Features 3in clear view tube, easy to use controls and good stability. Y amp. Sensitivity: 1V p.p./CM. Bandwidth 1.5 cps-1.5 MHz. Input imp. 2 meg Ω. 25 PF. X amp sensitivity: .9V p.p./CM. Bandwidth 1.5 cps-800 KHz. Input imp. 2 meg Ω. 20 PF. Time base: 5 ranges 10 cps-300 KHz. Synchronisation: Internal/external. Illuminated scale. 140 x 215 x 330 MM. Weight 5 1/2 lbs. 220/240V. A.C. Supplied brand new with handbook.  
**TO3 Price £35 p.p. 10/-**

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2-station, £3.10.0; 3-station, £5.15.0; 4-station, £6.12.6 (2-station uses no wires) mains operated, £11.19.6. Telephone amplifier, 59/6.

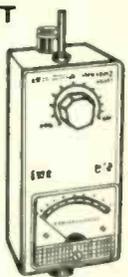


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$\frac{1}{2}$ W: 10 x 4.3

Leads: 35

10% ranges; 10 Ohms to 10 Megohms (E12 Renard Series).

5% ranges; 4.7 Ohms to 1 Megohm (E24 Renard Series).

Prices—per Ohmic value.

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|---------------------|------|--------|--------|---------|
| $\frac{1}{2}$ W 10% | 2d.  | 1/6    | 3/3    | 10/4    |
| $\frac{1}{2}$ W 5%  | 2½d. | 1/9    | 3/8    | 11/8    |
| $\frac{1}{2}$ W 10% | 2½d. | 1/9    | 3/8    | 11/7    |
| $\frac{1}{2}$ W 5%  | 3d.  | 2/-    | 4/-    | 12/10   |

## CAPACITORS

Subminiature Polyester film, Modular for P.C. mounting. Hard epoxy resin encapsulation. Radial leads.

±10% tolerance, 100 Volt working.

Prices—per Capacitance value (µF)

|                                    | each | 10 off | 25 off | 100 off |
|------------------------------------|------|--------|--------|---------|
| 0.001, 0.002, 0.005, 0.01, 0.02 .. | 6d.  | 4/3    | 8/4    | 30/-    |
| 0.05 .. .. .                       | 8d.  | 6/-    | 12/6   | 41/8    |
| 0.1 .. .. .                        | 10d. | 7/1    | 15/6   | 51/-    |
| 0.2 .. .. .                        | 1/2  | 10/-   | 20/10  | 68/6    |

Polystyrene film, Tubular, Axial leads. Unencapsulated ±5% or ±1pf tolerance, 160 Volt Working.

Prices—per Capacitance value (µF)

|  | each | 10 off | 25 off | 100 off |
|--|------|--------|--------|---------|
| 10, 12, 15, 18, 22, 27, 33, 39, 47, each |      | 10 off | 25 off | 100 off |
| 56, 68, 82, 100, 120, 180, 220, ..       | 5d.  | 3/7    | 7/9    | 24/-    |
| 270, 330, 390 .. .. .                    | 6d.  | 4/-    | 8/8    | 26/8    |
| 470, 560, 680, 820, 1,000, 1,500 ..      | 7d.  | 5/-    | 10/10  | 33/4    |
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| 22,000 .. .. .                           |      |        |        |         |

## POTENTIOMETERS (Carbon)

Superior grade enclosed controls. Low rotational noise. Body dia., 1in. Spindle, 2in. x ¼in. Tolerance, 20%.

Linear: 1K to 2M. ( $\frac{1}{2}$ W at 40°C).

Logarithmic: 5K to 2M. ( $\frac{1}{2}$ W at 40°C).

Prices per ohmic value

|     | each | 10 off | 25 off | 100 off |
|-----|------|--------|--------|---------|
| 2/- | 18/4 | 41/8   | 150/-  |         |

## GANGED STEREO POTENTIOMETERS (Carbon)

$\frac{1}{2}$ W at 70°C. Long Spindle.

Logarithmic and Linear: 5k to 1M +1M.

Prices per ohmic value

|     | each | 10 off | 25 off | 100 off |
|-----|------|--------|--------|---------|
| 8/- | 70/- | 162/6  | 575/-  |         |

## SKELETON PRE-SET POTENTIOMETERS (Carbon)

High quality pre-sets suitable for printed circuit boards of 0.1in. P.C.M. 100 ohms to 5 Megohms (Linear only). Miniature: 0.3W at 70°C. ±20% below  $\frac{1}{2}$ M, ±30% above  $\frac{1}{2}$ M.

Horizontal (0.7in x 0.4in. P.C.M.) or Vertical (0.4in. x 0.2in. P.C.M.). Subminiature: 0.1W at 70°C. ±20% below 2.5M. ±30% above.

| Prices—per ohmic value      | each | 10 off | 25 off | 100 off |
|-----------------------------|------|--------|--------|---------|
| Miniature (0.3W) .. .. .    | 1/-  | 8/9    | 18/9   | 66/8    |
| Subminiature (0.1W) .. .. . | 10d. | 7/1    | 14/7   | 46/8    |

## ELECTROLYTIC CAPACITORS (Mullard.)

Subminiature (all values in µF) —10% to +50%.

|               | each | 10 off | 25 off | 100 off |
|---------------|------|--------|--------|---------|
| 4V .. .. .    | 32   | 64     | 125    | 250     |
| 6.4V .. .. .  | 25   | 50     | 100    | 200     |
| 10V .. .. .   | 16   | 32     | 64     | 125     |
| 16V .. .. .   | 10   | 20     | 40     | 80      |
| 25V .. .. .   | 6.4  | 12.5   | 25     | 50      |
| 40V .. .. .   | 4    | 8      | 16     | 32      |
| 64V .. .. .   | 2.5  | 5      | 10     | 20      |
| Price .. .. . | 1/4  | 1/2    | 1/-    | 1/1     |

## Small (all values in µF)

|               | each | 10 off | 25 off | 100 off |
|---------------|------|--------|--------|---------|
| 4V .. .. .    | 800  | 1,250  | 2,000  | 3,200   |
| 6.4V .. .. .  | 640  | 1,000  | 1,600  | 2,500   |
| 10V .. .. .   | 400  | 640    | 1,000  | 1,600   |
| 16V .. .. .   | 250  | 400    | 640    | 1,000   |
| 25V .. .. .   | 160  | 250    | 400    | 640     |
| 40V .. .. .   | 100  | 160    | 250    | 400     |
| 64V .. .. .   | 64   | 100    | 160    | 250     |
| Price .. .. . | 1/6  | 2/-    | 2/6    | 3/-     |

## POLYESTER CAPACITORS (Mullard)

Tubular 10%, 160V: 0.01, 0.015, 0.022µF, 7d. 0.033, 0.047 µF, 8d. 0.068, 0.1 µF, 9d. 0.15 µF, 11d. 0.22 µF, 1/- 0.33 µF, 1/3 0.47 µF, 1/6 0.68 µF, 2/3 1 µF, 2/8 400V: 1,000, 1,500, 2,200, 3,300, 4,700pF, 6d. 6,800pF, 0.01, 0.015, 0.022 µF, 7d. 0.033 µF, 8d. 0.047 µF, 9d. 0.068, 0.1 µF, 11d. 0.15 µF, 1/2 0.22 µF, 1/6 0.33 µF, 2/3 0.47 µF, 2/8.

SEMICONDUCTORS: OA5, OA81, 1/9. OC44, OC45, OC71, OC81, OC81D, OC82D, 2/-, OC70, OC72, 2/3. AC107, OC75, OC170, OC171, 2/6. AF115, AF116, AF117, ACY19, ACY21, 3/3. OC140, 4/3. OC200, 5/-, OC139, 5/3. OC25, 7/-, OC35, 8/-, OC23, OC28, 8/3.

SILICON RECTIFIERS (0.5A): 170 P.I.V., 2/9. 400 P.I.V., 3/-, 800 P.I.V., 3/3. 1,250 P.I.V., 3/9. 1,500 P.I.V., 4/-, (6A): 200 P.I.V., 3/-, 400 P.I.V., 4/-, 600 P.I.V., 5/-, 800 P.I.V., 6/-.

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Freq. 85Kc/s-25Mc/s in 8 ranges. Incremental: +/— 1% at 1Mc/s. Output: continuously variable 1 microvolt to 1 volt. Output Impedance: 1 microvolt to 100 millivolts, 10 ohms 100mV-1 volt-52.5 ohms. Internal Modulation: 400 c/s sinewave 75% depth. External Modulation: Direct or via internal amplifier. A.C. mains 200/250V, 40-100 c/s. Consumption approx. 40 watts. Measurements: 19¼ x 12¼ x 10 in. The above come complete with Mains Leads, Dummy Aerial with screened lead, and plugs. As New, in Manufacturer's cases, £40 each. Carr. 30/-. DISCOUNT OF 10% FOR SCHOOLS, TECHNICAL COLLEGES, etc.

**HRO RECEIVER.** Model 5T. This is a famous American High Frequency superhet, suitable for CW, and MCW, reception crystal filter, with phasing control. AVC and signal strength meter. Complete HRO 5T SET (Receiver, Set of 5 Coils & Power Unit) for £27/10/-, carr. 30/-.

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(Conversion as per "Surplus Radio Conversion Manual, Vol. No. 2," by R. C. Evenson and O. R. Beach.)

**AIRCRAFT RECEIVER ARR. 2:** Valve line-up 7 x 9001; 3 x 6AK5; and 1 x 12A6. Switch tuned 234-258 Mc/s. Rec. only £3 each, 7/6 post; or Rec. with 24 v. power unit and mounting tray £3/10/- each, 10/- post.

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**MARCONI RECEIVER 1475 type 88:** 1.5-20 Mc/s, second-hand condition £10.0.0 each. New condition £25.0.0 each, carr. 15/-.

**RACAL EQUIPMENT:** RA. 17 Outer Metal case for receiver available, as new, £10 each, carr. £1. Frequency Meter type SA20: £35 each, carr. £1. Frequency Counter type SA21: £65 each, carr. 30/-. Diversity Switching Unit type MA168: £35 each, post 10/-. Converter Frequency Electronic VHF Type SA.80 (for use with the SA.20): 25 Mc/s-160 Mc/s, £40 each, carr. £1.

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**OSCILLOSCOPE Type 13A,** 100/250 v. A.C. Time base 2 c/s.-750 Kc/s. Bandwidth up to 5 Mc/s. Calibration markers 100 Kc/s. and 1 Mc/s. Double Beam tube. Reliable general purpose scope, £22/10/- each, 30/- carr.

**COSSOR 1035 OSCILLOSCOPE,** £30 each, 30/- carr.

**COSSOR 1049 Mk. 111,** £45 each, 30/- carr.

**RELAYS:** GPO Type 600, 10 relays @ 300 ohms with 2M and 10 relays @ 50 ohms with 1M., £2 each, 6/- post. 12 Small American Relays, mixed types £2, post 4/-.

Many types of American Relays available, i.e., Sigma; Allied Controls; Leach; etc. Prices and further details on request 6d.

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**Actuator Type SR-43:** 28 v. D.C. 2,000 r.p.m., output 26 watts, 5 inch screw thrust, reversible, torque approx. 25 lbs., rating intermittent, price £3 each, post 5/-.

**SYNCHROS:** and other special purpose motors available. British and American ex stock. List available 6d.

**TCS MODULATION TRANSFORMERS,** 20 watts, pr. 6,000 C.T., sec. 6,000 ohms. Price 25/-, post 5/-.

**AUTOMATIC PILOT UNIT Mk. 2.** This complex unit of diodes and valves, relays, magnetic clutches, motors and plug-in amplifiers, with many other items, price £7/10/-, £1 carriage.

**FOR EXPORT ONLY:** B.44 Trans-ceiver Mk. III. Crystal control, 60-95 Mc/s. **AMERICAN EQUIPMENT:** BC-640 Transmitter, 100-156 Mc/s., 50 watt output. For 110 or 230 v. operation. ARC 27 trans-ceivers, 28 v. D.C. input. Also have associated equipment. BC-375 Transmitter. BC-778 Dinghy transmitter. SCR-522 trans-ceiver. Power supply, PP893/GRC 32A; Filter D.C. Power Supply F-170/GRC 32A; Cabinet Electrical CY 1288/GRC 32A; Antenna Box Base and Cables CY 728/GRC; Mast Erection Kits, 1186/GRC; Directional Antenna CRD.6; Comparator Unit, CM.23; Directional Control CRD.6, 567/CRD and 568/CRD; Azimuth Control Units, 260/CRD. Test Set URM.44, complete with Signal Generator TS.622/U.

**SOLENOID UNIT:** 230 v. A.C. input, 2 pole, 15 amp contacts, £2/10/- each post 6/-.

**CONTROL PANEL:** 230 v. A.C., 24 v. D.C. @ 2 amps., £2/10/- each, carr. 12/6.

**AUTO TRANSFORMER:** 230-115 v.; 1,000 w. £5 each, carr. 12/6. 230-115 v.; 300VA, £3 each, carr. 10/-.

**OHMITE VARIABLE RESISTOR:** 5 ohms, 5 1/2 amps; or 2.6 ohms at 4 amps. Price (either type) £2 each, 4/6 post each.

**POWER SUPPLY UNIT PN-12B:** 230 v. A.C. input, 395-0-395 v. output @ 300 mA. Complete with two x 9H chokes and 10 mfd. oil filled capacitors. Mounted in 19in. panel, £6/10/- each, £1 carr.

**TX DRIVER UNIT:** Freq. 100-156 Mc/s. Valves 3 x 3C24's; complete with filament transformer 230 v. A.C. Mounted in 19in. panel, £4/10/- each, 15/- carr.

**POWER UNIT:** 110 v. or 230 v. input switched; 28 v. @ 45 amps. D.C. output. Wt. approx. 100 lbs., £17/10/- each, 30/- carr. **SMOOTHING UNITS** suitable for above £7/10/- each, 15/- carr.

**DE-ICER CONTROLLER MK. III:** Contains 10 relays D.P. changeover heavy duty contacts, 1 relay 4P, C/O. (235 ohms coil). Stud switch 30-way relay operated, one five-way ditto, D.C. timing motor with Chronometric governor 20-30 v., 12 r.p.m.; geared to two 30-way stud switches and two Ledex solenoids, 1 delay relay etc., sealed in steel case (4 x 5 x 7 ins.) £3 each, post 7/6.

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**ADVANCE TEST EQUIPMENT:** VM78 A.C. Millivoltmeter (transistorised) £55 each; TT1S Transistor Tester (CT472) £37/10/- each; VM77C Valve Voltmeter £40 each. Carr. 10/- extra per item.

**NIFE BATTERIES:** 4 v. 160 amps, new, in cases, £20 each, £1 10/- carr.

**FUEL INDICATOR Type 113R:** 24 v. complete with 2 magnetic counters 0-9999, with locking and reset controls mounted in a 3in. diameter case. Price 30/- each, postage 5/-.

**UNISELECTORS (ex equipment):** 5 Bank, 50 Way, 75 ohm Coil, alternate wipe, £2/5/- each, post 4/-.

**FREQUENCY METERS:** BC-221, meter only £30 each, BC-221 complete with stabilised power supply £35 each, carr. 15/- LM13, 125-20,000 Kc/s., £25 each, carr. 15/- TS.175/U, £75 each, carr. £1. TS323/UR, 20-450 Mc/s., £75 each, carr. 15/- FR-67/U: This instrument is direct reading and the results are presented directly in digital form. Counting rate: 20-100,000 events per sec. Time Base Crystal Freq.: 100 Kc/s. per sec. Power supply: 115 v., 50/60 c/s., £100 each, carr. £1.

**CT.49 ABSORPTION AUDIO FREQUENCY METER:** freq. range 450 c/s-22 Kc/s., directly calibrated. Power supply 1.5 v.-22 v. D.C. £12/10/- each, carr. 15/-.

**CATHODE RAY TUBE UNIT:** With 3in. tube, colour green, medium persistence complete with nu-metal screen, £3/10/- each, post 7/6.

**APNI ALTIMETER TRANS./REC.,** suitable for conversion 420 Mc/s., complete with all valves 28 v. D.C. 3 relays, 11 valves, price £3 each, carr. 10/-.

**TEST EQUIPMENT**

|                  |                                   |                               |               |
|------------------|-----------------------------------|-------------------------------|---------------|
| <b>MARCONI</b>   | TF-1274                           | VHF Bridge Oscillator         | £75 each      |
|                  | TF-1275                           | VHF Bridge Detector           | £75 each      |
|                  | TF-1067/1                         | Heterodyne Frequency Meter    | £85 each      |
|                  | TF-899                            | Valve Millivoltmeter          | £35 each      |
|                  | TF-978                            | VHF Admittance Bridge         | £85 each      |
|                  | TF-894A                           | Audio Tester                  | £55 each      |
|                  | TF-329G                           | Circuit Magnification Meter   | £45 each      |
|                  | TF-428/2                          | Valve Voltmeter               | £12/10/- each |
|                  | TF-428/1                          | Valve Voltmeter               | £8/10/- each  |
|                  | TF-726C                           | UHF Signal Generator          | £65 each      |
|                  | TF-934                            | Deviation Test Meter          | £35 each      |
|                  | 6075A                             | Deviation Test Meter          | £65 each      |
| TF-987/1         | Noise Generator                   | £20 each                      |               |
| TF-956           | (CT.44) A.F. Absorption Wattmeter | £20 each                      |               |
| <b>FIRZ HILL</b> | V.200                             | Sensitive Valve Voltmeter     | £35 each      |
|                  | B.810                             | Incremental Inductance Bridge | £75 each      |
| <b>SOLATRON</b>  | CD-513                            | Oscilloscope                  | £45 each      |
|                  | CD-513-2                          | Oscilloscope                  | £47/10/- each |
|                  | AW-553                            | Power Amplifier               | £30 each      |
| <b>AIRMEC</b>    | Type 701                          | Signal Generator              | £50 each      |
| <b>PHILLIPS</b>  | Type GM-6008                      | Valve Voltmeter               | £35 each      |
| <b>DAWE</b>      | Type 402C                         | Megohm Meter                  | £12 each      |

**CANADIAN C52 TRANS/REC.:** Freq. 1.75-16 Mc/s on 3 bands. R.T., M.C.W. and C.W. Crystal calibrator etc., power input 12V. D.C., new cond., complete set £50. Used condition working order £25. Carr. on both types £2/10/- Transmitter only £7/10/- (few only) Carr. 15/- Power Unit for Rec., new £3/5/- Used power units in working order £2/5/- Carr. 10/-.

**AVOMETERS:** Model 47A, £10 each, 10/- post. Excellent secondhand cond. (meters only).

**DECADE RESISTOR SWITCH:** 0.1 ohm per step. 10 positions. 3 Gang, each 0.9 ohms. Tolerance ±1% £3 each, 5/- post. 90 ohms per step. 10 positions, total value 900 ohms. 3 Gang. Tolerance ±1% £3/10/- each, 5/- post.

**TELESCOPIC ANTENNA:** In 4 sections, adjustable to any height up to 20 ft. Closed measures 6 ft. Diameter 2 in. tapering to 1 in. £5 each + 10/- carr. Or £9 for two + £1 carr. (brand new condition).

**COAXIAL TEST EQUIPMENT:** COAXSWITCH—Mnfrs. Bird Electronic Corp. Model 72RS; two-circuit reversing switch, 75 ohms, type "N" female connectors fitted to receive UG-21/U series plugs. New in ctns., £6/10/- each, post 7/6. CO-AXIAL SWITCH—Mnfrs. Transco Products Inc., Type M1460-22, 2 pole, 2 throw. (New) £6/10/- each, 4/6 post. 1 pole, 4 throw, Type M1460-4. (New) £6/10/- each, 4/6 post.

**PRD Electronic Inc. Equipment:** FREQUENCY METER: Type 587-A, 0.250-1.0 KMC/SEC. (New) £75 each, post 12/6. FIXED ATTENUATOR: Type 130c, 2.0-10.0 KMC/SEC. (New) £5 each, post 4/- FIXED ATTENUATOR: Type 1157S-1, (new) £6 each, post 5/-.

ALL GOODS OFFERED WHILST STOCKS LAST IN "AS IS" CONDITION UNLESS OTHERWISE STATED

CALLERS BY TELEPHONE  
APPOINTMENT ONLY

**W. MILLS**

3-B TRULOCK ROAD, TOTTENHAM, N.17

Phone: Tottenham 9213

# ELECTRONIC BROKERS

## MEASURING INSTRUMENTS AND RECORDERS

### NEW AMERICAN 5" CHART RECORDER

Good general purpose potentiometric recorder. Suitable for research and laboratory work. Range 0-10 m.v. Variable zero set, Zenor divide reference. Input impedance. Max 100 Kohms. Price £89.10.0. P. & P. 30/-.

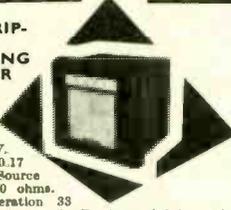


### PORTABLE AC/DC PEN RECORDER

A most versatile pen recorder. Produces a trace on a curvilinear 3 1/2 in. strip chart. Two speeds 1 in. and 6 in./hr. Limiting contacts to give alarm, and limits the current when it exceeds the high and/or low preset values. Range: 0 - 1MA D.C. Meter Resistance 400 ohms; 0 - 1MA A.C. Meter Resistance 1800 at 50 Hz; -10 to + 5 dB into 600 n Impedance Source. Chart speed: 1 in. and 6 in./hr. Chart width: 3 1/2 in. curvilinear. Power supply: 230V 50 Hz driving Synchronous Motor. Price: £52.10.0. Postage and packing £1 5s. 0d.

### KENT STRIP-CHART INDICATING RECORDER

Chart width 9 1/2 in. 10 mV. Sensitivity ± 0.17 of full scale. Source impedance 100 ohms. Speed of operation 33 sec. for full-scale travel. Chart speed 1/2 in., 3 in., 6 in. per hour. Single point. £49.10.0. P. & P. 30/-.

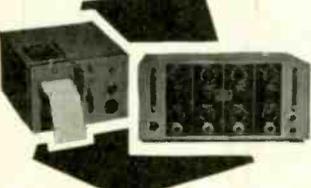


### RECORDER SP 20 Series

General Purpose Single Pen potentiometric instrument for continuous recording for any input signal from 0-10mV D.C. Suitable for use with Spectrophotometer and other laboratory instruments. Chart speed 0.5 to 8.4 cm/min. Linearity ± 0.25%. Fully transistorised. Chart width 200 mm. Input impedance 10K ohms max. Available S.P. 20 Plain Linear, S.P. 21 Flat Bed, S.P. 22 Linear/Log. £135 each. P. & P. 40/-.

### PEN RECORDER

Portable 1, 2 and 4 channel pen recorders by Kelvin Hughes. General purpose recorders providing clear instantaneous and permanent records of phenomena with comparatively high rates of change. The torsion-strip suspension of the moving-coil renders the instrument immune to the effects of vibration and acceleration. Six possible chart speeds, chart width 55 mm, length 150 ft., linearity 5 v. at 3 m.A. response D.C. to 100 c/s. Single pen with amplifier £89; 2 pen with amplifier £125. 4 pen with amplifier £149. Also 5 pen recorder complete with amplifiers, specification as above but housed in cabinet £225. P. & P. extra.



### A.F. GENERATOR TYPE H MODEL I.

High impedance, output from 20V. R.M.S. to 200 micro volts. Frequency Range 15c/s to 50kc/s. Distortion less than 1%. Square wave output 800 micro volts to 80 volts peak.

### PULSE AMPLITUDE ANALYSER £105

12 mV OHM SAFETY METER 12 milli-amps 5 ohm, suitable for testing circuits where currents must be limited £12/10/- p. p. 17/8.

6 Pen Event Recorder, 6 in. Chart width. Available in wide range of chart speeds. Rack mounted £79/10/0 Case to suit extra.

### ULTRA VIOLET RECORDER 12 Channel

NEP 1050 with 6 galvanometers £280.

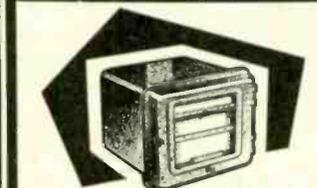
### ULTRA VIOLET PHOTOGRAPHIC RECORDER 12 Channel mirror Galvanometer

Honeywell 1000 with 6 galvos £280. 24 Channel Slesmic Recorder by Film & Equipments £325. Carriage extra.

## NEW PORTABLE RECORDING AMMETER



Specification. Type: Moving Coil, D.C. Range: 0-5 amp. D.C. Chart Width: 100 mm. Scale Length: 127 mm. Chart Speeds: 20, 60, 180, 600, 1800 and 3400 mm/hr. Dimensions: 180b x 163 w x 245mm. Weight: 5.5kg. List price £85. Our price £35.



