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Wireless World

ELECTRONICS, RADIO, TELEVISION

MARCH 1964

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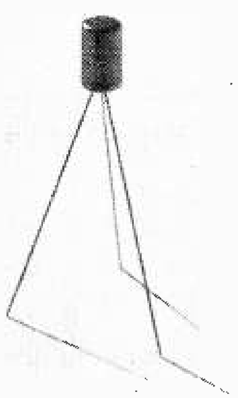
AC127 MULLARD N.P.N TRANSISTOR

for portable receivers

IN PORTABLE RADIO RECEIVERS, space is obviously at a premium, and any means of eliminating comparatively bulky components like the audio output transformer are of particular significance to the set manufacturer. Transformerless audio stages suitable for use in these radios can now be readily designed using the Mullard AC127 transistor, and the latest pocket and personal portables incorporate this new device.

The AC127 is an n.p.n. transistor and thus uses n-type germanium for the emitter and collector and p-type germanium for the base, instead of the



p-type emitter and collector and n-type base of p.n.p. transistors. In conjunction with the OC81 p.n.p. transistor, the AC127 forms a complementary matched pair of transistors that makes up the output stage of the LFK3 a.f. package. The package is completed with the p.n.p. OC81D driver transistor.

The AC127 is a high-gain device, its amplification factor being greater than 50 at 200mA. Its peak current rating is 500mA, which enables an output power of up to 700mW to be obtained using a 9V battery.

In the LFK3, the collector currents of the output transistors are matched to within 20% at 50mA, and both output transistors are cross-matched with the OC81D to give reduced circuit gain spreads. The sensitivity of the package is such that outputs of up to 300mW can be achieved using the package alone. For higher outputs, an additional pre-amplifier stage is necessary, and use of a second AC127 in this pre-amplifier stage enables an output power of 500mW to be attained.

AD140 MULLARD OUTPUT TRANSISTOR

for car radios

In conjunction with a miniature driver transistor type OC82DM, the Mullard AD140 power transistor forms the audio package, type LCR2. This alloy junction output transistor has a high current gain, and possesses good linearity and frequency characteristics.

The package forms a two-stage class A audio amplifier capable of delivering an output of 3W when driven directly from the detector of an all-transistor receiver. The sensitivity of the amplifier with respect to a 1kΩ source is typically 25mV for full output. The LCR2 is thus meeting the need for high audio gain in car radios, ensuring an excellent standard of performance while offering an economic design.

NOTE: Replacements for packages should be ordered by the individual transistor type numbers.

TRIODE–PENTODE FOR TELEVISION TUNERS AND I.F. AMPLIFIERS

The performance and versatility of the recently introduced triode-pentode PCF801 make it an ideal valve for television receivers designed for both v.h.f. and u.h.f. reception. The PCF801 can function as an oscillator-mixer in

WHAT'S NEW IN THE NEW SETS

These articles describe the latest Mullard developments for entertainment equipment

v.h.f. tuners and as an i.f. amplifier following a u.h.f. tuner. Two frame grids are incorporated in the valve: the triode grid and the pentode control grid, which has also been designed with a variable-mu characteristic. Outstanding properties of the PCF801 are small inter-electrode capacitances, a high conversion conductance and a remote cut-off characteristic.

As an oscillator-mixer, the triode oscillator performance is largely independent of supply voltage variations and the frequency shift when bias is applied to the mixer control grid is kept to a minimum. In the pentode mixer a conversion conductance of 5mA/V is achieved with an r.m.s. oscillator signal amplitude of only 1·6V.

As a controlled i.f. amplifier, large i.f. signals from a u.h.f. tuner can be handled without risk of cross-modulation or over-modulation occurring. In addition, feedback of the i.f. signal to the r.f. bandpass filter is eliminated, so that difficulties in the adjustment of this filter are avoided.

MVE 3209

Wireless World

VOL 70 NO 3 MARCH 1964

In Search of Value

THE question of resale price maintenance as it affects the interests of radio retailers has been amply discussed in our sister journal *Wireless and Electrical Trader*. We ourselves are not directly involved in the processes of distribution, but indirectly these processes can and do influence design and production, which are very much matters of concern to *Wireless World* readers.