### POTENTIOMETRIC 6 POINT STRIP CHART RECORDER BRAND NEW

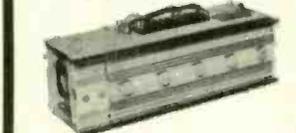
For use with thermocouples, pyrometers and other e.m.f. sources, 6 point. Range (-100) -0-+100 mV; 0-1,600 deg. C. 6 1/2 in. chart width; pen speed 8 sec. Accuracy ± 0.5%; 10 chart speeds 20-720mm/hr. Tropicalised. Including tools and spares. Listed at over £200. Our price £79.10.0. Also available 0-100mV P.S.D. £89.10.0.

## POWER SUPPLIES

### AIRMEC 698B KLYSTRON POWER SUPPLY

Rack mounted (19 in.). Mains operated. Cathode volts from 1.0 to 2.4 kv. negative. Grid Volts, 0 to 220V negative. Reflector Volts, 0-500V negative. Cathode Current, 0.18mA max. Heater 4V at 1.5A. Internal Modulation—Square wave 2-4 KHz 7V p-p. Saw Tooth 150-600 Hz 0-30V peak. Price £45. P. & P. 40/-.

### ★ HIGH PRECISION ★ FULLY STABILISED TRANSDUCERISED LOW VOLTAGE POWER SUPPLIES



Incorporating  
 • S.C.R. Panel for overload protection.  
 • OVERLOAD & CIRCUIT BREAKER WITH MANUAL RESET button.  
 • RIPPLE better, better than 3000 : 1.  
 • CHOKE OF CAPACITOR transistorised 120/130 volt A.C. INPUT.  
 Available in the following types:  
 6 Volt 9 Amp.....£12.10.0  
 6 Volt 12 Amp.....£17.10.0  
 6 Volt 16 Amp.....£22.10.0  
 12 Volt 6 Amp.....£22.10.0  
 12 Volt 8 Amp.....£25.0.0  
 12 Volt 22 Amp.....£25.0.0  
 20 Volt 16 Amp.....£25.0.0  
 24 Volt 4 Amp.....£22.10.0  
 30 Volt 8 Amp.....£18.10.0  
 36 Volt 7 Amp.....£25.0.0  
 Ex-equipment but fully tested in our laboratory. Carr. 30/-

### ADVANCE TRANSDUCERISED DC POWER UNITS

| Input Volt | Output Volt   | Amps | Price    |
|------------|---------------|------|----------|
| DC 4       | 200-245 ± 15% | 12   | £17/10/- |

## METERS

2 in. dia. mounting A.C. voltmeter 0-300 V. A.C. £1.15.0. Carriage 6/-.  
 3 1/2 in. dia. Electrostatic Kilo Voltmeter in wooden case. £2.15.0. Carriage 10/-.  
 Precision A.C. & D.C. Wattmeter. Model 8.67 certified. Accuracy to 1% up to 133 c/s. Range 250/450 V. and 0.5 to 1 A. £29.10.0. Carriage 30/-.  
**D.729 B.M. PHASEMETER AND SUPPLY UNIT**  
 May be used as a Voltmeter, distortion of waveforms, "Q" meter, in phase and quadrature components. Gives indication of phase angle 0°-360°. Frequency range 2 c/s-100 Kc/s. £225. P. & P. extra.

### BRAND NEW S.E. LABORATORIES TRANSDUCER complete with encapsulated Amplifier/demodulator S.E. 441/2

Frequency D.C.—60 c.p.s.  
 Available in the following ranges:  
 SE150, SE50 or SE165A.  
 0-25 p.s.i. 0-350 p.s.i. 0-2000 p.s.i.  
 0-50 p.s.i. 0-500 p.s.i. 0-3000 p.s.i.  
 0-200 p.s.i. 0-750 p.s.i. 0-4000 p.s.i.  
 Also available differential types ± 0 p.s.i., ± 10 p.s.i.  
 List price £70+ Our price £15

## COMPUTOR AND PERIPHERAL EQUIPMENT



### 7 TRACK DIGITAL MAGNETIC TAPE STORAGE DECK

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 30 Kc/s to 90 Kc/s. Bit density 557 b.p.i. 1/2 in., 10 1/2 in. spools 230 V. to 380 V. A.C. Capstan Motor speed 1,500 r.p.m. 48 V. D.C. Rewind motors complete with vacuum Assembly. Finished in brush aluminium and matt-black. Size 27 in. x 26 in. x 8 in. Weight 90 lb. Price £72.10.0. Carriage extra.

### MODEL 72 MAGNETIC TAPE DATA STORAGE UNIT

This unit consists of 1/2 in. 8 channel read-write heads. Can be used to record any 6 bit code. Data can be read in either a forward or backward direction plus giving search facilities. The unit consists circuits for receiving and storing instruction signals. Recording density 250 characters per inch. Tape speed 100 in. per second, price £190. Excellent condition.

### 3 1/2 TRACK Ex-computer record/replay head complete with guides. Little used. Price £12.10.0 Carriage 15/-.

### BRAND NEW Orsham Lion 1 in. 1 + 7 track record/replay heads. Of the highest professional quality. Cost £100 plus price £12.10.0. Carr. 15/-.

### 8 TRACK 1 in. Record/replay heads with sprocket drive, driven by synchronous motor. Mounted with integrated head assembly eliminating alignment problems. This can be fitted to any suitable type of transport system. Price £8.10.0. Carriage 15/-.

### BRAND NEW COMPUTER TAPES AND EMPTY SPOOLS

| Quantity   | Price   |
|--|---------|
| 1/2 in. certified 2,400 ft. 800 b.p.l.           | £8.10.0 |
| 1/2 in. 2,400 ft.                                | £8.10.0 |
| 1/2 in. Highest grade 2,400 ft.                  | £3.0.0  |
| 1/2 in. 10 1/2 in. dia. spool and cassette       | £1.10.0 |
| 1/2 in. 8 1/2 in. dia. spool and cassette        | £1.10.0 |
| 1/2 in. metal 10 1/2 in. dia. spool and cassette | £2.10.0 |
| 1/2 in. N.A.B. centres 10 1/2 in. spool only     | £1.0.0  |

### TAPE PUNCH MODEL 25 7 HOLE

A multiwire tape punch designed for general application involving the conversion of parallel wire electrical impulses into punched paper-tape at 33 characters per second. Unit complete! self-contained requiring only motor power and signal supplies. Price £45.

### 7 HOLE NON PARITY TAPE PUNCH New condition £45.

### LOW SPEED 7 HOLE TAPE PUNCH 60 characters per second by well-known manufacturer. Price £45.

### TELETYPE 8 HOLE PAPER PUNCH M17 PRICE £75. Also available 5 hole punch BRPE2 as above. This model has interchangeable heads. Complete with spooler. Price £35.

### HIGH SPEED 5/7 HOLE OPTICAL READER 20 characters per second. £19.10.

### CARD READERS 80 column 1500/80 model, punch } £325 80 column 1400/80 model verifier. } Excellent condition.

### HOLLERITH 80 COLUMN CARD PUNCH TYPE HO29 & VERIFIER H129 £225.

### DECODER 4 DIGIT READOUT Can be used in constructing frequency counter or Digital Voltmeter. Consists of 4 transistorised cards each containing 10 NOR gates £19.10.0. Circuits supplied with Decoder. 5 Digit £25. P. & P. 15/-

## PROGRAMME BOARDS BY SEALECTRO

These boards are basically a multi pole multi throw switch device consisting of a X-Y Matrix with two contact decks in the Z Plane running at 90 degrees to each other. Contact is made by either, shorting or plugging in pins. Ideal for prototype work, etc. Boards available in 24 x 80 2 pin £12.10.0. Pins available 1/3 each.



## MEMORY PLANES

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 x 8 in. Consisting of matrices 40 x 25 x 4 cores each one individually addressable and divided into 2 halves with independent sense and inhibit wires. £8.10.0. P. & P. 3/-.

## MULLARD MATRIX CORE STORE STACKS

|  |         |
|--|---------|
| A.W. 510 5 planes 8x16 cores/per plane   | £12/10  |
| A.W. 511 5 planes 18x32 cores/per plane  | £25     |
| A.W. 534 20 planes 64x64 cores/per plane | £89/10  |
| A.W. 537 8 planes 32x32 cores/per plane  | £55     |
| Single plane 40x25x4                     | £8/10   |
| Plexi-writer 7 hole punch and keyboard   | £189/10 |

## MEMORY STORE

M. M. 1044 complete with logic circuits mounted in Imhof cabinet £400

## COMPUTERS

Burroughs E 201 225 word store. £450

## SYNCHRONOUS MOTORS

Model 87, 1-rev. per hour. Self starting complete with gear shaft 1/2" dia. 1/2" long. 200/250 V 50 Hz. New Condition Ex. Equipment. 30/- P. & P. 3/-.

## TRANSFER CASE



For sending data by personal carrier, GPO post, passenger train, etc. Ideal. Suitable for despatching tape 20/- P. & P. 5/-.

## 8 HOLE OPTICAL READER PRICE £35

## CANCELLED EXPORT ORDER

90 Column card sorter and punch type 426/0 price on application.

## SPOOLERS 1" and 1 1/2"

Both hand and motor drives available at £3.0.0 and £5.0.0 respectively.

## BRAND NEW TAPE SPOOLER

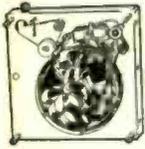
Suitable for 1 in., 1/2 in. and 1/4 in. tapes. Fully self-contained £99.10.0.

## 5" TAPE PUNCH

Suitable for machine control complete with 50 reels of tape £35.

# B LOW COST ELECTRONIC AND SCIENTIFIC EQUIPMENT AND COMPONENTS

## CONTINUOUS TAPE CASSETTE



Suitable for sleep-learning, teaching programmes, programming machine tools, telephone answering etc. Complete with replay/record head and separate erase head. 1/2" tape twin track. Speed 3 1/2" per sec. Length of tape 88 feet, but will hold three times this amount. £3.9.6 p. & p. 7/6.

## SINGLE SPEED TAPE DECK

Driven by 240V 50 Hz power supply. Speed 3 1/2" per sec. Remote control operation, 3 motors, record/replay heads with separate erase head. Fast erase facilities and counter. Price £21/9/6 p & p 10/-

## VEEDER ROOT 6 DIGIT COUNTER



Suitable for counting all kinds of production runs, business machine operation. Mechanically driven. Type KA1337. Reset manual knob. Ex-equipment but new condition. Special price 25/- plus 5/- & p.

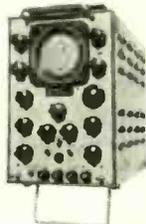


**MINIATURE SQUARE COUNTER 6 DIGIT**  
by Veeder Root. Rotary ratchet type, adds 1 count for each 36° movement of shaft 9/6 + 2/6 p. & p.

## OSCILLOSCOPES



Cosor 1035. £25.  
Cosor 1035 Mk. II. £35.  
Cosor 1049 Mk. III. £40.  
Solartron AD 513.2 L.F. & Servos & CD 5238.2 Long Persistent Tube. £49.10.  
Furtech 0100. £25.  
Airmec 249. £25.  
Solartron AD 557 Pulse & Radar Field. £55.



Solartron CD 7118.2 Double Beam DC.7 Mtg. £65. Calibration extra.  
Mullard L101 Double Beam £98.10.  
Airmec 723. £19.10.

**ALL ORDERS ACCEPTED SUBJECT TO OUR TRADING CONDITIONS A COPY OF WHICH MAY BE INSPECTED AT OUR PREMISES DURING TRADING HOURS OR WILL BE SENT ON APPLICATION THROUGH THE POST.**

## REPEAT CYCLE TIMERS

These timers repeat a set cycle of switching operations via a cam and micro switch, for as long as the motor is energised.  
Single Cam RB 21 in 2 min., 4 min., 5 min., 6 min. cycles @ 45/-.  
Twin Cam BD 22 in 1 min., 2 min., 3 min., 4 min., 5 min. cycles @ 55/-.  
4 Cam RD 24 in 4 min., and 5 min. cycles @ 75/-.  
6 Cam RD 26 in 1 min., 2 min., 3 min., 4 min., 5 min. cycles @ 95/-.  
8 Cam RD 28 in 2 min., 3 min., 4 min., 5 min. cycles @ 115/-.  
All + p. & p. 5/-.



## UNISELECTOR

8 and 4 Banks, 25 contact per bank, 2 sets of wipers 2 in. radius. Complete with surge capacitor. 25/- and 45/- respectively.

## MINIATURE DIGITAL DISPLAY

Operates on a rear projection 6.3 pilot lamp. The lamp projects the corresponding digit on the condensing lens through a projector lens, on to the viewing screen at the front of the unit. 1 in. width, 3 1/4 in. deep, 1 1/4 in. high. Weight 3 1/2 oz. Character size 1/2 in. high, 0.9 with 8 right hand decimal point and degree. Available to special order, words and other characters or colour, at cost of artwork or plates. List price 6 gns. Our price 49/6.



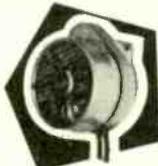
## MOTORS

### HYSTERESIS REVERSIBLE MOTOR

Incorporating two coils. Each coil when energised will produce opposite rotation of output shaft. 240V 50 Hz. 1/2 r.p.m. 1/6 r.p.m., 1/6 r.p.m., 120V 50 Hz, 1/10 r.p.m., 6 r.p.m. 30/- each. P. & P. 3/-.

### HIGH TORQUE INDUCTION MOTOR

3-30 oz/inch. Available in the following speeds only 240V 50 Hz 15 r.p.m., 1 r.p.m., 2 r.p.m., 120 V 50 Hz 20 r.p.m. 30/- each. P. & P. 3/-.



### LOW TORQUE HYSTERESIS MOTOR MA23

Ideal for instrument chart drives. Extremely quiet, useful in areas where ambient noise levels are low. High starting torque enable relative high inertia loads to be driven up to 6-oz/in. Available in the following speeds and ranges: 240V 50 Hz 15 r.p.m., 4 r.p.m., 2 r.p.m., 1 1/2 r.p.m., 1 r.p.m., 1/2 r.p.m., 1/3 r.p.m., 1/4 r.p.m., 1/5 r.p.m., 1/6 r.p.m., 1/10 r.p.m., 1/12 r.p.m., 1/40 r.p.m., 1/60 r.p.m., 1/75 r.p.m., 1/120 r.p.m., 1/180 r.p.m., 1/360 r.p.m., 1/720 r.p.m., 1/1440 r.p.m., 1/20, 1/40 r.p.m., 120V 50 Hz 1/6 r.p.m., 1/5 r.p.m., 1/15 r.p.m., 1/18 r.p.m., 1/20 r.p.m., 1/30 r.p.m., 1/60 r.p.m., 1/120 r.p.m., 1/240 r.p.m., 1/360 r.p.m., 1/720 r.p.m. 25/- each. P. & P. 3/-.

### HYSTERESIS CLUTCH MOTOR

with integral clutch allowing the motor to drop out of engagement with the gear train, thereby facilitating easy resetting when used in timers or in conjunction with a light spring. 6 oz. torque at 1 r.p.m. 240 v., 50 c/s. L-left, R-right, 15 r.p.m., 8 r.p.m., R & L, 6 r.p.m., 4 r.p.m., 1/2 r.p.m., 1/5 r.p.m., 1/6 r.p.m., R & L, 1/10 r.p.m., 1/12, 1/15 r.p.m., L. Also 120 v. 50 c/s 2, 1/6, 1/12, 5/12, 4/11, 1/10 r.p.m. 25/- P. & P. 3/-.

### HIGH PRECISION MAINS MOTOR

230V 50 Hz 1/8 h.p. continuously rated, 3000 r.p.m. Made by Croydon Engineering Model KA 60 JPB. Suitable for capstan motor. Size 8 in. long, 4 1/2 in. diameter with 6 in. diameter flange and 4 fixing holes. £4.10.0 each. £1.5.0 postage and packing.

### HI-SPEED QUICK RESET ELECTRO MAGNETIC COUNTERS

Push button reset 6 digits. 48 v. D.C. 3.5 watts. 20 counts per second. Size 3.875 x 2.825 in. Panel mounting. List £8. Our price 59/6.



## PRECISION POTENTIOMETERS



### TEN TURN 360° ROTATION BRAND NEW

| Res. Ohms   | Linearity | Manufacturer | Model   | Price |
|-------------|-----------|--------------|---------|-------|
| 100/100/100 |           | Beckman      | A       | 180/- |
| 100         | 0.5       | Beckman      | A.8     | 60/-  |
| 200         | 0.5       | Beckman      | A       | 60/-  |
| 500         | 0.1       | Beckman      | A       | 70/-  |
| 500         |           | Colvern      | 2501    | 45/-  |
| 500         |           | Foxes        | PX4     | 40/-  |
| 500         |           | Colvern      | 2610    | 50/-  |
| 2K          | 0.5       | Beckman      | 8A1101  | 60/-  |
| 2K          |           | Beckman      | 7216    | 60/-  |
| 2K          |           | Reliance     | GPM15   | 40/-  |
| 10K         | 0.5       | Beckman      | A       | 60/-  |
| 10K         | 0.1       | Beckman X    | A       | 70/-  |
| 15K         |           | Foxes        | GPM15   | 50/-  |
| 18K         |           | Beckman      | A       | 60/-  |
| 20K         | 0.5       | Beckman      | A       | 60/-  |
| 30K         |           | Colvern      | 2402    | 30/-  |
| 30K         |           | Beckman      | 8A95C   | 60/-  |
| 30K         | 0.1       | Beckman      | A.88    | 70/-  |
| 30K         | 0.5       | Beckman      | 8A 1692 | 60/-  |
| 30K         | 0.25      | Beckman      | 8A 1692 | 65/-  |
| 80K         |           | Reliance     | 07.10   | 45/-  |
| 50K         |           | Colvern      | 2503    | 45/-  |
| 50K         | X         | Foxes        | PX4     | 45/-  |
| 50K         | 0.5       | Beckman      | A       | 60/-  |
| 50K         | 0.1       | Beckman      | A       | 70/-  |
| 100K/100K   |           | Ford         | A       | 100/- |
| 100K        | 0.1       | Beckman      | A       | 45/-  |
| 100K        | 0.5       | Beckman      | A       | 60/-  |
| 100K        |           | Colvern      | 2501    | 45/-  |
| 100K        |           | Colvern      | 2610    | 50/-  |
| 298K        | 0.1       | Beckman      | 8A3902  | 70/-  |
| 300K        | 0.1       | Beckman      | A       | 70/-  |

### THREE TURN 780° ROTATION

|         |     |         |      |      |
|---------|-----|---------|------|------|
| 100/100 | 0.5 | Beckman | A    | 60/- |
| 300     |     | Beckman | 9303 | 45/- |
| 10K     | 0.5 | Beckman | C.88 | 45/- |
| 20K/20K | 0.1 | Beckman | C.8  | 60/- |
| 10K/10K | 0.1 | Beckman | C    | 90/- |
| 50K     | 0.5 | Beckman | C.8  | 35/- |

### FIFTEEN TURN 5400° ROTATION

|         |  |           |           |       |
|---------|--|-----------|-----------|-------|
| 25K/25K |  | Beckman B | .10 watts | £8.10 |
| 46K/46K |  | Beckman B | .10 watts | £8.10 |

### TWENTY TURN 7200° ROTATION

|              |                  |        |      |
|--------------|------------------|--------|------|
| 250 ohms     | General Controls | PXM130 | 80/- |
| 1 Meg.       | General Controls | PXM130 | 80/- |
| 50K Reliance |                  |        | 40/- |

### 156 TURN 56, 160° ROTATION

|          |               |         |       |
|----------|---------------|---------|-------|
| 460 ohms | Kelvin Hughes | KTP0701 | £9.10 |
|----------|---------------|---------|-------|

### FIVE TURN 1800° ROTATION

|          |         |          |      |
|----------|---------|----------|------|
| 500 ohms | Colvern | CLB 2505 | 40/- |
| UL5K     | Colvern | CLB 2605 | 40/- |

### SINE COSINE

|                 |                   |          |          |
|-----------------|-------------------|----------|----------|
| Kelvin & Hughes | SCPS. 14-4K       | £17.10.0 |          |
| Colvern         | 8601              | 50K      | £17.10.0 |
| CLB 9402        | Cam Corrected 25K | £17.10.0 |          |
| 8CP4            | 32K               | £17.10.0 |          |
| 8CP1            | 35K               | £17.10.0 |          |

### PRECISION BECKMAN 40 TURN 14,400° ROTATION

Wirewound Precision Potentiometer. SE 107A 20 watts at 40°C. 3 1/4" Diameter. Serro Mounting. 200 K. Brand New £12.10. List Price £30.

## GENERATORS

**SIGNAL GENERATOR**  
T.P. 801A Sine Wave, Square Wave Generator. Frequency Range: 10-310 Mc/s. Output Voltage (maximum) 200 millivolts ± 2db. Output impedance 75 ohms. Mark/Space Ratio 50/50 on square wave. Price £120. Packing and carriage £2.

**SIGNAL GENERATOR**  
T.P. 517F/1 Sine Wave, Square Wave Generator. Frequency Range: 120-300 Mc/s. Auxiliary 1A-58 Mfg. c/s. Output Voltage 0.2 Volts. Output impedance 75 ohms.

**MARCONI T.F. 144G**  
Frequency Range 85 kc/s. 25Mc/s. Output voltage 1 micro-volt to 1 volt. Output impedance 1 micro-volt, 100 millivolt, 10 ohms, 100 millivolts to 1 volt, 52.5 ohms. £75 + £2 carriage.

**AVO SIGNAL GENERATOR**  
Frequency Range 50 kc/s-80Mc/s. Output 0.5 Volts. Price £15. Carriage £1/10s.

**SQUARE WAVE GENERATOR**  
Frequencies: 1M, 100kc/s, 10kc/s, 50c/s. Load impedance 75 ohms. Output Voltage 10V, 75 ohms. 0-14 volts into 2000 ohms. Rise time from 30-50 Mill micro seconds at 1 meg. Cycle.

**MARCONI VALVE VOLTMETER TF 428B/1**  
Frequency response on probe 10Kc/s/3-100Mc/s. Five separate voltage ranges. Overload Protection 100-250 A.C.I.P. Input 1M Ohm Acc. ±2% or 0.02V. Size: 10 x 18 1/2 x 9in. -15lb. £51/9/6.

## VOLSTAT

Advance CVN500A. Input 190-260V. 50 Hz. Output 240V. R.M.S. 500 watt P.R.I. £25  
CV500/27. Input 05-130V. 60 Hz. Output 85V. R.M.S. Load 4 amps P.R.I. £21/0  
CV55E. Input 190-260V. 50 Hz. Output 6v. 25 watts £9/10/0  
CV501. Input 190-260V. 50 Hz. Output 230V. 50 watts £12/10/0  
Carriage extra 15/-.

## OSCILLATORS

**MUIRHEAD D729 PHASE-METER AND POWER SUPPLY**  
gives direct indication of phase angle 0°-360° and difference in level between two sinusoidal voltages (transfer function) over the frequency range 2 cycles per sec. to 100 Kc/s. £276 Carriage £2.

### TORQUE MOTOR 225 by ELLIOTT

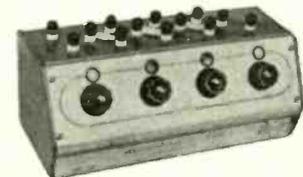
Originally designed to operate hydraulic valves or motors under extreme environmental conditions. The torque motor is practically unaffected by vibration or sudden shock. It consists of a moving iron rotor with a travel of 7° either side of centre. Min. torque 500g per centimeter. Current 45 mA. £9/10/0 p & p 5/-.

### DAWE 444C AUTOMATIC L.F. SWEEP OSCILLATOR (NEW)

Amplitude 0-10V. Frequency Range 5Hz-5 KHz ±2% ±0.5 Hz. 18 Sweep Rates of 10 octaves/min. Frequency Response 0.5 dB. £89.10.0. Carriage extra.

## BRAND NEW LABORATORY TEST EQUIPMENT—AT LESS THAN HALF PRICE

### HIGH VALUE RESISTANCE BOX TYPE R.7003



Specification. Range: 0.01-111 Meg. in 0.01 Megohm divisions. Accuracy: 0.05%. Maximum power rating: 0.1W per step. Case: Hammer finished stove enamel. List price £60. Our price £22/10/-.

### PORTABLE WHEATSTONE BRIDGE



Specification. Type: Moving Coil Galvanometer. Ranges: 1. 0.05 to 5 ohms. 2. 0.5 to 50 ohms. 3. 5 to 500 ohms. 4. 50 to 5,000 ohms. 5. 500 to 50,000 ohms. Scales: Switched. Bildivire: 0.5. Case: Moulded plastic. Internal Source: 4V. Dry battery. Dimensions: 200 x 110 x 65mm. Weight: 0.9 kg. List price £25. Our price £9/19/6.