Price cutting and price maintenance have been coexistent factors in the distributive trades for as long as most of us can remember. Coexistence has been possible because of the interplay of pressures and counter-pressures and of the normal adjustments of advance or retreat in a competitive environment. Most people, and that includes the customers, know or can make a shrewd guess at what is going on. Therefore the Government's recent general disapproval of resale price maintenance, combined with its expressed intention to sanction exceptions, introduces only one new factor—official intervention and arbitration at one point in the chain of bargaining between prime producer and consumer. What geologists might describe as this sudden slip fault in the Government's control of the economy is likely to send tremors and vibrations far and wide. There will be general turmoil and some local damage, but there need not be confusion, for the radio industry has often had to face sudden changes in the middle belt of distribution as the result of the action of powerful private interests—and, of course, the vicissitudes of purchase tax.

Assuming that the necessary legislation goes through and that the tribunals have fulfilled their functions in deciding which products may or may not carry fixed prices, there will still be plenty of room for manœuvre. As yet there is no compulsion to buy a television or radio receiver, nor is a manufacturer prosecuted if he discontinues their manufacture. No one seriously suggests that a bargain between individuals must always be subject to official approval as well as to stamp duty. The continuance of trade depends on the existence of some residual advantage to both buyer and seller after allowance has been made for all the disadvantages.

The practice of resale price fixing enables the manufacturer to offer an inducement to many small dealers to stock his goods and so bring them within easy reach of the consumer—geographically if not always financially. As well as covering the cost of stocking and the consequent locking-up of capital, the retailer's discount is also intended to cover reasonable installation and servicing. This is a form of insurance in which the customer whose set gives no trouble is in fact subsidizing his less fortunate neighbours. With a highly technical product like television the cost of servicing can be quite high—enough to break both dealer and manufacturer if by some miscalculation or even mischance a design turns out to be unreliable.

The breakdown of resale price maintenance is essentially a breaking-up of the lump sum which it costs to develop, produce, distribute, install and service a "consumer durable" article. The fixed selling price dictated by the manufacturer is designed to cover all contingencies; some people will get less than they paid for, some more. This will be very soon apparent to those who elect to pay cash and metaphorically to carry the sealed carton from a cut-price warehouse, for the cost of servicing can no longer be expected to be rationalized by the manufacturer.

If price maintenance is abolished it seems to be generally agreed that only the exceptionally efficient small retailer will stay in business and that distribution will be concentrated in the hands of a few supermarkets, whose multi-million-pound orders will be the life or death of the few remaining manufacturing combines. Faced with the necessity of winning these contracts, can they afford to fix their selling price at a level which will leave a margin for research and development of ideas other than those directly connected with lowering the price of the product? They *must* if only to sustain performance and ensure reliability.

At this level, towards which the industry has already been pushed by purchase tax on more than one occasion, concerted action through a trade association is the only safe course. Otherwise the quality of the product may fall to a level at which even the customer may perceive that low price does not necessarily represent good value for money.

If this happens radio engineers will ultimately shoulder the blame, for the essence of good engineering is value—doing for a shilling what other people can do equally well for a pound.

The Unijunction Transistor

ITS OPERATION AND APPLICATIONS

By H. R. HENLY*

THE unijunction transistor is an interesting device which has found application largely as a trigger for silicon controlled-rectifiers. It has, however, many other uses and the purpose of this article is to acquaint the reader with a few of them. Let us first consider what it is and how it works.

Characteristics:—The unijunction comprises a bar of n-type silicon with two ohmic (i.e. non-rectifying) contacts, one at each end. These are designated base 1 and base 2—Fig. 1. A third rectifying contact is made on the other side of the bar, near to base 1. The bar behaves as a linear resistance of, typically, between 5 and 10 kΩ. In normal operation base 2 is biased positively with respect to base 1, causing a small inter-base current to flow. With no emitter current flowing the bar behaves as a potential divider with a proportion η (known as the intrinsic stand-off ratio) of the inter-base voltage appearing at the emitter junction, effectively back-biasing the emitter diode by this amount. Thus the emitter diode will only conduct when the emitter-base 1 voltage is more positive than

$$V_E = \eta V_{BB} + V_D \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where V_E = emitter—base 1 voltage
V_{BB} = inter-base voltage
V_D = forward voltage drop of emitter diode.

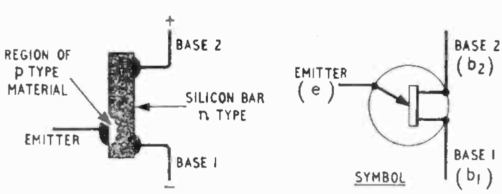


Fig 1. Construction of unijunction transistor.