### PORTABLE MULTIRANGE METER



Specification. Range: 0-50 & 0-300µA. D.C. 0-3, 0-30 & 0-120mA. D.C. 1.2 & 12 amps. D.C. 0.6-3 & 6-30 mA. A.C. 24-120 mA. A.C. 0.24-12A. A.C. 3-12-30-300-600-1,200 & 6,000 V. D.C. 0.6-3, 2.4-12, 6-30, 60-300, 120-600, 240-1,200 & 1,200-6,000 V. A.C. 3-333 ohms. 0.3-30 Kohms. 0.03-3 megohms D.C. Resistance —12 to +75 Decibels. Frequency: 50 cps. Input Resistance A.C.: 20,000 ohms/volt. Input Resistance A.C.: 2,000 ohms/volt. Dimensions: 255 x 215 x 170 mm. Weight: 8 kg. Supplied with 2 voltage dividers, H.V. leads, spare rectifiers, 1.5 & 22.5 V. battery. List price £25. Our price £12.19.6. P. & P. 15/-.

### MUTUAL INDUCTANCE BOX TYPE R.7005

Specification Range: 0-11,100 mH in 0.002 mH divisions. Accuracy: ±(0.3 + 0.012 M) % where M = value of mutual inductance in mH set on the box. Frequency range: 0-2.5 Kc/s for all decades except X1=0-15 Kc/s. Maximum current: 0.5A for decades 1A for variometer (both primary and secondary windings). Case: Polished teak. List price £65. Our price £26.10.



### MUTUAL INDUCTANCE COIL TYPE R.7006

Specification. Value: 0.001 H. Accuracy: ±0.3%. Operating Frequency: 5 Kc/s, 10 Kc/s. Maximum current: 1A. 3A. Resistance of coils: 4 ohm, 1 ohm. Case: Moulded plastic. List price 8 gns. Our price 50/-.

ILLUSTRATED LEAFLETS AVAILABLE

**CURRENT RANGE OF BRAND NEW L.T. TRANSFORMERS. FULLY SHROUDED (\*excepted) TERMINAL BLOCK CONNECTIONS. ALL PRIMARIES 220/240v.**

| No.  | SEC. TAPS     | AMPS | PRICE    | CARR. |
|------|---------------|------|----------|-------|
| 1A   | 25-33-40-50   | 15   | £9 10 0  | 10/6  |
| 1B   | 25-33-40-50   | 10   | £6 19 6  | 8/6   |
| 1C   | 25-33-40-50   | 6    | £5 19 6  | 8/6   |
| 1D   | 25-33-40-50   | 3    | £3 12 6  | 7/6   |
| 2A   | 4-16-24-32    | 12   | £6 10 0  | 7/6   |
| 2B   | 4-16-24-32    | 8    | £4 17 6  | 7/6   |
| 2C   | 4-16-24-32    | 4    | £3 5 0   | 6/-   |
| 2D   | 4-16-24-32    | 2    | £2 2 6   | 5/-   |
| 3A*  | 25-30-35      | 40   | £14 17 6 | 15/-  |
| 3B*  | 25-30-35      | 20   | £9 7 6   | 9/6   |
| 3C   | 25-30-35      | 10   | £6 10 0  | 7/6   |
| 3D   | 25-30-35      | 5    | £3 15 0  | 6/6   |
| 3E   | 25-30-35      | 2    | £2 15 0  | 6/6   |
| 4A*  | 12-20-24      | 30   | £11 15 0 | 10/-  |
| 4B   | 12-20-24      | 20   | £7 10 0  | 8/6   |
| 4C   | 12-20-24      | 10   | £4 15 0  | 7/6   |
| 4D   | 12-20-24      | 5    | £3 5 0   | 6/6   |
| 5A   | 3-12-18       | 30   | £8 15 0  | 7/6   |
| 5B   | 3-12-18       | 20   | £6 10 0  | 7/6   |
| 5C   | 3-12-18       | 10   | £3 17 6  | 6/6   |
| 5D   | 3-12-18       | 5    | £2 12 6  | 6/6   |
| 6A   | 48-56-60      | 2    | £3 5 0   | 5/6   |
| 6B   | 48-56-60      | 1    | £2 7 6   | 5/6   |
| 7A*  | 6-12          | 50   | £9 7 6   | 9/6   |
| 7B   | 6-12          | 20   | £5 10 0  | 7/6   |
| 7C   | 6-12          | 10   | £3 10 0  | 6/6   |
| 7D   | 6-12          | 5    | £2 10 0  | 5/6   |
| 8A   | 12-24         | 1    | £1 9 6   | 5/6   |
| 9A   | 17-32         | 8    | £5 12 6  | 5/6   |
| 10A* | 9-15          | 2    | £1 5 0   | 5/6   |
| 11A  | 6-3           | 15   | £2 5 0   | 5/6   |
| 12A  | 30-25-0-25-30 | 2    | £3 5 0   | 5/6   |

**AUTO TRANSFORMERS**

240v.-110v. or 100v. Completely Shrouded fitted with Two-pin American Sockets or Terminal blocks. Please state which type required.

| Type | Watts | Approx. Weight | Price    | Carr. |
|------|-------|----------------|----------|-------|
| 1    | 80    | 2½ lb          | £1 17 6  | 4 6   |
| 2    | 150   | 4 lb           | £2 7 6   | 5 0   |
| 3    | 300   | 6½ lb          | £3 7 6   | 6 0   |
| 4    | 500   | 8½ lb          | £4 15 0  | 6 6   |
| 5    | 1000  | 15 lb          | £6 12 6  | 7 6   |
| 6*   | 1750  | 25 lb          | £13 10 0 | 10 6  |
| 7*   | 2250  | 30 lb          | £16 10 0 | 12 6  |

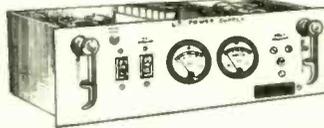
\*Completely enclosed in beautifully finished metal case fitted with two 2-pin American sockets, neon indicator, on/off switch, and carrying handle.

WE REGRET WE HAVE TO INCREASE ALL THE ABOVE TRANSFORMER PRICES BY 10 PER CENT OWING TO THE HIGH COST OF COPPER.

**Samson's**  
(ELECTRONICS) LTD.

9 & 10 CHAPEL ST., LONDON, N.W.1  
01-723-7851 01-262-5125

**AMERICAN HIGHLY STABILISED POWER SUPPLY UNIT**



Regulation between 7-15 volts D.C. at 20 amps. Fitted 0-30 D.C. ammeter, 0-15 D.C. voltmeter and overload protection switch. Built to a very high specification. Bench or rack mounting. Size 19 x 8 x 17 ins. A.C. input 110v. 50 cycles. ex equipment but guaranteed in perfect condition. Maker's price in excess of £200. Our price £25. Carr. 30/- 240/110 volt, 400 watts, Mains Transformer available if required. £3 extra.

**SPECIAL OFFER OF L.T. TRANSFORMERS**

Pri 110-120v.-200-240v. Sec. tapped 12, 18, 24, 30 v. Ba. Table top connections. Fully tropicalised. 75/- Carr. 7/6.

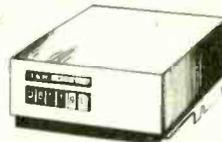
Pri tapped 110v. 220-250v. Sec. 55v. 24a., 14v. 10a., 60v. 2a. All windings very conservatively rated. Tropicallly finished. Terminal connections. Size 9x7½x7ins. Weight 65lbs. £10.19.6. Carr. 15/-.

Pri tapped 200-250v. Sec. 46v. Very conservatively rated at 29 amps. Size 11x7x7ins. Weight 75 lbs. approx. Manufactured by Partridge. £12.19.6. Carr. 15/-.

Pri 240v. Sec. 12v. 90 amps. Open frame flying leads. Size 7½x6½x6ins. £13.19.6. Carr. 15/-.

**DIGITAL HOUR METERS**

6 figs inc. 1/100ths, 1/1000ths 40v. A.C. but complete with transformer for 240v. A.C. operation. All in plastic case. Size 6½ x 6½ x 3in. Condition as new 45/- P. & P. 5/-.



**SMITHS SYNCHRONOUS MOTORS**  
A.C. 200-240v. 4 r.p.m. 3in. dia. Length of spindle 2½in. 22/6. P. & P. 2/6. As above, 1 r.p.m. 22/6. P. & P. 2/6.

**AMERICAN SYNCHRONOUS MOTORS**  
A.C. 230v. 50 cycles, 6 r.p.h. 2½in. dia. cog spindle. 12/6. P. & P. 2/6.

**VENNER SYNCHRONOUS MOTOR**  
A.C. 240v. 50 cycles, 40 r.p.m. 2½in. dia. Length of spindle ½in. 12/6. P. & P. 2/6.

**BERCO SLIDING RESISTORS**

1004 ohms 1 amp. Single Tube Slider. Length 18ins. 45/- P. & P. 7/6. 30 ohms 1.25 amps S.T. Right angle geared drive. 19/6. P. & P. 5/6. 45+12 ohms 6-5/4 amps Single Tube Fixed Length 22ins. 25/- P. & P. 7/6.

**G.P.O. 3000 TYPE RELAY (New and Boxed)**

20,000 ohms Heavy Duty Contacts. 2CO, 2M. 15/- P. & P. 2/-, 75 ohms Normal Contacts. 3M, 1B, 1CO. 6/- P. & P. 2/-, 500 ohms Heavy Duty Contacts. 3M, 3B. 8/6. P. & P. 2/-, 150 ohms Heavy Duty Contacts. 2M. 6/- P. & P. 2/-.

**SUNVIC TANK THERMOSTATS**

Type TOP. 250v. 15 amps NC. 5 amps NO. 190-70 deg. F. Length of stem 10½ins. 25/- P. & P. 5/-.

**AC 220-240v. SHADED POLE MOTORS**

1,500 r.p.m. Double spindle. Length 0-9in. and 0-6in. Overall size 3x3½x2ins. New and Boxed. 10/6. P. & P. 3/6.

**BURGESS MICRO SWITCHES**

Type MK 3BR/74. Norm closed or Norm open. ½in. raised Press Button. 8/6 for three. P. & P. 2/6.

**SIEMENS MINIATURE RELAY BASES**

Type T.STV 24 C. 6 Contact pin. 4 Coil pins. Cartons of 20, inc. spring clips. 15/- P. & P. 2/-.

**PULLEN SHUNT WOUND 24v. DC REVERSIBLE MOTORS**

Type 610 H.P. 1/75 r.p.m. 3,500 Cont/R. New and boxed. 15/- P. & P. 3/6.

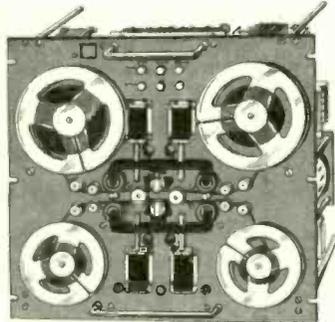
**MAINS ISOLATION TRANSFORMERS**

Pri tapped 240-220-110v. Sec. 240v. 1200 watts. Built into metal case with twin 13 amp Socket outlet, on/off switch, neon indicator and carry handle. £16.10.6. Carr. 15/-.

**GARDNER'S POTTED TRANSFORMERS**

Pri Tapped 200-240v. Sec. 35v. 7-2 amps. conservatively rated. 57/6. Carr. 6/6.

**UNIQUE TWIN TAPE DECK UNITS**



These superb twin tape deck units were originally designed for installations requiring the continuous replay of music or speech when connected to suitable amplifiers. Consisting of two completely self-contained tape decks operating at either 3½" (3 button ¼ track model) or 7½" (6 button 2 track model). Each tape drive unit is fitted with a unique automatic solenoid operated tape drive reversal mechanism actuated by metallic stop foil at end of tape or inserted where reversal is desired. Constructed to the highest specification with the finest components available to ensure the utmost reliability. Nothing has been spared in the construction and the superb heavy duty capstan motors (2 off) and rewind motors (4 off), top grade relays, solenoids, etc., all bear witness to the high standards set.

Available in two basic versions with either 3 or 6 button operation. The three push button model has interlocked controls operating both tape drive units simultaneously and is fitted with 2 Ferrograph ¼ track stereo heads. The 6 button model has independent control over each tape drive unit and is fitted with 2 Marriott ¼ track stereo heads. AC 230/250v. 50 c/s. Vertical or horizontal operation. Size 19" x 19" x 8" deep. Weight 54lb.

Originally costing approximately £450 each to manufacture, we are offering these at a fraction of their true worth!

3 BUTTON MODEL £30  
6 BUTTON MODEL £35

Limited number only—we cannot guarantee a choice of 3 or 6 button units—orders dealt with in strict rotation.

Carriage extra

Send for technical specification

**SYPHA SOUND SALES LTD.**

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Tel. 01-920 8200. Closed ½-day Thurs. (200 yds King's X Station)

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**SANWA MULTI TESTERS**

USED THROUGHOUT THE WORLD, SANWA'S EXPERIENCE OF 30 YEARS ENSURES ACCURACY, RELIABILITY, VERSATILITY. UNSURPASSED TESTER PERFORMANCE COMES WITH EVERY SANWA

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| 6 Months' Guarantee - Excellent Repair Service |          |
| Model P-18                                     | £3 7 6   |
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| Model 360-YTR                                  | £7 17 6  |
| Model AT-1                                     | £11 7 6  |
| Model 380-CO                                   | £13 5 0  |
| Model F-80TRO                                  | £13 16 0 |
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| Model EM-700                                   | £51 0 0  |

PLEASE WRITE FOR ILLUSTRATED LEAFLETS OF THESE SANWA METERS

**SOLE IMPORTERS IN U.K.; QUALITY ELECTRONICS LTD.**

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**EDDYSTONE COMMUNICATION RECEIVERS**

FROM £59-10-0

COVERING 10KHZ-870MHZ

ILLUSTRATED LEFT-830/7 HIGH GRADE G.P. HF/MF RECEIVER COVERING 300KHZ-30MHZ IN 9 RANGES. DOUBLE CONVERSION FROM 1.5 MHZ. PANORAMIC UNIT FOR VISUAL DISPLAY.

SEND 6d. STAMP FOR GENERAL RECEIVER LEAFLET OR SPECIFY FREQUENCY COVERAGE REQUIRED.

**SOUTH COAST EDDYSTONE CENTRE COSH & HAMMOND**

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EXPORT WELCOMED—RANGE IN STOCK—COMPONENTS

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**EVERYTHING BRAND NEW AND TO SPECIFICATION • LARGE STOCKS CATALOGUE WITH FULL TECHNICAL DATA—1/6d.**

## 30 WATT BAILEY AMPLIFIER COMPONENTS

MJ481 } matched pair output .. .. 59/- 40361 12/6, BC125 12/-, BC107 3/6, 40362 16/9,  
 MJ491 }  
 40361 } matched pair drivers .. .. 30/3 Main amp PC board free with each transistor set.  
 40362 }  
 Total for one channel £7.9.6 list, with 10% discount only £6.14.6.  
 Total for two channels £14.19.0 list, with 15% discount only £12.14.0.  
 Complete power supply kit £4.14.6 mono or stereo, subject to discount.  
 Complete regulated power supply kit £9.5.0 subject to discount. Further details on application.

|   |      |  |     |
|---|------|--|-----|
| <b>2N2926 PLASTIC range Silicon NPN, 120MHz fT:</b> |      |  |     |
| Red spot $\beta$ = 55 to 110 .. ..                  | 2/3  | Yellow spot $\beta$ = 150 to 300 .. .. | 1/9 |
| Orange spot $\beta$ = 90 to 180 .. ..               | 2/3  | Green spot $\beta$ = 235 to 470 .. ..  | 2/3 |
| <b>Texas Select range, TO92</b>                     |      |  |     |
| <b>30V, 600mA NPN</b>                               |      |  |     |
| 2N3704 $\beta$ = 90 to 330 .. ..                    | 3/9  | BC107 $\beta$ = 125 to 500, 45V .. ..  | 3/6 |
| 2N3705 $\beta$ = 45 to 165 .. ..                    | 3/5  | BC108 $\beta$ = 125 to 900, 20V .. ..  | 3/- |
| <b>25V 200mA PNP</b>                                |      |  |     |
| 2N3702 $\beta$ = 60 to 300 .. ..                    | 3/6  | BC109 $\beta$ = 240 to 900, 20V .. ..  | 3/6 |
| 2N3703 $\beta$ = 30 to 150 .. ..                    | 3/3  | 180mW 300MHz fT, TO92 plastic          |     |
| <b>Small signal NPN</b>                             |      |  |     |
| 2N3707 low noise .. ..                              | 4/-  | BC167 $\beta$ = 125 to 500, 45V .. ..  | 2/3 |
| 2N3711 $\beta$ = 180 to 660 .. ..                   | 3/11 | BC168 $\beta$ = 125 to 900, 20V .. ..  | 2/- |
|   |      | BC169 $\beta$ = 240 to 900, 20V .. ..  | 2/3 |
|   |      | BC109 and BC169 are low noise.         |     |

**FETS n-channel** Low cost general-purpose type 2N5163, 25V 5/- only. Audio/r.f. Texas 2N3819, 25V 9/-.

**NEW PLESSEY INTEGRATED CIRCUIT POWER AMPLIFIER TYPE SL403A**  
 Operates with 18V power supply. Sensitivity 20mV into 20M.ohms. 3.0 watts into 7.5 ohms. Only 57/- net.  
**PRACTICAL ELECTRONICS NOV. 69 STEREO AMP KIT, less metalwork .. £13.0.0**

**ZENER DIODES**  
 3V to 27V 5% 400mW. All preferred voltages. each 4/6

**SINCLAIR IC.10 INTEGRATED CIRCUIT AMP. & PRE-AMP.**

This remarkable monolithic integrated circuit amplifier and pre-amp is now available for dispatch from stock. It is the equivalent of 13 transistor/18 resistor circuit plus 3 diodes and the first of its kind ever. It is D.C. coupled and applicable for an unusually wide range of uses, all of which are detailed in the manual provided with it. Sinclair IC.10 as advertised, post free .. .. .



**59/6**  
NETT

## PEAK SOUND AMPLIFIER KITS

The new Englefield Kits



Build it  
12+12  
or  
25+25

Brilliant new styling and available in two forms:  
**STEREO 15 WATTS PER CHANNEL**  
 Supplied in kit form with complete amplifier and pre-amplifier modules and power supply components. Output per channel into 15 $\Omega$  —13 watts R.M.S. Price £38.4.0 Net

**STEREO 25 WATTS PER CHANNEL**  
 Supplied in kit form with complete amplifier, pre-amplifier and regulated power supply modules. Output per channel into 15 $\Omega$  —28 watts R.M.S. Price £58.15.0 Net

Specifications on these amplifiers in accordance with the Specifications in Guarantee published in Peak Sound advertisements.

Inputs:  
 Magnetic, RIAA 3.5mV  
 Ceramic 35mV  
 Tape 100mV  
 Radio 100mV

Signal to noise ratios: Better than 60dB all inputs.

**ENGLEFIELD CABINET** to house either above assemblies (as illustrated) £6.0.0.  
 Other Peak Sound Products as advertised.  
 Mainline Kits as advertised.

## BARGAINS IN NEW TRANSISTORS All power types supplied with free insulating sets

|             |             |                  |            |            |              |
|-------------|-------------|------------------|------------|------------|--------------|
| 2N696 5/6   | 2N2147 18/9 | 2N4289 2/11      | AF118 16/6 | BCY31 12/6 | BSX20 4/6    |
| 2N697 6/-   | 2N2369A 6/9 | 2N4291 2/11      | AF124 7/6  | BD121 18/- | M1480 21/-   |
| 2N706 3/5   | 2N2646 9/6  | 2N4292 2/11      | AF127 7/-  | BD123 24/3 | NKT211 5/8   |
| 2N1132 13/- | 2N2924 4/3  | 40406 16/3       | AF139 8/-  | BD124 16/- | NKT214 4/2   |
| 2N1302 4/-  | 2N2925 5/3  | 40408 14/6       | BA102 6/6  | BF115 7/6  | NKT217 12/-  |
| 2N1303 4/-  | 2N3053 5/6  | AC126 6/6        | BC147 4/3  | BF167 8/6  | NKT274 4/3   |
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| 2N1305 4/-  | 2N3055 16/6 | AC176 6/3        | BC149 4/3  | BF180 12/- | NKT404 14/6  |
| 2N1306 6/9  | 2N3391A 5/6 | ACY22 3/3        | BC157 3/6  | BF194 7/-  | NKT405 15/-  |
| 2N1307 6/9  | 2N3708 2/9  | ACY40 3/6        | BC158 3/3  | BFX29 12/3 | NKT713 5/5   |
| 2N1308 8/9  | 2N3904 9/-  | AD140 19/-       | BC159 3/6  | BFX85 8/3  | NKT773 5/3   |
| 2N1309 8/9  | 2N3906 9/-  | AD149 17/6       | BC177 6/-  | BFX88 7/9  | NKT781 6/-   |
| 2N1613 6/6  | 2N3794 2/11 | AD161 } 14/- pr. | BC178 5/3  | BFY50 4/9  | P346A 5/9    |
| 2N1711 7/4  | 2N4286 2/11 | AD162 }          | BC179 5/9  | BFY51 4/3  | V405A 7/9    |

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 ElectroSil type TR5, 2%, 1/4 watt rating. Very low noise, low temperature coefficient, low drift. A Professional resistor! All E24 preferred series of values from 10 $\Omega$  to 1 M $\Omega$ . Price: 1 to 24, 10d. each; 25 to 99, 9d. each; 100 up, 8d. each. (Resistance values may be mixed to obtain quantity reductions.)

**POTENTIOMETERS**  
 Carbon track. Long plastic spindles: each

Single gang linear: 220 $\Omega$ , 470 $\Omega$ , 1K, etc. Dual gang anti-log: 10K only 8/6  
 to 2.2M $\Omega$  2/6 Dual gang linear: 4K7, 10K, 22K, etc. to 1M $\Omega$  8/6  
 Single gang log: 4K7, 10K, 22K, etc. to 2.2M $\Omega$  2/6 Dual gang log: 4K7, 10K, 22K, etc. to 1M $\Omega$  8/6  
 Any type with 1/2 amp double pole mains switch: extra 2/3. Dual gang log/anti-log: 10K, 47K, 1M $\Omega$  only 8/6

**CARBON SKELETON PRE-SETS**  
 Small high quality, type PR: Linear only, 100 $\Omega$ , 220 $\Omega$ , 470 $\Omega$ , 1K, 2K2, 4K7, 10K, 22K, 47K, 100K, 220K, 470K, 1M $\Omega$ , 2M2, 5M, 10M $\Omega$  vertical or horizontal mounting, 1/- each.

**CAPACITORS CERAMIC DISC**  
 Hi-K, all  $\pm$ 20% tolerance: 1,000pF, 2,000pF, 5,000pF, 50V; 0.01 $\mu$ F, 0.02 $\mu$ F, 0.05 $\mu$ F, 50V, 4d. each.

**LARGE CAPACITORS**  
 High ripple current types: 2,000 $\mu$ F 25V, 7/-; 2,000 $\mu$ F 50V, 9/3; 5,000 $\mu$ F 25V, 10/3; 5,000 $\mu$ F 50V, 17/6.  
 S-Dec, 30/6; 2-DeC DeCstore, 69/6; 4-DeC, 119/6.

**MEDIUM RANGE ELECTROLYTICS**  
 Axial leads. Values ( $\mu$ F/V): 50/50, 1/6; 100/25, 1/6; 100/50, 2/-; 250/25, 2/-; 250/50, 3/3; 500/25, 3/3; 1,000/10, 4/-; 220 $\mu$  25V, 1/9; 470 $\mu$  10V, 2/-.

**MULLARD C426 SERIES ELECTROLYTICS**  
 Sub-miniature axial leads. Values: ( $\mu$ F/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; 16/40; 20/16; 20/64; 25/6.4; 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; 160/2.5; 200/6.4; 200/10; 250/4; 320/2.5; 320/6.4; 400/4; 500/2.5. All 1/3 each.

**MINIATURE ( $\mu$ F/V):** 5/10; 10/10; 25/10; 50/10, 9d. each. 25/25; 50/25; 100/10; 200/10, 1/- each. 50/50; 100/25, 1/6 each. 100/50; 250/25, 2/- each.

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**G.M. TUBES.** Brand new. G24/G38/G60 at 27/6 ea. G53/1, brass cased, £6 ea.

**PHOTOMULTIPLIERS.** 6097B at £5 ea. EMI 6097X at £8/10/- ea.

**SOLARTRON** stab. P.U. type AS516 300v 50mA. £3/10/-; AS517 300v 100mA. £6, P. & P. 10/- extra. **TRANSISTOR OSCILLATOR.** Variable frequency 40 c/s to 5 kc/s. 5 volt square wave o/p. for 6 to 12v DC input. Size 1 1/2 x 1 1/2 x 1 1/2 in. Not encapsulated. Brand new. Boxed. 11/6 ea.