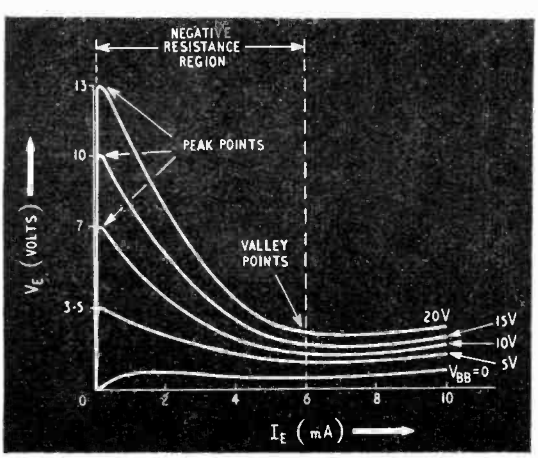


Fig. 2. Emitter characteristics.

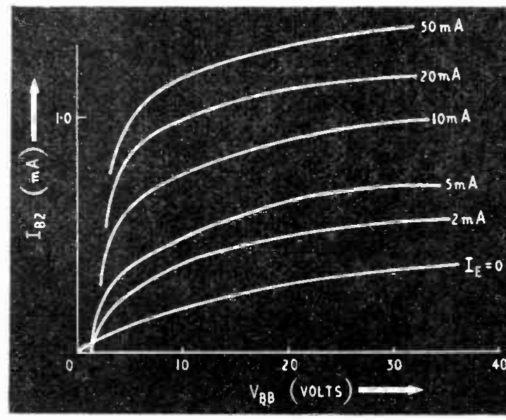


Fig. 3. Inter-base characteristics.

The emitter current consists largely of holes, the majority carriers of p material, which are injected into the bar. These carriers drift in the direction of the applied field, i.e., toward base 1, causing a decrease in the resistivity of this region. Thus, as the emitter current increases, the emitter voltage decreases, producing the negative-resistance characteristic of Fig. 2. The family of characteristics shown is typical of the device for various inter-base voltages. The inter-base characteristics of Fig. 3, show the base 2 current as a function of inter-base voltage V_{BB} and emitter current I_E.

The emitter characteristics have three regions of interest; the peak-point voltage V_P at which the device enters the negative-resistance region, the region to the left of this point where the device is cut-off and the valley-point voltage V_V where the emitter input resistance becomes positive.

The important properties of the device are:—

(i). The peak-point voltage is constant for a given inter-base voltage V_{BB} and depends solely on the construction of the device. It is given by

$$V_P = \eta V_{BB} + V_D \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

The effect of temperature on η is very small, about 0.01% per degree Centigrade and is swamped by variation of V_D with temperature. Stabilisation of V_P against temperature change can be achieved by placing a resistor of suitable value in the base 2 lead. This resistor is given by

$$R_2 = \frac{0.7\, R_{BB}}{\eta\, V_{BB}} + \frac{(1-\eta)\, R_1}{\eta} \quad \ldots\ldots\ldots\ldots \quad (3)$$

where R_{BB} = inter-base resistance and R_1 = external load resistor (if any) in series with base 1.

*G.P.O. Engineering Department

(ii). In the cut-off region, the input impedance is very high, equivalent to a back-biased diode.

(iii). The input impedance in the valley region is positive, typically 5 to 25 ohms.

A very useful equivalent circuit may be built up using silicon transistors. This is shown in Fig. 4, and comprises two transistors in a complementary bi-stable circuit which is held inoperative by the potential divider R_1 and R_2. Thus the effective η of the device may be varied, since $\eta = R_2/R_1 + R_2$. There is, however, some sacrifice of temperature stability in using conventional resistors for the potential divider. The use of a silicon resistor with a positive temperature coefficient for R_2 would improve its characteristics.

If temperature stability is of no importance then two germanium transistors may be used resulting in further economies (approximately half the cost of a unijunction). R_S is a stabilising resistor, and should be about 1 kΩ.

Applications:—There are numerous applications for this device, [1,2] and a few of the more interesting will be given here. In all cases the equivalent circuit may be used in place of the unijunction shown.

The first and most common is the relaxation oscillator of Fig. 5. This is widely used for triggering s.c.r.'s, since the output pulse is short and from a low impedance source. The operation of the circuit is simple; capacitor C is charged through resistor R_1 towards the supply voltage V_{BB}. When the capacitor potential reaches V_P the unijunction fires and the capacitor discharges into the emitter circuit. The circuit returns to the cut-off state when the emitter current has fallen to the valley current I_V, and the process is repeated. The charging time-constant is CR_1 since the current into the emitter prior to firing is negligibly small, and the oscillation period is given by:—

$$T = CR_1 \log_e \left(\frac{1}{1-\eta}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

which is independent of supply voltage.