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**AMPLIFIERS.** Compact unit by Parmeko—rated 17 watts, capable of double. 2-KT66/2B254M; ROC81; 2-EP86; 5U4, matching to 15 ohms. High impedance or transformer input. Size 1 1/2 x 8 1/2 x 8 1/2 in. high. Standard mains input. Fully tested £8/10/-, including carriage.

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S.T.C. sealed 2 pole c/o 48V. 2,500 ohm 3/6 ea. **CARPENTERS** polarised Single pole c/o 20 and 85 ohm coil as new. Complete with base 9/6 ea. Single pole c/o 680, 1,110 and 1,570 ohm coil. As new 6/6 ea. Synchronous chopper AEI type CK4. As new 17/6 ea. Top connector 2/6 ea.

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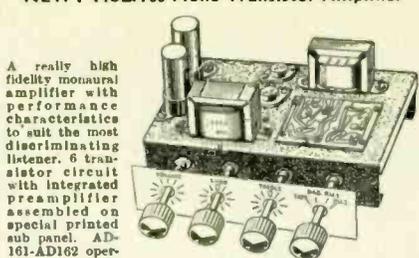
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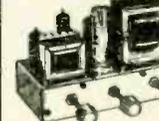
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**10/14 WATT HI-FI AMPLIFIER KIT** A stylishly finished monaural amplifier with an output of 14 watts from 2 EL84 in push-pull. Super reproduction of both music and speech, with negligible hum. Separate inputs for mike and gram allow records and announcements to follow each other. Fully shrouded section wound output transformer to match 3-15Ω speaker and 2 independent volume controls and separate bass and treble controls are provided giving good lift and cut. Valve line-up: 2 EL84s, EOC83, RF86, and E280 rectifier. Simple instruction booklet 1/6 (Free with parts). All parts sold separately. ONLY 27/9/6. P. & P. 8/6. Also available ready built and tested complete with standard input sockets. £8/5/-, P. & P. 9/6.

**10/14 WATT HI-FI AMPLIFIER KIT** A stylishly finished monaural amplifier with an output of 14 watts from 2 EL84 in push-pull. Super reproduction of both music and speech, with negligible hum. Separate inputs for mike and gram allow records and announcements to follow each other. Fully shrouded section wound output transformer to match 3-15Ω speaker and 2 independent volume controls and separate bass and treble controls are provided giving good lift and cut. Valve line-up: 2 EL84s, EOC83, RF86, and E280 rectifier. Simple instruction booklet 1/6 (Free with parts). All parts sold separately. ONLY 27/9/6. P. & P. 8/6. Also available ready built and tested complete with standard input sockets. £8/5/-, P. & P. 9/6.



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| Stock No. | Capacity       | Voltage | Price s. d. | No. Required | £ s. d. | Stock No. | Capacity   | Voltage | Price s. d. | No. Required | £ s. d. |
|-----------|----------------|---------|-------------|--------------|---------|-----------|------------|---------|-------------|--------------|---------|
| 1         | 1 uf           | 6       | 4           |              |         | 42        | 16 uf      | 50 REV  | 2 0         |              |         |
| 2         | 4 uf           | 25      | 4           |              |         | 43        | 16/16      | 275     | 2 0         |              |         |
| 3         | 4 uf           | 4       | 4           |              |         | 44        | 16         | 275     | 1 0         |              |         |
| 4         | 6 uf           | 6       | 4           |              |         | 45        | 350        | 12      | 9           |              |         |
| 5         | 3 uf           | 25      | 4           |              |         | 46        | 20/4       | 275     | 1 0         |              |         |
| 6         | 64 uf          | 9       | 4           |              |         | 47        | 250        | 50      | 2 0         |              |         |
| 7         | 20 uf          | 6       | 4           |              |         | 48        | 500        | 25      | 1 6         |              |         |
| 9         | 30 uf          | 15      | 6           |              |         | 49        | 400        | 15      | 1 0         |              |         |
| 10        | 8 uf           | 12      | 4           |              |         | 50        | 400        | 2.5     | 3           |              |         |
| 11        | 8 uf           | 6       | 4           |              |         | 51        | 64         | 275     | 1 9         |              |         |
| 12        | 1 uf           | 350     | 6           |              |         | 52        | 32/32      | 350     | 2 6         |              |         |
| 13        | 8/8/8          | 350     | 1 0         |              |         | 53        | 8/8/8      | 275     | 1 9         |              |         |
| 14        | 50 uf          | 6       | 4           |              |         | 54        | 500        | 6       | 6           |              |         |
| 16        | 32             | 150     | 9           |              |         | 55        | 64         | 275     | 1 3         |              |         |
| 17        | 64             | 2.5     | 3           |              |         | 56        | 25         | 6       | 3           |              |         |
| 18        | 100/200/200/50 | 275     | 7 6         |              |         | 57        | 100        | 9       | 6           |              |         |
| 19        | 50/80          | 300     | 3 0         |              |         | 58        | 400        | 50      | 2 0         |              |         |
| 21        | 24             | 275     | 1 0         |              |         | 59        | 400        | 30      | 1 6         |              |         |
| 22        | 10             | 25      | 3           |              |         | 60        | 500        | 4       | 3           |              |         |
| 23        | 125            | 2.5     | 3           |              |         | 61        | 150        | 30      | 1 6         |              |         |
| 24        | 2              | 150     | 3           |              |         | 62        | 64/32/8    | 275     | 2 6         |              |         |
| 25        | 16/32          | 350     | 2 6         |              |         | 64        | 40         | 6.4     | 3           |              |         |
| 26        | 32             | 275     | 1 6         |              |         | 65        | 50         | 25      | 6           |              |         |
| 28        | 75/75/75/75    | 150     | 2 6         |              |         | 66        | 250        | 50      | 1 9         |              |         |
| 30        | 12.5           | 40      | 9           |              |         | 67        | 30         | 6       | 3           |              |         |
| 31        | 640            | 2.5     | 3           |              |         | 68        | 100/100/50 | 275     | 5 0         |              |         |
| 32        | 3,000          | 35      | 7 6         |              |         | 69        | 50/50/50   | 350     | 4 0         |              |         |
| 33        | 3,000          | 15      | 3 0         |              |         | 70        | 40/40/20   | 275     | 2 0         |              |         |
| 34        | 3,000          | 30      | 7 0         |              |         | 71        | 400        | 6.4     | 3           |              |         |
| 35        | 250            | 70      | 2 0         |              |         | 72        | 320        | 10      | 3           |              |         |
| 36        | 2,500          | 9       | 2 0         |              |         | 73        | 32/32      | 275     | 2 6         |              |         |
| 38        | 750            | 12      | 1 9         |              |         |           | + 25       | 25      |             |              |         |
| 39        | 100 uf         | 275     | 2 6         |              |         |           |            |         |             |              |         |
| 40        | 30 uf          | 10      | 3           |              |         |           |            |         |             |              |         |

Total:

## RESISTORS. 5% EXCELLENT QUALITY.

Tick the values required.

7/6d. per 100 of any one value.

2/- per dozen of any one value.

|   |           |           |          |          |           |             |             |
|---|-----------|-----------|----------|----------|-----------|-------------|-------------|
| 13 ohms                                 | 560 ohms  | 3.3 k ohm | 10 k ohm | 39 k ohm | 91 k ohm  | 1.2 meg ohm | 8.2 meg ohm |
| 22 ohms                                 | 750 ohms  | 3.6 k ohm | 16 k ohm | 43 k ohm | 130 k ohm | 1.5 meg ohm | 9.1 meg ohm |
| 36 ohms                                 | 1 k ohm   | 4.3 k ohm | 18 k ohm | 47 k ohm | 360 k ohm | 1.8 meg ohm | 10 meg ohm  |
| 47 ohms                                 | 1.5 k ohm | 4.7 k ohm | 22 k ohm | 51 k ohm | 430 k ohm | 3.6 meg ohm |             |
| 91 ohms                                 | 1.8 k ohm | 5.6 k ohm | 24 k ohm | 62 k ohm | 470 k ohm | 5.1 meg ohm |             |
| 220 ohms                                | 2.2 k ohm | 6.8 k ohm | 27 k ohm | 75 k ohm | 560 k ohm | 6.2 meg ohm |             |
| 470 ohms                                | 2.4 k ohm | 7.5 k ohm | 30 k ohm | 82 k ohm | 620 k ohm | 7.5 meg ohm |             |
| or our selection (mixed) 6/6d. per 100. |           |           |          |          |           |             |             |

Total:

## SILVER MICA/CERAMIC/POLYSTYRENE CONDENSERS

Available in following values. Tick those required

10/- per 100 of any one value.

3/- per dozen of any one value.

|        |       |       |       |       |        |        |        |        |        |          |          |
|--------|-------|-------|-------|-------|--------|--------|--------|--------|--------|----------|----------|
| 2 pf   | 5 pf  | 12 pf | 25 pf | 50 pf | 80 pf  | 135 pf | 180 pf | 250 pf | 680 pf | 1,000 pf | 2,500 pf |
| 3.9 pf | 6 pf  | 15 pf | 27 pf | 58 pf | 82 pf  | 140 pf | 190 pf | 330 pf | 800 pf | 1,100 pf | 2,700 pf |
| 4 pf   | 8 pf  | 18 pf | 30 pf | 62 pf | 100 pf | 158 pf | 200 pf | 420 pf | 820 pf | 1,500 pf | 3,000 pf |
| 4.7 pf | 10 pf | 22 pf | 39 pf | 72 pf | 125 pf | 170 pf | 240 pf | 600 pf | 900 pf | 2,200 pf | 6,200 pf |

Total:

# COMPARE THESE PRICES!!

## MULLARD POLYESTER CONDENSERS

|          | No.      | Price |
|----------|----------|-------|
| 1,000 pf | 3d. each | 400V  |
| 1,500 pf | 3d. each |       |
| 1,800 pf | 3d. each |       |
| 2,200 pf | 3d. each |       |
| .15 uf   | 6d. each | 160V  |
| .22 uf   | 6d. each | 160V  |
| .27 uf   | 6d. each | 160V  |
| 1 uf     | 1/- each | 125V  |

Total:

25% discount lots of 100 per type.

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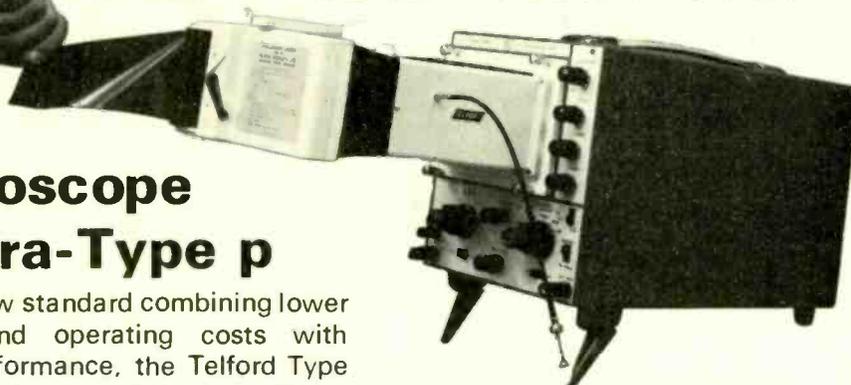
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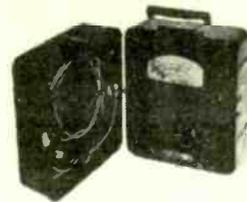
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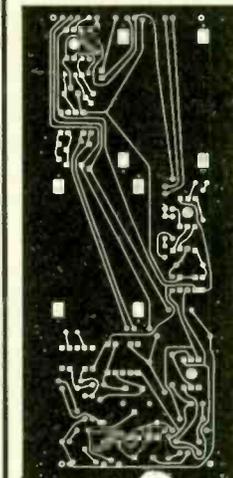
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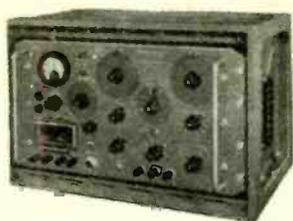
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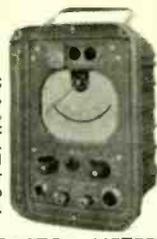
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**VALVE VOLT METER TYPE TF 958.** Measures AC 100mV; 20 c/s to 100 mc/s, DC 50mV to 100V, multiplier extends ac range to 1.5kV. Balanced input and centre-zero scale for DC. AC up to 100MHz. £32.10.0.



**DISTORTION FACTOR METER TYPE TF 142E.** Frequency range: 100-8,000Hz in four ranges. Distortion range: 0.05 to 50%. Input impedance 600Ω, attenuation 0-60db continuously variable. Sensitivity 1mV. £42.10.0. Carriage 20/-.

**IMPEDANCE BRIDGE TYPE TF 369 (No. 5).** Measures L & C at 80Hz, 1kHz, 10kHz. Ranges:—L: 1μH-100H. C: 1mF-100μF. R: 0.1ohms 100ohms. AC Bridge volts monitored and variable. Automatic detector sensitivity control. £105. Carriage 30/-.

**FM DEVIATION METER TYPE TF 791B.** Frequency range: 4-250MHz, deviation 1-75kHz. Specification and price on application.

**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 20mV from 75 ohms source. £85. DITTO but 801/A/1 with additional high level output. £89. Both P. & P. 20/-, including necessary connectors, plugs, and instruction manual.

**PULSE GENERATOR TYPE TF 675F.** Repetition frequency: 50Hz to 50kHz. Pulse duration: 0.15 to 100μ sec; built in 0.1 and 0.5μ sec delay lines. £40.10.0. Carriage 20/-.

**CIRCUIT MAGNIFICATION METER TYPE TF 329F.** Frequency range: 50kHz to 50MHz. Magnification 10 to 500 Q, Tuning Capacitor: 40 to 450pF with ±3pF vernier. Fully overhauled and calibrated. £70. Carriage 30/-.

**TF 899 VALVE VOLT METER, 10mV to 2V, £17.10.0. Carriage 30/-.**

**F.M. DEVIATION METER TF 934, £57.10.0. Carriage 30/-.**

**VIDEO OSCILLATOR TF 885A & 885A/1, £55 and £85 resp. Carr. 30/-.**

## HEWLETT-PACKARD TEST EQUIPMENT

**MODEL 524B ELECTRONIC COUNTER WITH MODEL 525B PLUG IN UNIT.** Basic counter measures frequencies from 10Hz to 10MHz and time from 0 to 10 kHz. Automatic positioning of decimal point, eight place registration. Full self check facility from built in frequency standards. Plug in unit extends frequency range of basic counter to 100 to 220MHz. Full specification and price on request.

**MODEL 400D VALVE MILLIVOLT METER.** Voltage range: 1mV to 300V F.S.D. in 12 ranges. Frequency range: 10Hz to 4MHz. Input impedance 10MΩ and 15pF. Accuracy 2%. £38.10.0. Carriage 12/-.

**MODEL 430C MICROWAVE POWER METER.** Power range: 0.1 to 10mW F.S.D. in five ranges, also calibrated in DBM from -20 to +10. Frequency range: 10MHz to 'R' Band, depending on Bolometer mount. £58.10.0. Carriage 30/-.

## SOLARTRON EQUIPMENT

**VF 252 VALVE VOLT METER.** Voltage range: 1.5mV to 15V F.S.D. in nine ranges. 10:1 attenuator input; accuracy 1%. Frequency range: 10Hz to 100kHz. Input impedance: Greater than 50MΩ with 20pF. Full specification upon request. £33.10.0. Carriage 15/-.

Regulated and stabilised P.S.U. SRS 15A, 20 to 500V positive at 300mA in two ranges. Variable and fixed 170V negative output. £35. Carriage 20/-.

CD 711S.2. Double beam, DC to 7MHz 'scope, £85. Carriage 30/-.

CD 643.2. Single beam Laboratory



Model, DC to 14MHz price upon application. QD 910. Storage Oscilloscope, as new. Price on request.

**ENGLISH ELECTRONIC INSULATION TESTERS 0-10KV** with built-in ionisation amplifier, £35.

**AIRMEC INSULATION TESTER 0-15KV** with built-in ionisation amplifier, £28.

**KELVIN & HUGHES PEN RECORDERS** £35. Carriage 15/-.

**END OF RANGE ITEMS** in 'as seen' condition: CR 100—£10; H.R.O.—£10; Colls at 15/-; AR 88, less case, £12.10.0; TF 144 Signal Generator (Rack Models) £20; Furzehill VTM 10mV to 100V—£15.

**GAUMONT KALEE (RANK STUDIO) MODEL 1740 WOW & FLUTTER METER.** £105. Carriage 7/6.

**BOONTON SIGNAL GENERATOR TS 497/B/URR, 2-400MHz.** £95. Carriage 30/-.

**TS 418 B/U SIGNAL GENERATOR, 400-1000MHz.** £105. Carr. 30/-.

**AVO SIGNAL GENERATOR CT 378, 2-225MHz.** £58.10.0. Carr. 18/-.

**TELEPHONE ENQUIRIES** relating to TEST EQUIPMENT should be made to 01-748 8006 Extension 23. To view TEST EQUIPMENT please phone for appointment

## TRANSISTORS, ZENER DIODES etc.

|            |       |             |            |      |       |      |           |      |              |
|------------|-------|-------------|------------|------|-------|------|-----------|------|--------------|
| OA5        | 2/6   | OA2223 to   | OC82       | 5/-  | AC128 | 6/8  | CR81/10   | 5/-  | MPP10211/-   |
| OA10       | 3/-   | OA2225 10/- | OC82DM3/3- | 4/6  | AC176 | 7/8  | CR81/20   | 9/8  | MPP103 9/8   |
| OA70       | 2/-   | OC26 15/-   | OC83       | 4/6  | AC228 | 4/6  | CR81/30   | 10/- | MPP104       |
| OA71       | 2/-   | OC22 10/-   | OC83B      | 3/-  | AD140 | 13/- | CR81/35   | 10/- | MPP105       |
| OA79       | 1/3   | OC25 7/8    | OC139      | 6/8  | AF117 | 5/-  | CR81/35   | 11/6 | Z Range      |
| OA81       | 1/8   | OC26 5/8    | OC140      | 9/8  | AF117 | 5/-  | CR81/40   | 12/8 | Zener diodes |
| OA200      | 1/8   | OC28 12/8   | OC170      | 5/-  | AF118 | 10/- | CR83/20   | 10/- | 3/6 ea.      |
| OA202      | 2/-   | OC29 15/-   | OC171      | 6/-  | AF124 | 7/8  | CR83/20   | 10/- | 7/6 ea.      |
| OA210      | 7/8   | OC35 10/8   | OC172      | 7/8  | AF127 | 5/-  | CR83/30   | 10/- | Z8B range    |
| OA211      | 9/8   | OC38 8/8    | OC200      | 7/8  | AF139 | 10/- | CR83/30   | 11/8 | 5/- ea.      |
| OA2200111  | OC44  | 4/-         | IN31       | 3/8  | AF178 | 12/8 | CR825/025 | 15/- | 5/- ea.      |
| OA220110-  | OC45  | 2/6         | IN21B      | 5/-  | AFY19 | 22/6 | CR83/40   | 12/6 | Z8 range     |
| OA2202 to  | OC71  | 2/6         | IN25       | 12/- | ASV26 | 5/6  | GET103    | 4/-  | 7/6 ea.      |
| OA2206 8/6 | OC72  | 4/6         | IN43       | 4/-  | ASV28 | 5/8  | GET115    | 9/8  |              |
| OA2207 9/6 | OC73  | 11/-        | IN70       | 4/-  | BC107 | 3/8  | GET118    | 8/8  |              |
| OA2208 to  | OC75  | 6/-         | 2N1306     | 6/8  | BFY51 | 4/8  |           |      |              |
| OA2213 6/8 | OC76  | 5/-         | 2N1307     | 6/8  | BFY52 | 4/6  |           |      |              |
|            | OC81  | 4/-         | 28303      | 10/- | BSY27 | 5/-  |           |      |              |
|            | OC81D | 3/-         | AC126      | 6/8  | BYZ13 | 5/-  |           |      |              |
|            |       |             | AC127      | 7/8  | BYZ16 | 5/-  |           |      |              |

MANY OTHERS IN STOCK include Cathode Ray Tubes and Special Valves. U.K. P. & P. up to 10/- 1/-; to £1 2/-; over £1 2/- in £, over £3 post free. C.O.D. 4/- extra.

**TELEMETRY STATION**  
We are able to offer, one only. Telemetry Station of very recent American manufacture. Comprising Helical Antenna, oscilloscope receiver and associated units, Ampex tape recorder and power supply for the entire installation. Interested clients with a knowledge of this type of equipment are invited to phone or write for further particulars.

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**4 CHANNEL H.F. TRANSMITTER RECEIVER STATION.** Comprising PTC 941 Crystal-controlled Receiver 1.6-14 mc/s. Sensitivity 1 microvolt for 1W, output at all frequencies at 10db S/N and PTC 931 60W Transmitter for RT, CW and MCW operation with push-button control for selection of any one of four pre-set channels. Full details and specification on request.

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**ADMIRALTY B.40 RECEIVERS**



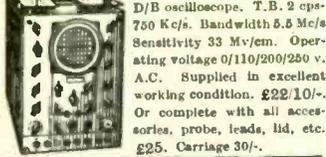
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11 valve high grade communication receiver suitable for tropical use. 1-20 Mc/s. on 4 bands. AM/CW/PM operation. Incorporates precision vernier drive, B.F.O. Aerial trimmer, internal speaker and 12v. D.C. internal power supply. Supplied in excellent condition, fully tested and checked. £15.0.0. Carr. 20/-.

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Double beam. D.C. To 5 Mc/s. Excellent condition. £55 each. Carr. 20/-.

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A crystal controlled heterodyne frequency meter covering 1.7-5 Mc/s. Operation on 6 v. D.C. Ideal for amateur use. Available in good used condition £5-19.6 Carr. 7/6. Or brand new with accessories £7-19.6 Carr. 7/6.

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5 BAND AM/CW/SSB AMATEUR AND SHORT WAVE. 150 kc/s-400 Kc/s AND 550 Kc/s-30 Mc/s. F.E.T. front end ● 2 mechanical filters ● Huge dial ● Product detector ● Variable BFO ● Noise limiter ● 8 meter ● 24 in. Bandspread ● 250 v. A.C./12 v. D.C. net earth operation ● RF gain control. Size 15 1/2 in. x 8 1/2 in. x 8 1/2 in. Wt. 18 lbs. EXCEPTIONAL VALUE £45. CARR. 10/- S.A.E. FOR FULL DETAILS.

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4 band receiver covering 500 Kc/s to 30 Mc/s. continuous and electrical bandspread on 10-15, 20, 40 and 80 meters. 8 valve plus 7 diode circuit. 4/8 ohm output and phone jack. 88B-CW ● ANL ● Variable BFO ● 8 meter. ● Sep. Bandspread dial ● IF 455 Kc/s ● audio output 1.5 w. ● Variable RF and AF gains controls. 115/250 v. A.C. mains. Beautifully designed. Size 7 x 15 x 10 in. With instruction manual and service data. £42. Carriage paid Trio Communication Type Headphones. Normally £5-19.6. Our price £3-15.0 if purchased with above receiver.



**TRIO TS 510 AMATEUR TRANSCEIVER with speaker and mains P.S.U. £12. IN STOCK!**

**TRIO JR-500SE 10-80 Metre AMATEUR RECEIVER**

Covers all the amateur bands in 7 separate ranges between 3.5 and 29.7 Mc/s, 7 valves, 2 transistors and 5 diodes plus 8 crystals: output 8 and 500 ohm and 5,000 ohm phone jack, Crystal controlled oscillator. Variable BFO. VFO. AVC. ANL. 8 meter. 88B-CW. Stand-by switch. Special double gear dial drive with direct reading down to 1 kHz. Remote control socket for connection to a transmitter. Audio output 1 watt. 115/250 v. A.C. mains. Superb modern styling. Size 7 x 13 x 10 in. with instruction manual and service data. £89-10.0. Carr. Paid.



**TRIO JR-310 NEW AMATEUR BAND 10-80 METER RECEIVER IN STOCK £77.10.0**



**RCA COMMUNICATIONS RECEIVERS AR88D**

Latest release by ministry BRAND NEW in original cases. 110-250v. A.C. operation. Frequency in 6 Bands. 535 Kc/s-30 Mc/s continuous. Output impedance 2.5-600 ohms. Incorporating crystal filter, noise limiter, variable BFO, variable selectivity, etc. Price £87-10.0. Carr. 22.



**LAFAYETTE PF-40 SOLID STATE VHF FM RECEIVER**

A completely new transistorised receiver covering 152-174 Mc/s. Fully tunable or crystal controlled (not supplied) for fixed frequency operation. Incorporates 4 INTEGRATED CIRCUITS. Built-in speaker and illuminated dial. Squelch and volume controls. Tape recorder output. 75 Ω aerial input. Headphone jack. Operation 230 v. A.C./12 v. D.C. Neg. earth. £37/10/- Carr. 10/-.

**SOLARTRON CDT11S.2. DOUBLE BEAM OSCILLOSCOPE**



An extremely high quality oscilloscope originally costing £400. Switched beam. Identical Y1, Y2 Amplifiers D.C. to 9 Mc/s. Sensitivity 3mV/CM to 100 V/CM. Time base 10 μs/sec. to 10 M/sec. Calibrator. X amplifier D.C. to 2.5 Mc/s. Z Modulation. 110/250 v. A.C. Supplied in good working order. £85. Carriage 50/-.



**CRYSTAL CALIBRATORS NO. 10**

Small portable crystal controlled wavemeter. Size 7 in. x 7 1/2 in. x 4 in. Frequency range 500 Kc/s-10 Mc/s (up to 30 Mc/s on harmonics). Calibrated dial. Power requirements 300 V.D.C. 15mA and 12 V.D.C. 0.3A. Excellent condition. 89/6. Carr. 7/6.

**SEW PANEL METERS**

Type MR.38P. 1 21/32 in. square fronts.

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| 50 μA        | 40/- | 50mA      | 27/6 | 100V. D.C.  | 27/6 |
| 50-0-50 μA   | 37/8 | 100mA     | 27/6 | 150V. D.C.  | 27/6 |
| 100 μA       | 37/8 | 150mA     | 27/6 | 300V. D.C.  | 27/6 |
| 100-0-100 μA | 35/- | 200mA     | 27/6 | 500V. D.C.  | 27/6 |
| 200 μA       | 35/- | 300mA     | 27/6 | 750V. D.C.  | 27/6 |
| 500-0-500 μA | 27/6 | 500mA     | 27/6 | 15V. A.C.   | 27/6 |
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| 2mA          | 27/6 | 2 amp     | 27/6 | 200V. A.C.  | 27/6 |
| 5mA          | 27/6 | 5 amp     | 27/6 | 500V. A.C.  | 27/6 |
| 10mA         | 27/6 | 10V. D.C. | 27/6 | 8 meter 1mA | 32/- |
| 20mA         | 27/6 | 20V. D.C. | 27/6 | VU meter    | 42/- |

**LAFAYETTE STEREO AMPLIFIER MODEL STEREO 10**

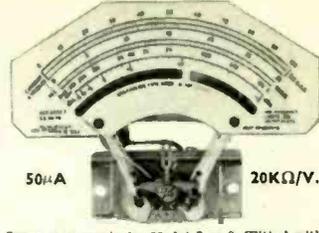


Completely transistorised 5 watts per channel I.H.F. music power. Inputs for gram and tuner. Separate volume controls and variable tone control for Bass and Treble. A compact size. High performance stereo amplifier ideal for limited space systems. Beautifully finished in grey and aluminium. Size 7 1/2 in. x 2 1/2 1/2 in. x 5 1/2 in. AC. 220/240v. Price £11.19.6 Carr. 7/6.

**POWER RHEOSTATS**

High quality ceramic construction. Windings embedded in vitreous enamel. Heavy duty brush wiper. Continuous range. Wide range available ex-stock. Single hole fixing. 1/4 in. dia. shafts. Bulk quantities available. 25 WATT. 10/25/50/100/250/500/1000/1500/2500 or 5000 ohms. 14/6. P. & P. 1/6. 50 WATT. 10/25/50/100/250/500/1000/2500 or 5000 ohms. 21/- P. & P. 1/6. 100 WATT. 1/5/10/25/50/100/250/500/1000 or 2500 ohms. 27/6. P. & P. 1/6.

**AVOMETER MOVEMENTS**



Spare movements for Model 8 or 9. (Fitted with Model 9 scale) or basis for any multimeter. Brand New and Boxed 89/6. P. & P. 3/6

**AVP 48A**  
Perfect order with set of shunts and resistances £12-10.0. P. & P. 7/6.

**T.E.40 HIGH SENSITIVITY A.C. VOLTMETER**

10 meg. input 10 ranges: 0.1/0.3/1.3/3/10/30/100/300 v. R.M.S. 4 cps-1.2 Mc/s. Decibels -40 to +50 dB. Supplied brand new complete with leads and instructions. Operation 230 v. A.C. £17/10/- Carr. 5/-.



**TE-65 VALVE VOLTMETER**

High quality instrument with 28 ranges. D.C. volts 1.5-1,500 v. A.C. volts 1.5-1,500 v. Resistance up to 1,000 megohms. 220/240v. A.C. operation. Complete with probe and instructions £17/10/0. P. & P. 6/- Additional Probes available: R.F. 35/- H.V. 42/6.



**COSOR 1049 DOUBLE BEAM OSCILLOSCOPES**

D.C. coupled. Band width 1 Kc/s. Perfect order. £25. Carr. 30/-.

**AM/FM SIGNAL GENERATORS**

Oscillator Test No. 2. A high quality precision instrument made for the Ministry by Airtec. Frequency coverage 20-80 Mc/s. AM/CW/PM. Incorporates precision dial, level meter, precision attenuator 1 μV-100mV. Operation from 12 volt D.C. or 0/110/200/250 v. A.C. Size 12 x 8 1/2 x 9 in. Supplied in brand new condition complete with all connectors, fully tested. £45. Carr. 20/-.



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**TE-16A TRANSISTORISED SIGNAL GENERATOR**

5 Ranges 400 KHz-30 MHz. An inexpensive instrument for the handyman. Operates on 9v. battery. Wide easy to read scale. 800 KHz modulation. 6 1/2" x 5 1/2" x 3 1/2". Complete with instructions and leads. £7/19/8. P/P 4/-.



**TRANSISTORISED L.C.R. A.C. MEASURING BRIDGE.**

A new portable bridge offering excellent range and accuracy at low cost. Ranges: R. 1 Ω-111 MEG Ω 6 Ranges ± 1% L. 1 μH-111 HENRIES. 6 Ranges -2% C. 10PF ± 1110MPF. 6 Ranges ± 2% TURNS RATIO 1:1/1000-1:11000. 6 Ranges ± 1%. Bridge voltage at 1,000 CPS. Operated from 9 volt. 100 μA. Meter Indication. Attractive 2 tone metal case. Size 7 1/2" x 5" x 2". £20. P. & P. 5/-.



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0/115/200v. Step up or step down. Fully shrouded 150 W. 42/6. P. & P. 3/6 300 W. 58/6. P. & P. 4/6 500 W. 24/10/0. P. & P. 6/6 1,000 W. 28/10/0. P. & P. 7/6 1,500 W. 27/19/8. P. & P. 8/6 7,500 W. 215/10/0. P. & P. 20/-.

**G. W. SMITH & Co. (Radio) Ltd.**  
ALSO SEE OPPOSITE PAGE

ARF-100 COMBINED AF-RF SIGNAL GENERATOR



AF-SINE WAVE 20-200,000 cps. Square wave 20-30,000 cps. O/P HIGH IMP. 21 v. P/P 600 Ω 3.8 v. P/P. R.F. 100 kc/s-300 Mc/s. Variable R.F. Attenuation. Int./Ext. Modulation. Incorporates dual purpose meter to monitor AF output and % mod. on R.F. 220/240 v. A.C. £30. Carr. 7/6.

VOLTAGE STABILISER TRANSFORMERS. 180-260v. Input. Output 230v. Available 150w or 225w. £12.10.0. Carr. 5/-.

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Accurate wide range signal generator covering 120 kc/s-200 Mc/s. on 6 bands. Directly calibrated. Variable R.F. attenuator. Operation 200/240 v. A.C. Brand new with instructions. £15.

P. & P. 7/6. S.A.E. for details.

PEAK SOUND PRODUCTS

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Sine: 20 cps to 200 kc/s. on 4 bands. Square 20 cps to 30 kc/s. Output Impedance 5,000 ohms. 200/250 v. A.C. operation. Supplied brand new and guaranteed with instruction manual and leads. £16.10.0. Carr. 7/6.



P. & P. 7/6. S.A.E. for details.

MARCONI TF885 VIDEO OSCILLATORS

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LAFAYETTE TE-46 RESISTANCE CAPACITY ANALYSER



2 pf-2,000 mfd. 2 ohms-200 meg. ohms. Also checks impedance turns ratio insulation. 200/250 v. A.C. Brand New, £17.10 Carr. 7/6.

MARCONI TF.142E DISTORTION FACTOR METERS

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It has the fullest capacity for checking on A, B and Ico. Equally adaptable for checking diodes, etc. Spec: A: 0.7-0.9967. B: 6-200. Ico: 0/50 micro-amps. 0.5 mA. Resistance for diodes 200 Ω + 1 MEG. Supplied complete with instructions, battery and leads. £5/19/6. P. & P. 2/6.



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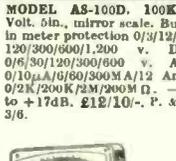
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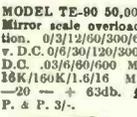
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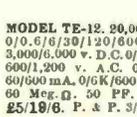
MODEL TE-90 50,000 O.P.V. Mirror scale overload protection. 0/3/12/60/300/600/1,200 v. D.C. 0/6/30/120/300/1,200 v. D.C. 0/6/60/600MA. D.C. 18K/160K/1.6/16 MEG Ω. -20 + + 63db. £7/10/0. P. & P. 3/-.



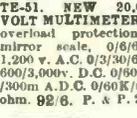
MODEL TE-70. 30,000 O.P.V. 0/3/15/60/300/600/1,200 v. D.C. 0/6/30/120/600/1,200 v. A.C. 0/30/μA/3/30/300mA. 0/16K/160K/1.6M/16 MEG Ω. £5/10/-.



MODEL TE-80. 20,000 O.P.V. 0/10/50/100/500/1,000 v. A.C. 0/5/25/50/250/500/1,000 v. D.C. 0-50/μA. 5/50/500mA. 0/6K/60K/600K/6 meg. £4/17/6. P. & P. 3/-.



MODEL TE-12. 20,000 O.P.V. 0/0.6/6/30/120/600/1,200/3,000/6,000 v. D.C. 0/6/30/120/600/1,200 v. A.C. 0/60/μA/6/60/600mA. 0/6K/60K/6M/6 meg. 60 Meg Ω. 50 PF. 2 MFD £5/19/6. P. & P. 3/6.



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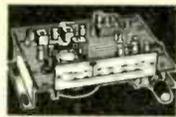


MODEL TE-10A. 20K Ω/Volt 5/25/50/250/500/2,500 v. D.C. 10/50/100/500/1,000 v. A.C. 0/50/μA/2.5 mA/250 mA D.C. 0/6K/6 meg. ohm. -20 to +22 dB. 10-0, 100 mfd. 0.100-0.1 mfd. 69/6. P. & P. 2/6.



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Z12. 12 watt amplifier 89/6. P24. Power supply Unit 89/6. STEREO 25. Pre-amplifier 29/19/6. Q.14 Speakers 27/19/6. Micromatic Radio Kit 49/6. Built 59/6.

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Wonderfully comfortable. Lightweight adjustable vinyl headband, 6ft. cable and stereo jack plug, 25-17,000 cps. 8 Ω imp. 67/6. P. & P. 2/6.

HOSIDEN DH04S 2-WAY STEREO HEADPHONES



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Heavy duty light flasher employs a condenser discharge principle operating on an electro mechanical relay. (As inset.) Housed in strong plastic case. Flashing rate between 60-120 per minute. 12 volt D.C. operation. Maximum load 6 amps. Size 9 1/2 in. dia. by 4in. Supplied brand new at a fraction of original cost. 6/6 each, P. & P. 2/6. £3 for 17/6. P. & P. 4/6.

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| 0A2    | 5/9  | 6BR8  | 8/1  | 6V6G    | 3/6  | 20D4   | 20/5 | 306    | 13/1 | DL95     | 7/1   | EC8H1   | 5/9      |      |
| 0B2    | 6/1  | 6BR7  | 16/8 | 6X4     | 4/3  | 30P2   | 14/0 | 807    | 11/9 | DM70     | 6/1   | EC8H3   | 8/1      |      |
| 0Z4    | 4/6  | 6BW6  | 12/9 | 6X6G    | 5/1  | 30L1   | 13/1 | 966    | 2/1  | DM71     | 7/6   | EC8H4   | 7/8      |      |
| 1A3    | 4/8  | 6BW7  | 11/1 | 6V6G    | 6/1  | 20P1   | 17/6 | 1821   | 10/6 | DW4/350  | 6/6   | EC8L0   | 6/6      |      |
| 1A5    | 5/1  | 6C8   | 3/9  | 6V7G    | 12/6 | 20P3   | 18/1 | 5763   | 10/1 | 8/6      | EC8L2 | 6/1     | HABCO8/1 |      |
| 1A7G   | 7/3  | 6C9   | 11/1 | 7BB     | 10/9 | 20P4   | 18/6 | 6060   | 5/8  | DW4/500  | 6/6   | EC8L3   | 9/1      |      |
| 1C5    | 4/9  | 6C6D6 | 19/6 | 7B7     | 7/7  | 20P5   | 18/1 | 7193   | 10/1 | DY86     | 5/9   | EC8L4   | 12/1     |      |
| 1D5    | 6/9  | 6C8H  | 6/1  | 7C8     | 6/1  | 25L6T  | 5/8  | 7475   | 4/1  | DY87     | 5/9   | EC8L6   | 8/1      |      |
| 1D6    | 9/6  | 6CL6  | 8/6  | 7F8     | 12/6 | 25Y5   | 6/1  | A1834  | 20/1 | DY87     | 5/9   | EC8L6   | 8/1      |      |
| 1PD1   | 6/6  | 6CW4  | 12/1 | 7E7     | 12/1 | 25Y6   | 6/1  | A2134  | 10/1 | ES0F     | 24/1  | EC8L800 | 10/1     |      |
| 1PD9   | 4/3  | 6D3   | 7/6  | 7H7     | 5/6  | 25Z4G  | 6/1  | A3042  | 15/1 | ES3F     | 24/1  | EC8L3   | 9/1      |      |
| 1G6    | 6/1  | 6D6   | 3/1  | 7H7     | 12/1 | 25Z5   | 7/1  | AC2PEN | 19/6 | ES8CC    | 12/1  | EF22    | 12/6     |      |
| 1B8GT  | 7/1  | 6F1   | 8/9  | 7Y4     | 6/6  | 25Z6G  | 8/6  | AC2PEN | 19/6 | E180F    | 17/6  | EF36    | 3/6      |      |
| 114    | 2/6  | 6F6   | 12/8 | 9B5W    | 7/1  | 30C1   | 9/6  | AC2PEN | 19/6 | E1814    | 10/6  | EF38    | 4/1      |      |
| 11D5   | 5/1  | 6F6G  | 6/1  | 9D7     | 9/1  | 30C15  | 13/6 | DD     | 19/6 | EA50     | 1/6   | EF39    | 5/1      |      |
| 11N5   | 8/1  | 6F12  | 3/1  | 9D7     | 9/1  | 30C17  | 16/1 | AC2PEN | 19/6 | EA76     | 13/1  | EF40    | 8/9      |      |
| 11S5GT | 7/9  | 6F13  | 3/1  | 9D7     | 12/6 | 30C18  | 11/6 | AC2PEN | 19/6 | EABCO8/6 | 6/1   | EF41    | 10/1     |      |
| 1K5    | 5/6  | 6F14  | 15/1 | 10D1    | 8/1  | 30F5   | 16/1 | AC2PEN | 19/6 | EAC91    | 3/1   | EF42    | 3/6      |      |
| 1B4    | 4/9  | 6F15  | 10/1 | 10D2    | 14/7 | 30FL1  | 15/1 | AC2PEN | 19/6 | EAF42    | 8/9   | EF44    | 10/1     |      |
| 1B5    | 4/3  | 6F18  | 7/6  | 10F1    | 15/1 | 30L1   | 12/6 | AC/TH1 | 10/1 | EB41     | 4/6   | EF80    | 4/6      |      |
| 1U4    | 5/1  | 6F24  | 11/9 | 10F9    | 9/1  | 30L14  | 6/3  | AC/TH1 | 10/1 | EB91     | 2/3   | EF83    | 9/6      |      |
| 1U5    | 6/9  | 6F24  | 11/9 | 10F9    | 9/1  | 30L15  | 12/6 | AC/TH1 | 10/1 | EB91     | 2/3   | EF83    | 9/6      |      |
| 2D21   | 5/6  | 6F25  | 13/1 | 10F18   | 7/1  | 30L15  | 13/9 | AC/TP  | 19/6 | EB91     | 2/3   | EF83    | 9/6      |      |
| 3A4    | 8/6  | 6F26  | 10/1 | 10FD11  | 10/1 | 30L17  | 15/6 | AC/VP2 | 19/6 | EB91     | 2/3   | EF83    | 9/6      |      |
| 3A5    | 10/1 | 6F28  | 10/6 | 10F14   | 12/6 | 30P4   | 12/1 | ARF3   | 7/1  | EB90     | 4/1   | EF89    | 5/1      |      |
| 3B7    | 5/1  | 6G6   | 2/6  | 12A6    | 3/6  | 30P4MB | ATP4 | 2/3    | EB91 | 8/6      | EF91  | 3/3     |          |      |
| 3D6    | 3/9  | 6H6GT | 1/9  | 12A6    | 3/6  | 30P12  | 13/9 | AZ1    | 8/1  | EBF80    | 6/9   | EP92    | 2/6      |      |
| 3Q4    | 6/8  | 6J6G  | 3/9  | 12A2C   | 6/1  | 30P12  | 13/9 | AZ1    | 8/1  | EBF83    | 6/9   | EP97    | 10/1     |      |
| 3Q5GT  | 6/1  | 6J6   | 3/9  | 12A2D   | 6/1  | 30P19  | 12/1 | AZ31   | 7/6  | EBF89    | 6/9   | EP98    | 10/6     |      |
| 3B4    | 5/9  | 6J7G  | 4/9  | 12A2E   | 7/6  | 30PL1  | 15/1 | BL43   | 10/1 | EBL21    | 11/1  | EF183   | 6/1      |      |
| BR40Y  | 8/9  | 6K6GT | 5/1  | 12A7G   | 3/9  | 30PL13 | 15/6 | CL33   | 18/6 | EC131    | 15/6  | EL35    | 10/1     |      |
| BU4G   | 4/9  | 6K7G  | 2/1  | 12A7T   | 3/9  | 30PL14 | 15/6 | CV6    | 10/6 | EC34     | 6/1   | EH90    | 7/6      |      |
| 5V4G   | 7/6  | 6K7GT | 4/6  | 12A7T   | 4/6  | 30PL15 | 15/6 | CY10   | 10/6 | EC70     | 4/9   | EK90    | 4/9      |      |
| 5Y3GT  | 5/6  | 6L1   | 19/6 | 12A7E   | 4/6  | 35A3   | 5/1  | CY31   | 7/6  | EC86     | 12/6  | EL32    | 3/6      |      |
| 5Z3    | 8/1  | 6L6GT | 7/9  | 12A7T   | 4/6  | 35A5   | 18/1 | D63    | 5/1  | EC88     | 12/1  | EL32    | 3/6      |      |
| 5Z4G   | 7/1  | 6L7GT | 12/6 | 12A7T   | 4/6  | 35D3   | 12/6 | D77    | 2/3  | EC92     | 6/6   | EL34    | 12/1     |      |
| 6A80Z  | 12/6 | 6L18  | 6/1  | 12A7E   | 4/6  | 35L6GT | 8/6  | DACS2  | 7/1  | EC93     | 12/6  | EL35    | 10/1     |      |
| 6A8G   | 5/8  | 6L19  | 19/1 | 12B2E   | 5/9  | 35W4   | 4/6  | DAPF1  | 4/1  | EC93     | 4/6   | EL37    | 17/1     |      |
| 6AC7   | 3/1  | 6LD20 | 6/6  | 12B2H   | 6/1  | 35Z23  | 10/1 | DAPF6  | 6/6  | ECC3330  | 11    | EL38    | 20/1     |      |
| 6A65   | 3/6  | 6N7GT | 8/6  | 12B2I   | 17/1 | 35Z4GT | 4/9  | DDC90  | 10/1 | ECX34    | 29/6  | EL41    | 10/3     |      |
| 6AK5   | 5/1  | 6P1   | 12/1 | 13J7GT  | 6/6  | 60B6   | 8/3  | DF33   | 7/9  | EC94     | 8/6   | EL42    | 9/9      |      |
| 6AK6   | 8/1  | 6P25  | 12/1 | 12K5    | 10/1 | 60C5   | 8/3  | DF91   | 2/9  | EC98     | 7/1   | EL56    | 5/3      |      |
| 6AL5   | 2/3  | 6P28  | 13/3 | 12K7GT  | 5/9  | 60CD60 | 4/1  | DF96   | 6/6  | EC93     | 4/6   | EL84    | 4/9      |      |
| 6AL4   | 18/6 | 6P28  | 15/1 | 12Q7GT  | 4/6  | 50L6GT | 9/1  | DF97   | 10/1 | EC98     | 5/6   | EL85    | 7/6      |      |
| 6AM6   | 3/3  | 6Q7G  | 6/1  | 12B47GT | 7/2  | 64B    | 6/6  | DH63   | 6/1  | EC98     | 5/6   | EL96    | 8/1      |      |
| 6A25   | 5/6  | 6Q7GT | 8/6  | 12B47   | 8/9  | 85A2   | 8/6  | DH76   | 4/6  | EC98     | 6/1   | EL91    | 2/6      |      |
| 6A6    | 20/1 | 6R7G  | 7/1  | 12B7    | 4/1  | 85A3   | 8/6  | DH77   | 4/6  | EC98     | 7/1   | EL95    | 5/3      |      |
| 6AT9   | 4/1  | 6R7   | 11/1 | 12B7    | 3/1  | 90AG   | 6/6  | DH81   | 10/9 | EC98     | 7/1   | EL95    | 5/3      |      |
| 6AT6   | 6/6  | 6ATGT | 6/1  | 12B7H   | 6/1  | 90AV   | 6/6  | DH101  | 25/1 | EC98     | 8/6   | EM90    | 7/6      |      |
| 6AV6   | 5/6  | 6B8GT | 6/1  | 12B7T   | 4/6  | 90CG   | 3/4  | DK32   | 7/8  | EC98     | 8/6   | EM91    | 7/6      |      |
| 6B8G   | 2/6  | 6B8T  | 6/1  | 12B7K   | 4/9  | 90CV   | 3/8  | DK40   | 10/1 | ECF80    | 6/6   | EM84    | 6/6      |      |
| 6B6    | 4/9  | 6B7   | 3/1  | 12B7GT  | 7/6  | 90C1   | 16/1 | DK91   | 5/6  | ECF82    | 6/6   | EM85    | 11/1     |      |
| 6B6    | 4/3  | 6B7   | 3/1  | 14B7    | 9/6  | 150B2  | 14/6 | DK92   | 9/1  | ECF86    | 9/1   | EM87    | 7/6      |      |
| 6B6    | 7/6  | 6B7   | 4/6  | 14B7    | 15/1 | 150C2  | 9/1  | DK96   | 7/1  | ECF84    | 6/6   | EY1     | 7/6      |      |
| 6B6    | 6/6  | 6B7GT | 4/6  | 18      | 12/6 | 30/1   | 20/1 | DL33   | 6/1  | 42/1     | EY81  | 7/6     | PCD189   | 10/6 |
| 6BQ5   | 4/9  | 6BQ7  | 7/6  | 19A5    | 4/9  | 302    | 18/6 | DL35   | 4/9  | ECH21    | 12/6  | EY83    | 8/3      |      |
| 6BQ7A  | 7/1  | 6U4GT | 12/1 | 19H1    | 40/1 | 303    | 15/6 | DL92   | 5/9  | ECH23    | 9/6   | EY84    | 7/6      |      |
| 6BR7   | 8/6  | 6U7G  | 7/1  | 20D1    | 13/1 | 305    | 18/6 | DL94   | 5/9  | ECH42    | 10/1  | EY86    | 6/6      |      |

|         |       |        |      |          |      |       |      |       |      |        |     |        |      |
|---------|-------|--------|------|----------|------|-------|------|-------|------|--------|-----|--------|------|
| EY87    | 6/8   | PCF86  | 9/1  | SP13C    | 18/6 | U193  | 6/8  | AC113 | 5/1  | BCY38  | 5/1 | GET119 | 4/1  |
| EY88    | 7/6   | PCF801 | 7/1  | 8P42     | 12/6 | U251  | 14/8 | AC114 | 8/1  | BCY39  | 4/6 | GET173 | 7/8  |
| EY91    | 3/1   | PCF802 | 9/1  | 8P01     | 3/3  | U281  | 8/1  | AC17  | 2/1  | BC108  | 3/6 | GET187 | 8/6  |
| EZ35    | 4/1   | PCF808 | 11/6 | TH43     | 10/1 | U282  | 8/1  | AC155 | 6/6  | BC113  | 5/1 | GET187 | 10/1 |
| EZ41    | 8/6   | PCF808 | 12/6 | TH233    | 7/1  | U301  | 11/1 | AC156 | 4/6  | BC115  | 3/1 | GET187 | 10/1 |
| EZ80    | 4/8   | PCL82  | 7/1  | UABCO8/6 | 6/1  | U329  | 14/6 | AC157 | 5/1  | BC116  | 5/1 | GET187 | 10/1 |
| EZ81    | 4/9   | PCL83  | 9/1  | UAF42    | 9/6  | U404  | 7/6  | AC165 | 5/1  | BC118  | 4/6 | GET187 | 10/1 |
| EZ90    | 4/3   | PCL84  | 7/6  | UB41     | 6/8  | U480  | 19/6 | AC166 | 6/1  | BC119  | 4/6 | GET187 | 10/1 |
| EW4     | 300/6 | PCL85  | 8/6  | UC41     | 6/8  | U490  | 6/9  | AC167 | 12/1 | BD119  | 5/1 | GET187 | 10/1 |
| FW4/800 | 10/1  | PCL86  | 8/6  | UC81     | 7/1  | VP2   | 3/8  | AC168 | 7/6  | BF154  | 9/1 | GET187 | 10/1 |
|         |       | PCL88  | 15/1 | UBF80    | 5/8  | VP2B  | 9/8  | AC169 | 6/6  | BF159  | 5/1 | GET187 | 10/1 |
|         |       | PEN45  | 7/1  | UBF89    | 6/9  | VP4B  | 10/6 | AC176 | 11/1 | BF163  | 4/6 | GET187 | 10/1 |
|         |       | PEN46  | 12/1 | UBH21    | 9/1  | VP13C | 7/1  | AC177 | 5/8  | BF173  | 7/6 | GET187 | 10/1 |
|         |       | PEN46  | 12/1 | UC92     | 5/6  | VP23  | 2/6  | AC178 | 3/1  | BF180  | 8/1 | GET187 | 10/1 |
|         |       | PEN46  | 12/1 | UC94     | 8/1  | VP41  | 7/8  | AC179 | 3/6  | BF181  | 8/1 | GET187 | 10/1 |
|         |       | PEN46  | 12/1 | UC95     | 6/9  | VP75  | 24/1 | AC191 | 3/9  | BF185  | 8/1 | GET187 | 10/1 |
|         |       | PEN46  | 12/1 | UC96     | 8/3  | VP105 | 5/1  | AC192 | 3/6  | BFY105 | 4/1 | GET187 | 10/1 |
|         |       | PEN46  | 12/1 | UC97     | 3/9  | VP150 | 5/1  | AC193 | 3/9  | BFY106 | 4/1 | GET187 | 10/1 |
|         |       | PEN46  | 12/1 | UC98     | 3/6  | VP151 | 7/1  | AC194 | 3/6  | BFY107 | 4/1 | GET187 | 10/1 |
|         |       | PEN46  | 12/1 | UC99     | 3/6  | VP152 | 7/1  | AC195 | 3/6  | BFY108 | 4/1 | GET187 | 10/1 |
|         |       | PEN46  | 12/1 | UC100    | 3/6  | VP153 | 7/1  | AC196 | 3/6  | BFY109 | 4/1 | GET187 | 10/1 |
|         |       | PEN46  | 12/1 | UC101    | 3/6  | VP154 | 7/1  | AC197 | 3/6  | BFY110 | 4/1 | GET187 | 10/1 |
|         |       | PEN46  | 12/1 | UC102    | 3/6  | VP155 | 7/1  | AC198 | 3/6  | BFY111 | 4/1 | GET187 | 10/1 |
|         |       | PEN46  | 12/1 | UC103    | 3/6  | VP156 | 7/1  | AC199 | 3/6  | BFY112 | 4/1 | GET187 | 10/1 |
|         |       | PEN46  | 12/1 | UC104    | 3/6  | VP157 | 7/1  | AC200 | 3/6  | BFY113 | 4/1 | GET187 | 10/1 |
|         |       | PEN46  | 12/1 | UC105    | 3/6  | VP158 | 7/1  | AC201 | 3/6  | BFY114 | 4/1 | GET187 | 10/1 |
|         |       | PEN46  | 12/1 | UC106    | 3/6  | VP159 | 7/1  | AC202 | 3/6  | BFY115 | 4/1 | GET187 | 10/1 |
|         |       | PEN46  | 12/1 | UC107    | 3/6  | VP160 | 7/1  | AC203 | 3/6  | BFY116 | 4/1 | GET187 | 10/1 |
|         |       | PEN46  | 12/1 | UC108    | 3/6  | VP161 | 7/1  | AC204 | 3/6  | BFY117 | 4/1 | GET187 | 10/1 |
|         |       | PEN46  | 12/1 | UC109    | 3/6  | VP162 | 7/1  | AC205 | 3/6  | BFY118 | 4/1 | GET187 | 10/1 |
|         |       | PEN46  | 12/1 | UC110    | 3/6  | VP163 | 7/1  | AC206 | 3/6  | BFY119 | 4/1 | GET187 | 10/1 |
|         |       | PEN46  | 12/1 | UC111    | 3/6  | VP164 | 7/1  | AC207 | 3/6  | BFY120 | 4/1 | GET187 | 10/1 |
|         |       | PEN46  | 12/1 | UC112    | 3/6  | VP165 | 7/1  | AC208 | 3/6  | BFY121 | 4/1 | GET187 | 10/1 |
|         |       | PEN46  | 12/1 | UC113    | 3/6  | VP166 | 7/1  | AC209 | 3/6  | BFY122 | 4/1 | GET187 | 10/1 |
|         |       | PEN46  | 12/1 | UC114    | 3/6  | VP167 | 7/1  | AC210 | 3/6  | BFY123 | 4/1 | GET187 | 10/1 |
|         |       | PEN46  | 12/1 | UC115    | 3/6  | VP168 | 7/1  | AC211 | 3/6  | BFY124 | 4/1 | GET187 | 10/1 |
|         |       | PEN46  | 12/1 | UC116    | 3/6  | VP169 | 7/1  | AC212 | 3/6  | BFY125 | 4/1 | GET187 | 10/1 |
|         |       | PEN46  | 12/1 | UC117    | 3/6  | VP170 | 7/1  | AC213 | 3/6  | BFY126 | 4/1 | GET187 | 10/1 |
|         |       | PEN46  | 12/1 | UC118    |      |       |      |       |      |        |     |        |      |

# R.S.T. VALVE MAIL ORDER CO.

BLACKWOOD HALL, 16A WELLFIELD ROAD  
STREATHAM, S.W.16

|              |            |             |             |             |             |
|--------------|------------|-------------|-------------|-------------|-------------|
| A61 9/8      | ECLL800    | PL509 37/6  | XR13/200    | 12AC6 10/-  | 2G402 6/-   |
| ACT9 500/-   | EP9 30/-   | PL802 16/6  | 120/-       | 12AD6 11/-  | 2G414 6/-   |
| ARF38 13/-   | EP7A 7/-   | PT15 15/-   | Z66 15/-    | 12AE6 9/6   | 2G415 6/-   |
| AZ31 10/-    | EP59 8/-   | FX4 14/-    | Z319 25/-   | 12AT6 4/9   | 2G418 6/8   |
| BT19 80/-    | EP25 14/-  | FX25 14/-   | Z759 23/-   | 12AT7 6/-   | 2G417 6/-   |
| BT79 57/-    | EF41 12/-  | PY32 10/9   | Z800 20/-   | 12AU7 5/9   | 2N247 9/8   |
| BT89 67/-    | EF50 5/-   | PY33 10/9   | Z801 30/-   | 12AX7 6/3   | 2N555 12/6  |
| C10 20/-     | EF80 4/3   | PY81 5/9    | Z803U 15/-  | 12BA6 6/-   | AC107 10/-  |
| CHL31 16/-   | EF86 6/6   | PY82 4/9    | OA2 6/3     | 12BE6 6/3   | AC127 7/8   |
| CHL35 15/-   | EF89 5/6   | PY83 7/-    | OB2 6/-     | 12E1 20/-   | AC129 6/8   |
| CV5 98/-     | EF91 2/9   | PY800 25/-  | OZ4 4/-     | 12K7G 7/-   | ACY19 6/8   |
| CV74 80/-    | EF92 2/6   | PY800 9/6   | 1CP31 130/- | 12K8GT 8/-  | ACY20 6/-   |
| CV82 50/-    | EF98 15/0  | PY801 9/6   | 1B3GT 7/3   | 12Q7GT 6/-  | ACY21 6/-   |
| CV315 80/-   | EF183 6/6  | PZ30 10/-   | 122 25/-    | 13E1 180/-  | AD140 13/8  |
| CV354 110/-  | EF184 7/-  | QF41 400/-  | 1221 21/8   | 20P4 20/-   | AF114 7/-   |
| CV370 300/-  | EF184 21/- | QQV02/6     | 2C39A 140/- | 24B1 110/-  | AF115 7/-   |
| CV372 57/-   | EF186 8/3  | QQV03/10    | 2C43 70/-   | 25Z3GT 8/-  | AF116 7/-   |
| CV408 50/-   | EH90 7/6   | QQV03/10    | 2E26 20/-   | 25Z6GT 8/8  | AF117 7/-   |
| CV428 45/-   | EL33 12/6  | QQV03/20    | 2K25 180/-  | 27M1 72/8   | BY100 5/8   |
| CV429 350/-  | EL34 10/6  | QQV03/20    | 3A/167M     | 30C15 15/-  | GET671 5/-  |
| CV450 25/-   | EL36 9/3   | QQV04/15    | 3A5 80/-    | 30C17 15/-  | GET876 6/-  |
| CV1144 60/-  | EL41 10/6  | QQV04/15    | 3B24 70/-   | 30P5 17/-   | NKT211 4/-  |
| CV1388 140/- | EL42 10/8  | QQV06-40A   | 3B240M      | 30PL1 15/-  | NKT216 7/8  |
| CV1522 180/- | EL41 9/-   | QQV06-40    | 3B241M      | 30L15 17/-  | NKT217 8/-  |
| CV1526 80/-  | EL44 4/9   | QQV06/40    | 3B241M      | 30L17 17/-  | NKT218 8/-  |
| CV1555 32/8  | EL45 7/9   | QQQ05/10    | 3B29 40/-   | 30P19 15/-  | NKT228 6/-  |
| CV2304 350/- | EL48 8/3   | QQQ05/10    | 3C24 60/-   | 30PL1 15/8  | NKT404 12/8 |
| CV2312 38/-  | EL50 6/6   | Q870/20 5/8 | 3C45 65/-   | 30PL13 18/6 | NKT675 6/-  |
| CV4003 10/-  | EL50 24/-  | Q875/20 5/8 | 3D21A 35/-  | 30PL14 15/- | NKT677 5/-  |
| CV4005 8/-   | EL50 24/-  | Q875/20 5/8 | 3E29 15/-   | 35L6 9/-    | NKT713 7/8  |
| CV4006 18/-  | EL50 24/-  | Q875/20 5/8 | 4C35 300/-  | 35L6GT 9/-  | OC15 20/-   |
| CV4007 7/-   | EL50 24/-  | Q875/20 5/8 | 4CX250B     | 35W4 4/6    | OC20 15/-   |
| CV4014 7/-   | EL50 24/-  | Q875/20 5/8 | 4CX250B     | 35Z4GT 6/6  | OC24 15/-   |
| CV4015 10/-  | EL50 24/-  | Q875/20 5/8 | 4X150A      | 4X150D      | OC25 11/-   |
| CV4024 6/-   | EL50 24/-  | Q875/20 5/8 | 4X150D      | 50C5 6/3    | OC28 7/6    |
| CV4025 7/-   | EL50 24/-  | Q875/20 5/8 | 4X150D      | 50CD6G      | OC28 16/-   |
| CV4031 7/-   | EL50 24/-  | Q875/20 5/8 | 4X150D      | 80 31/-     | OC29 15/-   |
| CV4033 7/-   | EL50 24/-  | Q875/20 5/8 | 4X150D      | 80 31/-     | OC35 11/8   |
| CV4044 12/-  | EL50 24/-  | Q875/20 5/8 | 4X150D      | 85A1 25/4   | OC44 8/-    |
| CV4045 10/-  | EL50 24/-  | Q875/20 5/8 | 4X150D      | 85A2 7/8    | OC45 4/8    |
| CV4046 90/-  | EL50 24/-  | Q875/20 5/8 | 4X150D      | 88L 180/-   | OC71 4/8    |
| CV4048 12/6  | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90A4 45/-   | OC72 6/-    |
| CV4062 17/6  | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C1 12/-   | OC74 8/-    |
| CV4064 30/-  | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C2 25/-   | OC75 6/-    |
| CV4065 12/6  | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C3 25/-   | OC76 8/-    |
| DAF91 4/6    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C4 25/-   | OC78 6/-    |
| DAF96 8/8    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C5 25/-   | OC81 4/-    |
| DCX90 20/-   | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C6 25/-   | OC81D 5/8   |
| DET3 1,000/- | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C7 25/-   | OC82 6/-    |
| DET19 6/8    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C8 25/-   | OC82D 6/-   |
| DET20 2/6    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C9 25/-   | OC83 6/-    |
| DET22 110/-  | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C10 25/-  | OC169 5/-   |
| DET23 110/-  | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C11 25/-  | OC170 7/-   |
| DET24 50/-   | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C12 25/-  | OC171 8/-   |
| DET25 15/-   | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C13 25/-  | OC200 7/6   |
| DF91 4/-     | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C14 25/-  | 8X642 3/8   |
| DF96 7/8     | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C15 25/-  | XA101 3/8   |
| DH63 6/-     | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C16 25/-  | XA111 6/8   |
| DH77 4/9     | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C17 25/-  | XA112 4/6   |
| DK35 7/9     | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C18 25/-  | XA125 5/-   |
| DK91 6/-     | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C19 25/-  | XA141 7/-   |
| DK92 9/-     | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C20 25/-  | XA142 8/-   |
| DK96 7/9     | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C21 25/-  | XA143 8/-   |
| DL66 25/-    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C22 25/-  | TUBES       |
| DL92 6/3     | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C23 25/-  | 1CP31 120/- |
| DL94 8/9     | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C24 25/-  | 2AP1 80/-   |
| DL96 7/8     | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C25 25/-  | 3BP1 65/-   |
| DL810 12/6   | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C26 25/-  | 3DP1 40/-   |
| DL816 30/-   | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C27 25/-  | 3E01 65/-   |
| DL819 30/-   | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C28 25/-  | 3F7 20/-    |
| DY86 6/-     | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C29 25/-  | 3GP1 40/-   |
| DY87 5/-     | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C30 25/-  | 5BP1 80/-   |
| DY88 11/6    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C31 25/-  | 5CP1 55/-   |
| DY89 11/6    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C32 25/-  | 5FP7 35/-   |
| DY90 9/6     | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C33 25/-  | 88L 80/-    |
| E88C0 12/-   | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C34 25/-  | 8SD 200/-   |
| E180F 17/6   | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C35 25/-  | ACR22 80/-  |
| E180F 80/-   | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C36 25/-  | C27A 180/-  |
| E180C 22/8   | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C37 25/-  | CV980 76/-  |
| EAB8C0 6/6   | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C38 25/-  | CV986 35/-  |
| EAF42 10/6   | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C39 25/-  | CV1598 50/- |
| EB91 3/-     | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C40 25/-  | CV1597 50/- |
| EB93 8/6     | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C41 25/-  | CV1588 35/- |
| EB94 10/6    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C42 25/-  | DH3/91      |
| EB95 4/9     | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C43 25/-  | 120/-       |
| EB96 7/6     | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C44 25/-  | E4504/B/16  |
| EBF83 9/-    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C45 25/-  | 76/-        |
| EBF89 8/6    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C46 25/-  | ECR30 35/-  |
| EBL21 12/-   | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C47 25/-  | ECR35 20/-  |
| EBL31 27/6   | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C48 25/-  | MW6-2 80/-  |
| EC033 15/-   | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C49 25/-  | O9D 80/-    |
| EC034 17/6   | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C50 25/-  | O9G 80/-    |
| EC070 15/-   | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C51 25/-  | O9L 80/-    |
| EC081 6/-    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C52 25/-  | VC97R 155/- |
| EC082 6/9    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C53 25/-  | VC97R 155/- |
| EC083 6/3    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C54 25/-  | VC97R 155/- |
| EC085 6/3    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C55 25/-  | VC97R 155/- |
| EC086 5/6    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C56 25/-  | VC97R 155/- |
| EC088 7/6    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C57 25/-  | VC97R 155/- |
| EC089 6/8    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C58 25/-  | VC97R 155/- |
| EC092 6/8    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C59 25/-  | VC97R 155/- |
| EC093 11/6   | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C60 25/-  | VC97R 155/- |
| EC094 12/6   | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C61 25/-  | VC97R 155/- |
| EC095 9/6    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C62 25/-  | VC97R 155/- |
| EC096 9/6    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C63 25/-  | VC97R 155/- |
| EC097 9/6    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C64 25/-  | VC97R 155/- |
| EC098 9/6    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C65 25/-  | VC97R 155/- |
| EC099 9/6    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C66 25/-  | VC97R 155/- |
| EC100 9/6    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C67 25/-  | VC97R 155/- |
| EC101 9/6    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C68 25/-  | VC97R 155/- |
| EC102 9/6    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C69 25/-  | VC97R 155/- |
| EC103 9/6    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C70 25/-  | VC97R 155/- |
| EC104 9/6    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C71 25/-  | VC97R 155/- |
| EC105 9/6    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C72 25/-  | VC97R 155/- |
| EC106 9/6    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C73 25/-  | VC97R 155/- |
| EC107 9/6    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C74 25/-  | VC97R 155/- |
| EC108 9/6    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C75 25/-  | VC97R 155/- |
| EC109 9/6    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C76 25/-  | VC97R 155/- |
| EC110 9/6    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C77 25/-  | VC97R 155/- |
| EC111 9/6    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C78 25/-  | VC97R 155/- |
| EC112 9/6    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C79 25/-  | VC97R 155/- |
| EC113 9/6    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C80 25/-  | VC97R 155/- |
| EC114 9/6    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C81 25/-  | VC97R 155/- |
| EC115 9/6    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C82 25/-  | VC97R 155/- |
| EC116 9/6    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C83 25/-  | VC97R 155/- |
| EC117 9/6    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C84 25/-  | VC97R 155/- |
| EC118 9/6    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C85 25/-  | VC97R 155/- |
| EC119 9/6    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C86 25/-  | VC97R 155/- |
| EC120 9/6    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C87 25/-  | VC97R 155/- |
| EC121 9/6    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C88 25/-  | VC97R 155/- |
| EC122 9/6    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C89 25/-  | VC97R 155/- |
| EC123 9/6    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C90 25/-  | VC97R 155/- |
| EC124 9/6    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C91 25/-  | VC97R 155/- |
| EC125 9/6    | EL50 24/-  | Q875/20 5/8 | 4X150D      | 90C92 25/-  | VC97R 155/- |
| EC           |            |             |             |             |             |

# R.S.C. SENSATIONAL HIGH FIDELITY STEREO 'PACKAGE' OFFERS

Matching as recommended for optimum performance. Compare prices with equipment and cabinets purchased individually.

## 30 Watt Output

★ Goldring Transcription Turntable on Plinth.  
 ★ Shure or Goldring Magnetic Pick-up Cartridge.  
 ★ Super 30 Amplifier in veneered housing.  
 ★ Pair of Stanway II Loudspeaker Units.  
 Special total price. Four fully wired units ready to "plug-in".  
**86 Gns.**  
 Carr. 30/-



'Package' prices apply providing all individual units are purchased from any branch within 3 months (see leaflet).

**30 Watt Output**  
 ★ Garrard SP25 Mk. II Turntable on Plinth.  
 ★ Goldring C590 Ceramic diamond tipped Cartridge.  
 ★ Super 30 Amplifier in veneered housing.  
 ★ Pair of Stanway II Loudspeaker Units.

## Extremely Attractive Plinths

Finished in Teak or Afrormosia veneer. Tinted Transparent Plastic "roll over" cover with handle.  
 Special total price. Four fully wired units ready to "plug-in".

## 13 Watt Output

★ Garrard SP25 Mk. II 4-speed Player Unit, on Plinth. ★ Goldring C590 Ceramic P.U. Cartridge with diamond stylus. ★ TA12 Amplifier in veneered housing. ★ Pair of Dorchester Loudspeaker Units.  
 Special total price. **51 Gns.**  
 Transparent Plastic cover 3 gns extra. **54 Gns.**  
 Terms Dep. £10 and 9 monthly payments £5.11.0 (Total £59.10.0) Carr. 25/-

**13 WATT 'PACKAGE'** as above but with Garrard 3000 and Sonotone 9 TA cartridge in lieu of 46 Gns. 8P25 and C890. Special total price **46 Gns.**  
 Transparent cover 3 gns. extra. Carr. 25/-

## AUDIOTRINE HIGH FIDELITY LOUSPEAKERS

Heavy construction. Latest high efficiency ceramic magnets. Treated Cone surround for low fundamental resonance. "D" indicates Tweeter Cone providing extended frequency range up to 15,000 c.p.s. Exceptional performance at low cost. Impedance 3 or 15 ohms.

Prices include carriage. PLEASE STATE IMPEDANCE

|                 |      |             |     |      |
|-----------------|------|-------------|-----|------|
| HF 510L 5" 10W  | 57/9 | HF 120 32"  | 18W | 79/9 |
| HF 801D 8" 8W   | 89/9 | HF 120D 12" | 15W | 79/9 |
| HF 811D 8" 10W  | 84/4 | HF 126 12"  | 15W | 85/5 |
| HF 102D 10" 10W | 85/- | HF 126D 12" | 15W | 85/5 |
| HF 100D 10" 16W | 85/5 |             |     |      |

**HIGH FIDELITY LOUSPEAKER UNITS**  
 Cabinets of latest styling Satin Teak or Afrormosia veneer. Acoustically lined or filled with woollen damping material. Ported where appropriate. Credit terms available.

**DORCHESTER** Size 16 x 11 x 9in. Appr. Range 45-15,000 c.p.s. Rating 8-10 watts. Pitted High Flux 13 x 8in. Dual cone speaker. Impedance 3 or 15 ohms. Carr. 7/6

**STANWAY II** Size 20 x 10 1/2 x 9 1/2in. Rating 10 watts. Incorporating Fane 13 x 8in. speaker with rubber cone surround and 11,000 line magnet. High flux tweeter. Handsome Scandinavian design cabinet. Range 35-20,000 c.p.s. Impedance 15Ω. Gives smooth realistic sound output. Inc. carr. **16 Gns.**

**GLOUCESTER** Size 25 x 16 x 10 1/2in. High flux 12,000 line speaker. Cross-over unit and Tweeter. Rating 10 watts. Frequency range 40-20,000 c.p.s. Impedance 15 ohms. **12 Gns.**

## R.S.C. TA6 6 Watt HIGH FIDELITY SOLID STATE AMPLIFIER

200-250v. A.C. mains operated Frequency Response 30-20,000 c.p.s. -2dB. Harmonic Distortion 0.3% at 1,000 c.p.s. Separate Bass and Treble 'lift' and 'cut' controls. 3 input sockets for Mike, Gram, Radio or Tape. Input selector switch. Output for 3-15 ohm speakers. Max. impedance 5mV. Output rating I.H.F. 3m. In fully enclosed enamelled case. 9 1/2 x 2 1/2 x 3 1/2in. Attractive brushed silver finish fascia plate 10 1/2 x 3 1/2in. and matching knobs. Complete kit of parts with full wiring diagrams and instructions. Or factory built with 12 months guarantee. **£8.19.9.** Carr. 7/6.

## R.S.C. COLUMN SPEAKERS

Covered in two-tone Rexine/Vynair, ideal for vocalists and Public Address. 15 ohm matching. **TYPE C87** 15 watts inc. five 7 x 4in. spkrs. **£7/19/11.** **TYPE C488** 30 watts. Pitted four 6in. high flux 8 watt speakers. Overall size approx. 42 x 10 x 5in. **18 Gns.** Or deposit **£7/-** and 9 mthly pmts. **34/9** (Total **£18/19/9**). Carr. 10/-.

**TYPE C412S**, 50 watts. Fitted four 12in. 11,000 lines 15 watt speakers. Overall size 56 x 14 x 9in. approx. **26 Gns.** Or deposit **£5/17/6** and 9 monthly payments Carr. 15/- of 54/6 (Total **£50/7/-**).

## R.S.C. TFM1 SOLID STATE VHF/FM RADIO TUNER

Total cost of parts with detailed wiring diagrams and instructions. **14 Gns.**

Inc. Carr. Or factory built 164 gns. Or in Teak finished cabinet as illustrated 181 gns. Terms: Deposit **£5** and 9 monthly payments **£2**. Total **£23**.

★ High-sensitivity ★ 200-250v. A.C. Mains operation. ★ Sharp A.M. Rejection. ★ Drift-free reception. ★ Output ample for any amplifier (approx. 500 m.v.). ★ Simple alignment instructions. ★ Output available for feeding tuning meter. ★ Output for feeding Stereo Multiplexer. Tuner head made of silicon Planar Transistors. ★ Designed for standard 80 ohm co-axial input.

CONTROLS: 5-position Input Selector, Bass, Treble, Vol., Bal., Stereo/Mono Sw., Tape Monitor Sw., Mains Sw.

INPUT SOCKETS: (1) P.U. (2) Tape Amp. (3) Radio (4) Mic. or Tape Head. (Operation of Input Selector assures appropriate equalisation.)

CHASSIS: Strong Steel construction. Approx. 12 x 3 x 8 in.

FACE PLATE: Attractive design in rigid Perspex. 8pin silver matching control knobs available.

## AUDIOTRINE HI-FI SPEAKER SYSTEMS

Consisting of matched 12in. 11,000 line 15 watt 15 ohm high quality speaker, cross-over unit and tweeter. Smooth response and extended frequency range ensure surprisingly realistic reproduction.

(4) High efficiency tweeter. (5) Wooten acoustic damping material. (6) Teak veneered cabinet. (7) Circuit and full instructions. **HEAR IT AT ANY BRANCH**

**SE10** For optimum performance with any 8in. Hi-Fi speaker. 22 x 15 x 9in. Ported **£5.10**

**SE10** For outstanding results with 10in. Hi-Fi speaker. 24 x 15 x 10in. Ported **£5.15**

**SE12** For high performance with 12in. Hi-Fi speaker and Tweeter. Size 25 x 16 x 10 1/2in. Pressurised. **£6.15**

**HI-FI 'SPEAKER ENCLOSURES**  
 Teak or Afrormosia veneer finish. Modern design. Acoustically lined. Prices inc. carr.

**TE8** Size 16 x 11 x 9in. Pressurised. Gives pleasing results with any 8in. Hi-Fi speaker. **£4.10**

**SE8** For optimum performance with any 8in. Hi-Fi speaker. 22 x 15 x 9in. Ported **£5.10**

**SE10** For outstanding results with 10in. Hi-Fi speaker. 24 x 15 x 10in. Ported **£5.15**

**SE12** For high performance with 12in. Hi-Fi speaker and Tweeter. Size 25 x 16 x 10 1/2in. Pressurised. **£6.15**

## THE 'YORK' HIGH FIDELITY 3'SPEAKER SYSTEM

\* Moderate size approx. 25 x 14 x 10 in. \* Range 30-20,000 Complete kit. c.p.s. Impedance 15 ohms. \* Performance comparable with units costing considerably more. Consists of (1) 12 in. 15 watt Bass unit with cast chassis, Roll rubber cone surround for ultra low resonance, and ceramic magnet. (2) 3-way quarter section series cross-over system. (3) 8 x 5 in. high flux middle range speaker (4) High efficiency tweeter. (5) Wooten acoustic damping material. (6) Teak veneered cabinet. (7) Circuit and full instructions. **20 Gns.**

## R.S.C. A10 30 WATT ULTRA LINEAR HI-FI AMPLIFIER

Highly sensitive. Push-Pull high output, with Pre-amp/Tone Control Stages. Performance figures: Hum level -70dB. Frequency response ±3dB 30-20,000 c.p.s. Sectionally wound output transformer. All high grade components. Valves EP86, EP86B, ECC83, 807, 807, GZ34. Separate Bass and Treble Controls. Sensitivity 36 millivolts. Suitable for High Impedance mic. or pick-ups. Designed for Clubs, Schools, Theatres, Dance Halls or Outdoor Functions, etc. For use with Electronic Organ, Guitar, String Bass, etc. Gram, Radio or Tape. Reserve L.T. and H.T. for Radio Tuner. Two inputs with associated volume controls so that two separate inputs such as Gram and Radio, 200-250 v. 50 c/s. A.C. mains. For 3 and 15 ohm speakers. Complete kit parts wiring diagrs. instructions. Twin-handled perforated cover 27/6. Or factory built with EL34 output valves and 12 months guarantee for 18 Gns. Tech. gns. apply to factory built units. Carr. 12/6. **15 Gns.**

TERMS: Deposit **£8.3.0** and 9 monthly payments of **34/-** (Total **£21/9/0**). Send S.A.E. for leaflet.

## INTEREST CHARGES REFUNDED

On Credit Sales settled in 3 months.

## R.S.C. A11 HIGH FIDELITY 12-14 WATT AMPLIFIER

Push-pull ultra linear output "built-in" tone control pre-amp. Two input sockets with associated controls allowing mixing of "mike" and gram, etc. etc. High sensitivity. 5 valves - ECC83 (2), EL84 (2), E81. High quality sectionally wound output transformer. Bass AND TREBLE CONTROLS. Frequency response ±3dB 30-20,000 c.p.s. Hum level -60dB. SENSITIVITY 40 millivolts. For Crystal or Ceramic P.U.s. High Impedance "mikes". For Musical Instruments such as String Bass, Electronic Guitars, etc. etc. Output **9 1/2 Gns.**

Size approx. 12 x 9 x 7in. For A.C. mains 200-250v. 50 c/s. Complete kit **9 1/2 Gns.**

Full instructions and point-to-point wiring diagrams. Carr. 11/6 (or factory built 12) Gns. Twin handled metal cover 27/6. Terms on assembled units. Deposit **£9/6** and 9 monthly payments of **25/-**. (Total **£15/6/8**). RSC A11T transistorised version of above complete kit **9 Gns.** (Assembled 13 gns.)

## R-S-C TA12 13 WATT STEREO AMPLIFIER

FULLY TRANSISTORISED, SOLID STATE CONSTRUCTION HIGH FIDELITY OUTPUT OF 6.5 WATTS PER CHANNEL

Designed for optimum performance with any crystal or ceramic Gram P.U. cartridge. Radio tuner, Tape recorder, "Mikes" etc.

★ 3 separate switched input sockets on each channel ★ Separate Bass and Treble controls ★ Slide Switch for mono use ★ Speaker Output 3-15 ohms ★ For 200-250 v. A.C. mains ★ Frequency Response 30-20,000 c.p.s. -2dB ★ Harmonic Distortion 0.3% at 1000 c.p.s. Hum and Noise 100 m.v. Mks. 5 m.v. -Tape Head 2.5 m.v.

★ 70dB ★ Sensitivity (1) 300 mV (2) 60 mV (3) 10 mV (4) 2 mV ★ Handsome brushed silver finish Facia and Knobs. Output rating I.H.F. 3m. Complete kit of parts with full wiring diagrams and instructions. **121 Gns.** Carr. 7/6. Factory built with 12 mth. gntee. **16 Gns.** Or Dep. **£5/2/6** and 9 mthly pmts. **31/6** (Total **£19/6/0**). Or in Teak or Afrormosia veneer housing **191 Gns.** or **£25/10/6** and 9 mthly pmts. **39/-** (Total **£23/11/6**).

## R.S.C. BATTERY/MAINS CONVERSION UNITS

Type BM1. An all-dry battery eliminator. Size 8 1/2 x 4 1/2 in. approx. Completely replaces batteries supplying 1.5 v. and 90 v. where A.C. mains 200-250 v. 50 c/s. is available. Complete kit with diagram 52/6 or. Ready for use. **3 Gns.**

**SELENIUM RECTIFIERS**  
 P.W. Bridged 612v. D.C. Output Input Max. 18v. A.C. 1a. 4/3; 1.5a. 5/8; 2a. 6/11; 3a. 9/9; 4a. 12/9; 6a. 15/9.

## R.S.C. MAINS TRANSFORMERS

FULLY GUARANTEED. Interleaved and Impregnated. Primaries 200-250 v. 50 c/s. Screened

**MIDGET CLAMPED TYPE 2x 2 1/2 x 2 1/2in.**

|                             |       |
|-----------------------------|-------|
| 250 v. 60 mA. 4.3 v. 2 a.   | 17/11 |
| 250-0-250v. 60mA. 6.3v. 2a. | 18/11 |

**FULLY SHROUDED UPRIGHT MOUNTING**

|                              |       |
|------------------------------|-------|
| 250-0-250v. 80mA. 6.3v. 2a.  | 24/9  |
| 200-0-250v. 100mA. 6.3v. 4a. | 39/9  |
| 300-0-300v. 100mA. 6.3v. 4a. | 39/9  |
| 300-0-300v. 130mA. 6.3v. 4a. | 47/11 |
| For Mullard 510 Amplifier    | 47/11 |
| 300-0-350v. 100mA. 6.3v. 2a. | 29/9  |
| 300-0-350v. 150mA. 6.3v. 4a. | 47/8  |
| 425-0-425v. 200mA. 6.3v. 4a. | 89/9  |
| 425-0-425v. 200mA. 6.3v. 4a. | 93/9  |
| 425-0-425v. 250mA. 6.3v. 4a. | 99/9  |

## TOP SHROUDED DROP-THROUGH TYPE

|                              |       |
|------------------------------|-------|
| 250-0-250v. 70mA. 6.3v. 2a.  | 25/9  |
| 250-0-250v. 100mA. 6.3v. 3a. | 27/9  |
| 250-0-250v. 100mA. 6.3v. 2a. | 28/9  |
| 250-0-350v. 80mA. 6.3v. 2a.  | 29/11 |
| 200-0-250v. 100mA. 6.3v. 4a. | 39/9  |
| 300-0-300v. 100mA. 6.3v. 4a. | 39/9  |
| 300-0-300v. 130mA. 6.3v. 4a. | 39/9  |

Suitable for Mullard 510 Amplifier **46/9**

|                              |       |
|------------------------------|-------|
| 300-0-350v. 100mA. 6.3v. 4a. | 39/9  |
| 350-0-350v. 150mA. 6.3v. 4a. | 46/11 |

**FILAMENT or TRANSISTOR POWER PACK TYPES**

|   |
|---|
| 6.3 v. 1.5a. 9/9; 6.3v. 2a. 9/9; 6.3v. 3a. 13/9; 6.3v. 4a. 22/9; 12v. 1a. 9/11; 15v. 3a. or 24v. 1.5a. 23/9; 0-9-18v. 1.5a. 19/11; 0-12-25-42v. 2a. 31/9. |
|---|

**CHARGER TRANSFORMERS 0-9-15v. 1.5a. 18/9; 2 1/2a. 19/11; 3a. 21/11; 4a. 25/11; 5a. 29/9; 6a. 36/9.**

**AUTO Step Up/Step Down TRANSFORMERS**

|  |      |
|--|------|
| 0-110/120v. 200-250v. 50-80 watts                | 19/9 |
| 100 watts, 33/6; 250 watts 49/9; 500 watts 105/- |      |

## R.S.C. SUPER 30 MKII HIGH FIDELITY STEREO AMPLIFIER

**HIGH GRADE COMPONENTS. SPECIFICATIONS COMPARABLE WITH UNITS COSTING CONSIDERABLY MORE**

Employing Twin Printed Circuits 200/250v. A.C. mains operation.

**TRANSISTORS:** 9 high-quality per channel. **OUTPUT:** 10 Watts R.M.S. continuous into 15Ω (Per channel) 15 Watts R.M.S. continuous into 3Ω

**INPUT SENSITIVITIES:** Mag. P.U. 4 m.v. Ceramic P.U. 35 m.v. Tape Amp. 400 m.v. Aux. 100 m.v. Mks. 5 m.v. -Tape Head 2.5 m.v.

**FREQUENCY RESPONSE:** ±2dB. 10-20,000 c.p.s.

**TREBLE CONTROL:** +17dB to -14dB at 10K/c/s.

**BASS CONTROL:** +17 dB to -14dB at 10 c/s.

**HUM LEVEL:** -80 db.

**HARMONIC DISTORTION:** 0.1% at 10 Watts 1,000 c.p.s.

**CROSS TALK:** 52 dB at 1,000 c.p.s.

**COMPLETE KIT OF PARTS, point to point wiring diagrams and detailed instructions. 22Gns.**

Carr. 15/-

**EMINENTLY SUITABLE FOR USE WITH ANY MAKE OF PICK-UP OR MIC. (Ceramic or Magnetic Moving Coil, Ribbon or Crystal.) CURRENTLY AVAILABLE. SUPERB SOUND OUTPUT QUALITY CAN BE OBTAINED BY USE WITH FIRST-RATE ANCILLARY EQUIPMENT. Unit factory built 28 Gns. or Deposit 27/5/- and 9 mthly. payments 5/6/3 (Total £32/11/3) or in Teak or Afrormosia veneer housing 31 Gns. Carr. 15/-. Terms: Deposit 27/3/6 and 9 mthly. payments 64/- (Total £35/19/6) Send S.A.E. for leaflet.**

## R.S.C. SUPER 15 HIGH FIDELITY AMPLIFIER

Solid state. Approx. as Super 30 but single channel. Complete kit with full constructional details and point to point wiring diagrams. **12 1/2 Gns.**

Carr. 12/6.

Or factory built: 151 Gns. Carr. 12/6. Terms: Deposit 4 Gns. and 9 monthly payments 31/1 (Total £18/3/9) or in Teak or Afrormosia veneered housing 19 Gns.

**BRADFORD** 10 North Parade (Half-day Wed.). Tel. 25349

**BLACKPOOL** (Agent) O & C Electronics 227 Church St.

**BIRMINGHAM** 30/31 Gt. Western Arcade. Tel. 021-236 1279. Half-day Wed.

**DERBY** 26 Osmaston Rd. The Spot (Half-day Wed.). Tel. 41361

**DARLINGTON** 18 Priestgate (Half-day Wed.). Tel. 68043

**EDINBURGH** 133 Leith St. (Half-day Wed.). Tel. Waverley 5766

**GLASGOW** 326 Argyle St. (Half-day Tues.). Tel. CITY 4158

**HULL** 91 Paragon Street (Half-day Thurs.). Tel. 20505

**R.S.C. HI-FI CENTRES LTD.**

MAIL ORDERS to: 102-106 Henconner Lane, Bramley, Leeds 13. No C.O.D. under £1. Terms C.W.O. or C.O.D. Postage 4/6 extra under £2. 5/9 extra under £5. Trade supplied. S.A.E. with enquiries please. Open all day Sats. MAIL ORDERS MUST NOT BE SENT TO SHOPS.

32 High Street (Half-day Thurs.). Tel. 56420 **LEICESTER**

5-7 County (Mecca) Arcade, Briggate (Half-day Wed.) Tel. 28252 **LEEDS**

73 Dale St. (Half-day Wed.). Tel. CENTRAL 3573 **LIVERPOOL**

238 Edgware Road, W.2 (Half-day Thurs.). Tel. PAD 1629 **LONDON**

60A Oldham Street (Half-day Wed.). Tel. CENTRAL 2778 **MANCHESTER**

106 Newport Rd. (Half-day Wed.). Tel. 47096 **MIDDLESBROUGH**

41 Blakett Street (opp. Fenwicks Store) (Half-day Wed.). Tel. 21469 **NEWCASTLE UPON TYNE**

13 Exchange Street (Castle Market Bldgs.) (Half-day Thurs.). Tel. 20716 **SHEFFIELD**

**Record Playing Units MONEY SAVING UNITS Ready to plug into Amplifier.**

**RP2C** Consisting of Garrard SP25 Mk. II (with heavy turntable fitted Goldring C890 high compliance ceramic Stereo/Mono cartridge with diamond stylus. Mounted on plinth. Transparent plastic cover included. **22 Gns.**

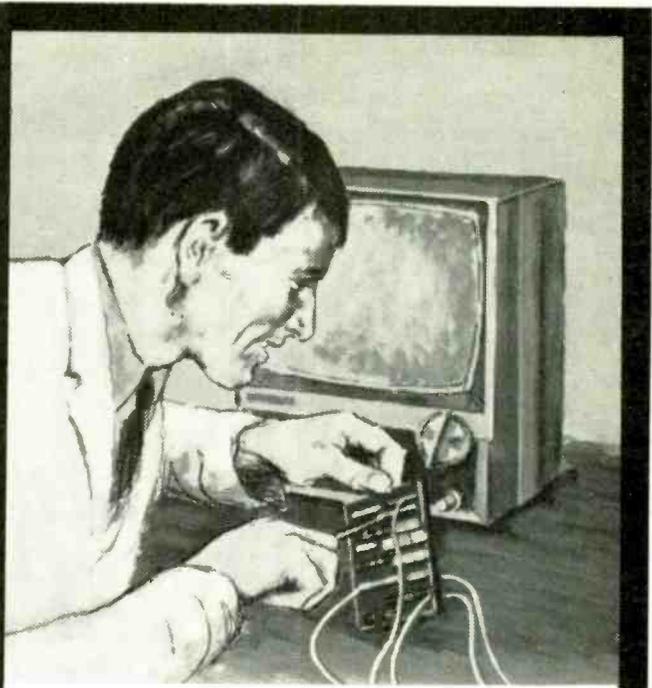
**RP3C** As above but with Goldring Lenco GL48 Transcription unit and C890 Cartridge. Cover included. Inc. carr. **28 Gns.**

**Various other types** with Magnetic P.U. Cartridges and "Lift off" or "Roll over" transparent covers at lowest prices.

**R.S.C. PLINTHS** for Record Playing units. Out for Garrard 1025, 2025, 3000, 3000, 59/9 AT60, 8P25 etc. etc. Available with Transparent plastic cover. Inc. carr. **6 Gns.**

**1 WATT TRANSISTOR AMPLIFIERS** Miniature size battery operated For 3-5Ω 1/2speakers. Brand new boxed. **7/9**

|   |   |   |
|---|---|---|
| <p><b>POWER TRANSISTORS</b> Ex Eupt. Sim. to OC28. 4 for 10/- p. &amp; p. 1/- 100 for £10. Post free</p>  | <p>750µH inductors 5/- doz. <b>THERMOSTATS.</b> 1" x 1" x 1 1/4". O.C. above 120°F. 1 1/2a. 250v. 5/- ea.</p> | <p><b>DESK TELEPHONES</b></p>  |
| <p><b>REED SWITCHES</b><br/>Glass encased, switches operated by external magnet—gold welded contacts. <b>Miniature.</b> 1in. long x approximately 1in. diameter. Will make and break up to 1A, up to 300 volts. Price 2/6 each. 24/- dozen.</p>   |   |   |
| <p><b>MINIATURE GLASS NEONS 12/6 doz.</b></p>   |   |   |
| <p><b>TRIM POTS</b> on 2" x 4" bds. + Ta. caps. and other components. 100Ω, 500Ω, 15K, 20K. Please state requirements. 5 for 10/- + 2/- p. &amp; p.</p>   |   |   |
| <p><b>THIS MONTH'S SNIP</b><br/>9 OA5, 3 OA10, 3 Pot Cores, 26 Resistors, 14 Capacitors, 3 GET 872, 3 GET 872B, 1 GET 875. All long leaded on panels 13" x 4". 2 for 10/- p. &amp; p. 1/6d. 4 for 20/-. Post free.</p>  |   |   |
| <p><b>COMPUTER PANELS</b> 2in. x 4in. 10 for 10/- + 1/6 p. &amp; p. Min. 35 transistors; 25 for £1 p. &amp; p. 3/6. min. 85 transistors; 100 for 65/- p. &amp; p. 6/8. min. 350 transistors; 1,000 for £30 + carr.</p>  |   |   |
| <p><b>GIANT PANELS</b> 5 1/2" x 4" min. 20 transistors 9 x 56 µH. Inductors, resistors, capacitors etc. 3 for £1 + 2/- p. &amp; p. As above, only 21 transistors, 70 diodes, 62 min. 1/10thW resistors, 3 for 25/- p. &amp; p. 2/-</p>  |   |   |
| <p><b>LARGE CAPACITY ELECTROLYTICS.</b> 4in., 2in. diam. Screw terminals. Top quality German manufacture. Will withstand short circuit discharge.<br/>4,000µF 72V d.c. wkg. 7/6<br/>6,300µF 72V d.c. wkg. 7/6<br/>16,000µF 12V d.c. wkg. 6/-<br/>1 1/2" x 4 1/2" screw terminals—<br/>2,500µF 55V d.c. wkg. 6/- ea.</p> |   |   |
| <p>0.22 MFD 250V POLYESTERS 5/- doz.<br/>2.2 MFD 50V TANTALUM 10/- doz.<br/><b>NEW PLESSEY CAPS</b><br/>1" x 3" 2000µF 25V d.c. 6/- each.<br/>1 1/2" x 4 1/2" 500µF 55V d.c. wkg. 8/- each.</p>   |   |   |
| <p>250 Resistors 1 and 1/2 watt. 12/6<br/>150 Hi-Stab Resistors, 1/2 and 1 watt 12/6</p>  |   |   |
| <p><b>DIODES EX EQPT SILICON</b><br/>150 PIV 10Amp 4 for 10/-<br/>150 PIV 20Amp 4 for 20/-</p> <p><b>KEYTRONICS,</b><br/>52 Earls Court Rd., London, W.8<br/>Tel. 01-478 8499<br/><b>MAIL ORDER ONLY.</b> Retail and Trade supplied. Export enquiries particularly welcome.<br/>S.A.E. FOR LIST</p>                     |   |   |



## Train for tomorrow's world in Radio and Television at The Pembridge College of Electronics.

The next full time 16 month College Diploma Course which gives a thorough fundamental training for radio and television engineers, starts on 1st January 1970.

The Course includes theoretical and practical instruction on Colour Television receivers and is recognised by the Radio Trades Examination Board for the Radio and Television Servicing Certificate examinations. College Diplomas are awarded to successful students.

The way to get ahead in this fast growing industry—an industry that gives you many far-reaching opportunities—is to enrol now with the world famous Pembridge College. Minimum entrance requirements: 'O' Level, Senior Cambridge or equivalent in Mathematics and English.

To: The Pembridge College of Electronics  
(Dept. WW11), 34a Hereford Road, London, W.2  
Please send, without obligation, details of the Full-time Course in Radio and Television.

NAME .....

ADDRESS .....

.....

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.....

# computer engineering

NCR requires additional ELECTRONIC, ELECTRO MECHANICAL ENGINEERS and TECHNICIANS to maintain medium to large scale digital computing systems in London and provincial towns.

Training courses will be arranged for successful applicants, 21 years of age and over, who have a good technical background to ONC/HNC level, City and Guilds or radio/radar experience in the Forces.

Starting salary will be in the range of £900/£1,250 per annum, plus bonus. Shift allowances are payable, after training, where applicable. Opportunities also exist for Trainees, not less than 19 years of age, with a good standard of education, an aptitude towards and an interest in, mechanics, electronics and computers.

*Excellent holiday, pension and sick pay arrangements. Please write for Application Form to Assistant Personnel Officer*  
NCR, 1,000 North Circular Road,  
London, NW2  
quoting publication and month of issue.

Plan your future with **NCR**

# APPOINTMENTS VACANT

**DISPLAYED SITUATIONS VACANT AND WANTED:** £7 per single col. inch.  
**LINE advertisements (run-on):** 8/- per line (approx. 7 words), minimum two lines.  
Where an advertisement includes a box number (count as 2 words) there is an additional charge of 1/-.  
**SERIES DISCOUNT:** 15% is allowed on orders for twelve monthly insertions provided a contract is placed in advance.  
**BOX NUMBERS:** Replies should be addressed to the Box number in the advertisement, c/o Wireless World, Dorset House, Stamford Street, London, S.E.1.  
No responsibility accepted for errors.

Advertisements accepted up to **DECEMBER 5** for the **JANUARY** issue, subject to space being available.

## REDIFFUSION

### COLOUR TELEVISION FAULTFINDERS & TESTERS

We have a number of vacancies in our Production Test Departments for experienced faultfinders and testers.

Knowledge of transistor circuitry and experience with Colour Receivers together with R.T.E.B. Final Certificate or equivalent qualifications required.

These will be staff appointments with all the expected benefits.

Applications to:

**Works Manager,  
Rediffusion Vision Service Ltd.,  
Fullers Way South,  
Chessington, Surrey (near Ace of Spades).  
Phone: 01-397 5411**

83

## Telecommunications Engineer

The above vacancy exists in the Scottish division of a large engineering company operating a number of establishments in the West of Scotland, in addition to factories throughout the United Kingdom. The successful candidate, who will operate from the Glasgow office, will be responsible to the Chief Electrical Engineer for planning, implementing and maintaining the rapidly expanding communications network throughout the Scottish factories.

Applicants should have experience in the operation and maintenance of H/F carrier systems, automatic telephone exchange installations and switching networks. A knowledge of data, facsimile and teleprinter transmission and P.A. systems would be an advantage.

Qualifications required are a degree, H.N.C., or C. & G. Full Technological Certificate in Telecommunications.

*All applications are confidential and will be acknowledged. If already employed by our client applicants name will not be divulged without permission. Applicants should indicate any company to whom they do not wish their applications forwarded. Please give details of age, experience and qualifications to Ref. 13186/53.*

Name and address in block capitals please.

**S & M SELECTION, 216 BOTHWELL STREET, GLASGOW, C.2.**

2610

## ELECTRONIC ENGINEERS

Vacancies exist in the Test Gear Department at West Leigh for Electronics Test Gear Engineers capable of full design responsibility, manufacture and delivery to the production floor. Products include sophisticated airborne communication equipment, automatic production test equipment and equipment employed in testing many of the Company's electronic components.

Qualifications should include H.N.C. but consideration will be given to applicants with equivalent experience.

Please apply in writing giving full particulars to the Personnel Officer, The Plessey Company Limited, Martln Road, West Leigh, Havant. Hampshire quoting ref. HAV/180/6

2634

An immediate vacancy occurs at  
**THE WIRELESS COLLEGE  
COLWYN BAY, NORTH WALES**

for an additional instructor to assist in preparing students for P.M.G./M.P.T. examinations. The primary responsibility will be the practical instruction on modern marine radio equipment. Applicants must hold a P.M.G. Certificate and should have a sound technical knowledge. Recent marine operating and/or teaching experience is desirable but not essential.

Write in the first instance to the Principal. 2622

### BBC

#### TRANSMITTER PLANNING AND INSTALLATION DEPARTMENT

#### requires ENGINEER

for work in connection with the planning, installation and commissioning of VHF and UHF transmitting stations. Duties will include assisting in the preparation of specifications, negotiations with manufacturers, liaison with other BBC Departments and acceptance tests on equipment.

The successful candidate may be a member of a team of several engineers each dealing with a particular aspect of a project or projects or he may be directly responsible for smaller projects. He may, alternatively, be responsible for supervising the work of installation technicians and/or transmitter mechanics.

Candidates must be qualified engineers and have had several years' experience of work on UHF and VHF transmitters. They should preferably be Chartered Engineers and a university degree or equivalent would be an advantage.

Commencing salary £2,030 p.a. to £2,238 p.a. in a scale having a maximum of £2,550 p.a. Request for application form to The Engineering Recruitment Officer, BBC, Broadcasting House, London W1A 1AA quoting reference 69.E.2287 W.W. 2620

## EAST AFRICAN POSTS AND TELECOMMUNICATIONS CORPORATION

# ASSISTANT ENGINEERS

## GRADE 1

to serve on contract for one tour of 24 months in the first instance. Basic salary E.A. Shgs. 24300 (£ Stg. 1417) a year rising to E.A. Shgs. 27780 (£1620) a year plus an Inducement Allowance, normally tax free, of £822 - 886 a year, paid direct into officer's bank in the U.K. Gratuity 25% of total emoluments drawn. Liberal paid leave. Furnished accommodation. Overseas Installation Grant. Free passages. Contributory pension scheme available in certain circumstances.

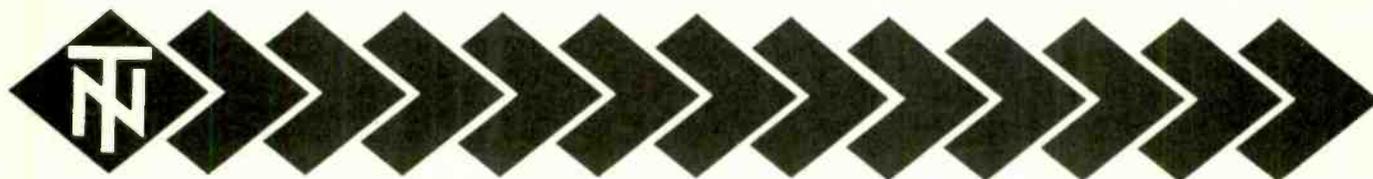
Candidates, 28-45 years, should possess the City and Guilds Intermediate Certificate (Telecomms.) plus a pass in Radio Grade 2 and must have a thorough knowledge of the installation and maintenance of HF and VHF radio equipment. A know-

ledge of microwave, carrier and telegraph equipment would be an advantage.

Selected officers' duties will be connected with the installation and maintenance of radio stations, and will involve travelling to outlying stations at a considerable distance from their headquarters, sometimes for periods of a week or more.

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/690815/WF.

2650



COMPUTER-CONTROLLED  
SWITCHING SYSTEMS

**PhD MSc BSc** in physics  
or electronics

**Dr.-Ing. Dipl.-Ing.**

Applicants experienced in  
**Hardware design**  
**Circuit design**  
**System analysis**  
**Switching systems**

will be given special tasks and rising chances.  
Experts in the cited fields achieve excellent salaries.  
The laboratories are located in Düsseldorf (Rheinland),  
Frankfurt (Main) or Munich.  
Knowledge of the German language is not required.

Send short form application to: D 6 Frankfurt (Main), Mainzer Landstraße 134-146

**TELENORMA ENTWICKLUNGS-GESELLSCHAFT MBH**

# CONTINUOUS EXPANSION

Standard Telephones & Cables, Microwave and Line Division based at Basildon are growing fast. In order to keep pace with this consistent growth rate we require the following

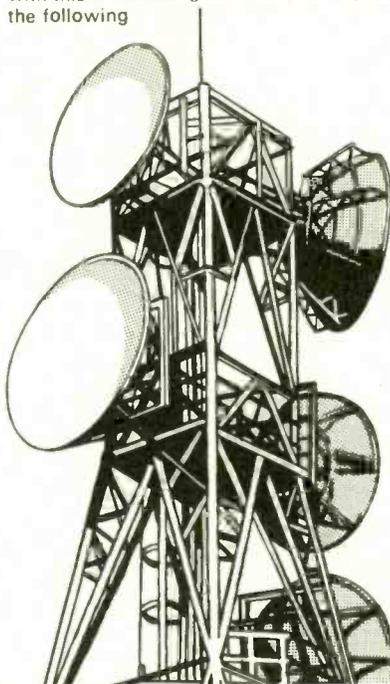
## Installation Engineers Technicians & Testers

Ref. 25720

To test and commission Multiplex, Co-axial Line and Microwave Radio Systems.

Ideal candidates will be less than 45 years of age with practical experience on some of the above equipment. These challenging posts call for drive, initiative and common sense. It is necessary for applicants to be prepared to work anywhere in the U.K.

*Applications should be addressed to*  
**The Personnel Officer,**  
**STC Chester Hall Lane,**  
**Basildon, Essex.**



## Test Technicians

Ref. 27221

The diversity of products manufactured at the Basildon Plant demands experienced testing staff for work on complex transmission systems.

Candidates should hold an ONC in electrical engineering and be able to offer considerable practical experience in the field of testing and fault clearing all types of land-unit, pcm and microwave equipment.

# STC

91

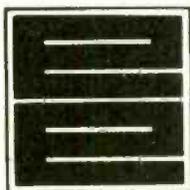
# R/F TEST ENGINEERS

Engineers are required for final test of Solid State R/F prototype and pre-production equipment operating at U.H.F. and microwave frequencies.

These positions would be ideally suitable to ex service radio/radar personnel or test engineers with experience in the use of R/F/Microwave test equipment and a knowledge of transistorised circuitry.

The Company offers first class holiday, sick payments and welfare facilities including an excellent group pension and insurance scheme.

*Please apply in writing to:*



**Personnel Officer,**

# Ether Engineering Ltd

**Park Avenue, Bushey, Herts. Phone: Watford 28566.**

2655

**NADGECO****AN INTERNATIONAL COMPANY  
ENGAGED ON WORK FOR NATO****ELECTRONICS SYSTEM Q.C. ENGINEER**  
**For field assignment in DENMARK**

*We are an international Company engaged on the design and installation of a complex computerised air defence system with sites throughout the European NATO countries. For the forthcoming installation phase of our project we require the services of a Quality Control Engineer for a period of about 18 months, to supervise the standard of installation (and time schedules) for the sites throughout Denmark.*

*We expect the ideal candidate to have good systems engineering experience backed by the appropriate qualifications. In addition he will be capable by way of some previous experience of implementing quality control and inspection procedures. It is obvious that previous radar and communications or site systems integration work would be a distinct advantage.*

*Although the job is by nature short term a career minded engineer will gain not only good experience in this field but would also be able to establish good working relations with senior colleagues within the international electronic industry.*

*Applicants and their families should be completely mobile and able to take up residence in Copenhagen within 2 months of joining the Company.*

*Salary and overseas allowances, which reflect the short term nature of the employment will be in the region of £4,000 p.a.*

*Applications giving concise details of experience and qualifications to:*

**R. A. Rich, Deputy Personnel Manager, Nadgeco Ltd., 98 The Centre, Feltham, Middlesex.**

*We are a division of one of the world's leading manufacturers of precision electronic test and measuring equipment, and we are looking for a*

**HEWLETT  PACKARD****TECHNICAL WRITER**

*to join our technical publications staff. We are thinking of a maintenance or service technician with a sound practical background in electronics and the ability to think and write clearly and logically. Some knowledge of the German language would be an asset, but is by no means a prerequisite.*

*We offer an attractive salary, outstanding benefits, and the attraction of a very favourable geographic location. Please apply to the Personnel Manager of*

**Hewlett-Packard GmbH, 7030 Böblingen, Herrenberger Str. 110, Germany, Tel.: (07031) 667 205.**

# GOVERNMENT OF ZAMBIA

REQUIRES

## GROUND ENGINEER [Radio/Electrical]

for the Government Flight Department, Ministry of Power, Transport and Works, on contract for one tour of 36 months in the first instance. Commencing salary according to experience in scale Kwacha 3408 rising to Kwacha 4056 a year (approx. £Stg. 1988 - 2366), plus an Inducement Allowance of Kw. 1002 - 774 (approx. £Stg. 585 - 452) a year. A Direct Payment of £291 is also payable direct to the officer's bank in the U.K. Gratuity 25% of total salary drawn. Both Gratuity and Direct Payment are normally TAX FREE. Free passages. Quarters at moderate rental. Children's education allowances. Liberal leave on full salary or terminal payment in lieu.

Candidates, preferably under 50 years of age, must

have the minimum qualification of Radio 'A' licence. Preference will be given to candidates holding electrical 'X' group 9. 1, with experience on American V.H.F. VOR. H.F, and possessing a Radio 'B' licence.

The officer will be required to work on Piper Aztec type aircraft and to carry out the maintenance of the radios of the Government Communication Flight Aircraft.

**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 MzZ/680906/WF**

2651

## V.H.F. TELEVISION RELAY & COMMUNAL AERIAL SYSTEMS

We are planning a considerable expansion of our activities and have the following vacancies:

### I. A SENIOR ENGINEER

to have control of all aspects of systems design, planning, estimating, installation and commissioning.

### II. ENGINEERS

capable of undertaking either:

- (a) System planning and estimating.
- (b) control of installation work.

or (c) test and commissioning duties.

Candidates for these appointments must have a good background of practical experience in this field of work, and an up-to-date knowledge of techniques and equipment.

Applications, which will be treated in strict confidence, should be sent to:

**BRITISH RELAY**

The General Manager,  
Special Services Division,  
British Relay House,  
41, Streatham High Road, S.W.16

2654

### HENRY'S RADIO LTD.

303 EDGWARE ROAD, LONDON, W.2  
HAVE THE FOLLOWING VACANCIES  
IN THEIR ORGANISATION

#### SALES ASSISTANTS

Young man with good general knowledge of electronic components required for our retail sales dept. Please telephone 723-1008/9 ext. 1.

#### SALES ASSISTANTS

Young man with a good general knowledge of HIGH FIDELITY EQUIPMENT required for our retail HI-FI SALES DEPT. Please contact MR. STEVENS, Telephone 723-6963. 2585

The Middlesex Hospital Medical School  
Cleveland Street, London W1

Department of Physiology

### ELECTRONIC TECHNICIAN

required for maintenance and further development of wide range of electronic equipment for medical teaching and research. Well equipped electronic workshop, opportunities for developing own ideas.

Salary scale: £1025-£1285.

Applications stating age, qualifications, experience and availability for interview, to the Secretary, Department of Physiology, The Middlesex Hospital Medical School, London W1P 6DB.

2632

## SUPERINTENDENT AVIONICS

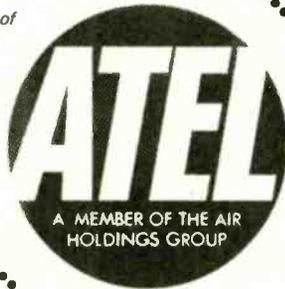
This is a new appointment in the Component Overhaul Division with responsibility to the Divisional Manager for the administration and technical control of the avionics section. This section comprises electrical instrument and radio overhaul workshops and it is desirable, therefore, that candidates have a minimum of 10 years' experience in the avionics components industry, preferably in a supervisory capacity. H.N.C. or equivalent in an appropriate discipline. Age range 30-40.

The Company is a member of the important Air Holdings Group and has wide interests ranging from aircraft maintenance and conversions to freight and baggage handling equipment.

The salary is good with commencement open to negotiation. Benefits include Pension Scheme, Free Life Assurance and participation in a productivity bonus scheme.

Applications with brief details of experience and qualifications to:

The Personnel Officer,  
Aviation Traders (Engineering) Limited,  
Southend Airport,  
Southend-on-Sea, Essex.



## Go places as a Computer Service Engineer

Men under 35 with experience in light engineering and electronics can build excellent careers in ICL servicing computers.

We want qualified men with HNC or C & G in electronics engineering, or a Forces training in electronics. Or, perhaps, you have a similar qualification which proves you have the serious interest in the subject necessary for further specialist training.

We pay realistic salaries while you train—about six months—on ICL equipment, learning how to sort out operational problems and maintain computers in peak condition.

You will have to take responsibility for highly sophisticated and expensive equipment, so if you have a worthwhile career in mind, here is the chance to apply your expertise and initiative to the full. Career progression and promotion are limited only by your ability.

On top of your basic salary we pay generous overtime and shift rates, plus travelling expenses. Working conditions in ICL are well above the average in industry.

Write giving brief details of your career, quoting reference WW 103 C.  
A. E. Turner, International Computers Limited,  
85/91 Upper Richmond Road, Putney, London SW15.

# Glaxo

## TECHNICAL ASSISTANT

### Instrumentation Investigation

This position involving the maintenance and building of instruments and instrument investigation is in the physical chemistry unit of Glaxo Research Ltd.

Ideally candidates should be under 25 and have reached at least 'A' level standard in physics and chemistry.

Experience in the construction of electronic devices is desirable but full training in the use of complex apparatus will be given.

There are opportunities for promotion, day release for further studies, generous pay scales, 3 weeks' holiday, sick pay and sports and social facilities.



Please write, quoting ref. ZH.39, to the Personnel Officer (MRG), Glaxo Laboratories Limited, Greenford, Middlesex.

2668

International Computers

ICL

# OXLEY<sup>®</sup>

Applications are invited for the position of

## Assistant to the Works Director

of Oxley Developments Company Ltd., Ulverston.

Applicants must be about 30 years of age and have Higher National Certificate or a degree in Science. Preference will be given to someone with all or part of the following experience or qualifications:-

(1) Knowledge of modern manufacturing methods in electronics, small mechanical components and mechanisms.

(2) Assistant or deputy to a Works Manager in a thriving concern.

(3) Experience in dealing with people, production control, and shop floor conditions; experience in cost accounting.

Oxley Developments is a vigorous and expanding Company offering scope and opportunity for the right man. The Works are located in open countryside at the southern end of the Lake District.

Applications giving details of education, qualifications, experience and salary and including copies of two references or names and addresses of referees to be addressed to:

The Personnel Manager,

**Oxley Developments Company Ltd.**

**PRIORY PARK · ULVERSTON · NORTH LANCASHIRE**

2664

## ELECTRONIC ENGINEERS

Service Engineers required for Offices, throughout the United Kingdom, of well-known Company manufacturing Electronic Desk Calculating Machines. Applicants should possess a sound knowledge of basic Electronics with experience in Electronics, Radar, Radio and T.V. or similar field. Position is permanent and pensionable. Comprehensive training on full pay will be given to successful applicants. Please send full details of experience to the Service Manager, Sumlock Comptometer Ltd., 102/108 Clerkenwell Road, London, E.C.1.

2663

# ELECTRONIC TEST ENGINEERS

Experienced Engineers/Technicians urgently required for testing Variable Speed Thyristor Drives and Solid State Multi-track Tape Recorders. Candidates with H.N.C./O.N.C. preferred. Previous experience in Solid State Testing is necessary.

Salary up to £1,400 for suitable applicants. Some assistance with housing and removal expenses may be given.

Write or phone:

**Chief Inspector,  
SIMON ELECTRONICS LTD.,  
Bond Avenue,  
Bletchley, Bucks.  
Bletchley 5331 (STD. 0908 2)**

2640

## ELECTRONICS TECHNICIAN UNIVERSITY OF BIRMINGHAM

TECHNICIAN required for the Department of Anatomy to assist in the design and construction of electronic apparatus for neurological research, also to participate in routine experimental procedures involving animals and man. Elementary knowledge of electronics desirable, but no previous experience in the medical sciences is necessary. Applicants should be studying for H.N.C. or an equivalent qualification in electronic engineering or physics. Salary range £773-£1,077 p.a.

Apply for application form to the Assistant Secretary (Personnel), Personnel Office, University of Birmingham, P.O. Box 363, Birmingham 15, quoting reference 401/T/139.

2614

## TEST ENGINEERS

Vacancies exist in our test department for junior test engineers to undertake prototype and production testing/servicing of advanced signal analysis computers.

Knowledge of modern digital and/or analogue techniques is essential.

Applications are invited from young men holding ONC or similar qualifications or having relevant practical experience.

Apply giving details of qualifications and experience to:

**Mr. N. Elliott,  
Data Laboratories  
28 Wates Way  
Mitcham, Surrey  
01.648.4643.**

2628

## Loughborough University of Technology LABORATORY TECHNICIANS

VACANCIES exist for TECHNICIANS/SENIOR TECHNICIANS with experience in either aeronautical or electronic fields. Duties include assistance in the construction and servicing of test equipment relating to research, student projects and general departmental work including mechanical construction and/or electronic instrumentation.

Applicants should have basic technical qualifications together with substantial practical mechanical or electronic experience preferably associated with the aircraft industry.

The surroundings and working conditions in the University are good and there are excellent leave conditions for all grades. The posts are superannuable. Salary scales:

SENIOR TECHNICIANS: £1,056-£1,311 p.a.

TECHNICIANS: £773-£1,077 p.a.

Please apply in writing, giving full details, to Professor K. L. C. Legg, Head of Department of Transport Technology, Loughborough, Leicestershire.

2613

## PROTOTYPE DEVELOPMENT

I seek a firm or individual of proven competence to design and produce prototype important invention (provisional PAT.) involving Octo-Electronics, R.F., Logic, control circuits and small high speed electro-magnetic mechanism (from specialists) Box No. 2635.



join the men  
who lead

## Electronic Packaging Engineer

An experienced Electronic Hardware Designer is required to carry out thermal and structural designs on advanced electronic systems for guided weapons.

The engineer appointed to this job will be capable of working on his own initiative in the provision of design and data service for low power electronic assemblies. He will also be required to formulate design rules for the guidance of less skilled personnel in the optimised design of such assemblies, with particular emphasis on thermal management and structural design.

Suitably qualified engineers who have been working in these areas for the past three years at least are invited to write or phone for an application form, quoting Ref. 1512 to:



Eric Buckmaster,  
1512 Personnel Department,  
British Aircraft Corporation,  
Guided Weapons Division,  
Stevenage, Herts. Tel: Stevenage 2422



**BRITISH AIRCRAFT CORPORATION**  
the most powerful aerospace company in Europe

2666

## RADIO ENGINEER FOR UGANDA

We have a vacancy for a well trained radio engineer with a good knowledge of electrical and electronic problems.

The person we are looking for should be a good organiser, must have real interest in his work and must be willing to train local staff. There are unlimited opportunities as the successful applicant will receive on the spot training in our medical and X-ray dept. This will necessitate regular journeys to all parts of Uganda. Our terms of service are good, the climate is wonderful and the work unusual. We offer good local and overseas leave facilities.

Those interested should write to:

**Twentsche Overseas Trading Co. (Uganda) Ltd.,**  
P.O. Box 7160,  
KAMPALA,  
Uganda,

giving details of previous experience, age and marital status.

2580

## RESEARCH and DEVELOPMENT

## ELECTRONIC ENGINEERS

### ... OUR WORK

Expanding exports and the increasing complexity of our products have intensified our development programmes for digital and analogue computers, linkage and special purpose computer peripherals. We wish to establish new teams of electronic engineers and if you are interested in joining us ...

### ... YOUR QUALIFICATIONS

should include a degree, H.N.C. or equivalent. You should have relevant experience, coupled with enthusiasm and ability and ...

### ... YOUR REWARDS

with Redifon will be a good salary, stability of employment, a wide range of interesting work and an opportunity to expand your experience into new fields in ...

### ... OUR COMPANY

We design and manufacture flight simulators and electronic teaching machines for world-wide markets. The laboratories are situated in a pleasant part of Sussex at Crawley, mid-way between London and the South Coast.

Application forms may be obtained from:

H. C. Hall, Personnel Manager,  
REDIFON LIMITED.

**Flight Simulator Division,**  
Gatwick Road, Crawley, Sussex.  
Telephone: Crawley 28811



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2611

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# JUNIOR TECHNICIAN

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2661

## ROYAL HOLLOWAY COLLEGE (University of London) Englefield Green, Surrey.

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2631

## OLYMPIA INTERNATIONAL require SENIOR CALCULATOR ENGINEERS (2)

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2615

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For details of this interesting appointment, write in the first instance to the Personnel Manager, Mullard Limited, Mullard House, Torrington Place, London, W.C.1, quoting Reference: RBT/1030.

# Mullard



2662

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84



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# PLESSEY



## TRAINEE ELECTRONICS SERVICE ENGINEER

A vacancy for a Trainee Electronics Service Engineer has arisen at the MANCHESTER Office of a National Company marketing Electronic Desk Calculators. Applications are invited from young men aged 17/18 who should preferably have had some training or practical experience in the field of Radio, Television or Electronics servicing or who practice these or similar subject as a hobby.

Please write in the first instance to: Mr. J. Cuthbert, Regional Service Supervisor, Sumlock Comptometer Ltd., Empire House, King Edward Street, Briggate, Leeds, LS1 6AU.

2630

## SENIOR LABORATORY TECHNICIAN

BBC have a vacancy for a Senior Laboratory Technician in the Radio Group of Research Department at Tadworth, Surrey. The duties consist of constructional and experimental work, carried out under the direction of Engineers, on transmitting and receiving systems including aerials and transmission lines. The post offers a variety of work in these fields. Applicants should have several years experience in laboratory work, a good basic knowledge of electrical theory and electronic devices, and possess O.N.C. or equivalent qualifications. They should have an interest in radio and television and in associated radio frequency measuring techniques.

The starting salary for this post is in the range of £1,453 to £1,609 per annum and rises by annual increments to £1,843. However, if no candidate fulfilling the above requirements is found the post may be filled at a lower grade.

Write for application form (enclosing addressed foolscap envelope and quoting reference 69.E.2303.W.W.) to The Engineering Recruitment Officer, BBC, London W1A 1AA.

2621

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Funds have been made available from the Sainsbury Centenary Grant for the Advancement of Research and Education in Food Science for the appointment of an experienced graduate electrical (electronic) engineer or similarly qualified person to join a research group investigating the chemistry of the substances responsible for the flavour of foods, using combined gas chromatography-mass spectrometry. His main duty would be to care for the sophisticated instruments involved and to develop the instrumentation further. He would be available also for consultation by other research groups in the Department. The appointment is for 3 years in the first instance in the range £1,460-£1,940, the point of entry depending on qualifications and experience. Superannuation under F.S.S.U. Applications (three copies) stating age, qualifications and experience and naming three referees should reach Dr. H. E. Nursten, Procter Department of Food and Leather Science, The University, Leeds, LS2 9JT, as soon as possible.

2633

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2612

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**DEPARTMENT OF NUCLEAR PHYSICS**, University of Oxford, has a vacancy for a senior technician to work with a group developing ion sources and very high voltage devices for the Oxford 20MV electrostatic generators. The work calls for initiative and responsibility. A qualification of H.N.C. in physics or electronics would be appropriate. Salary in the range £979 to £1,316 p.a. with children's allowances and six weeks paid leave per year. Possibility of working for a higher qualification exists. Write to T. L. Green, Nuclear

Physics Laboratory, Keble Road, Oxford, mentioning reference A111. [2618]

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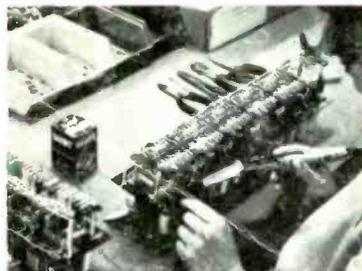


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