The value of R_2 is not critical. It is normally chosen in the range 20 to 100 ohms, the main criterion being that the potential developed across it due to inter-base leakage current, should be much less than that required to fire the s.c.r. The amplitude of the output voltage is a function of the capacitor C and R_2. Manufacturers' data sheets usually provide graphs relating these components. R_1 must be chosen so that the load-line intersects the $V_E - I_E$ characteristic in the negative region. The lower limit is typically 3 kΩ and the upper limit, set by the emitter drive requirements, is around 500 kΩ.

Clearly this circuit is not restricted to s.c.r. triggering, but may be used for many timing applications where a stable pulse source is required.

A novel application used by the author is the metronome circuit of Fig. 6. This comprises the relaxation oscillator of Fig. 5, followed by an output stage feeding a loudspeaker. Although the transformer used for interstage coupling was a midget a.f. type, a small pulse transformer could be used since the pulse is of very short duration. The circuit was built on a piece of phenolic board and mounted in a small plastic case. Details of components and approximate p.r.f. range are given in Fig. 6.

The operation of the relaxation oscillator may be controlled by another transistor, e.g. Fig. 7. In this circuit T1 is connected across the timing capacitor. If T1 is non-conducting the oscillator will function normally, since the current into T1 is negligible. When T1 is saturated all the available current is diverted away from C and oscillations cease. By

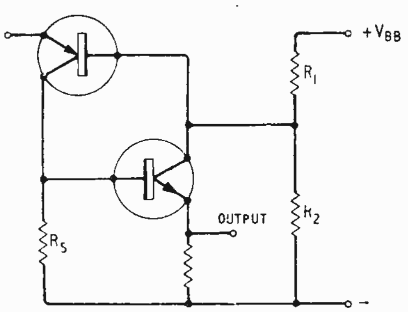


Fig. 4. Equivalent circuit of unijunction using two transistors.

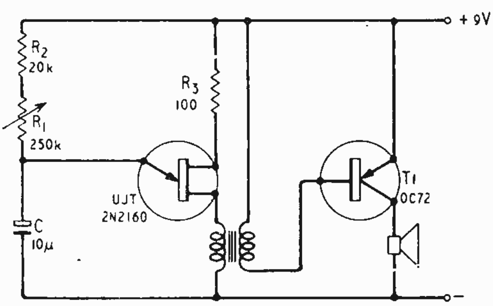


Fig. 6. Metronome to give approximately 20 to 200 beats per minute. Original speaker was 2¼-in, 80-ohm Plessey type.

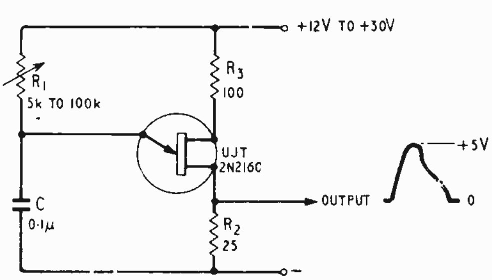


Fig. 5. Relaxation oscillator. The 2N2160 unijunction is obtainable from Texas Instruments Ltd., of Manton Lane, Bedford.

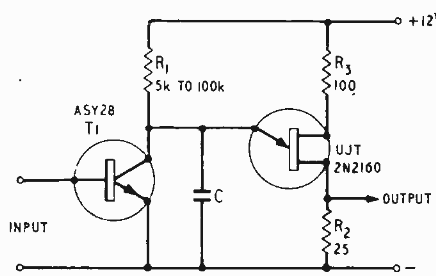


Fig. 7. Shunt control of oscillator frequency.

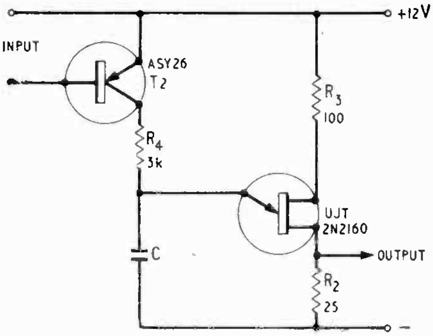


Fig. 8. Series control of oscillator frequency.

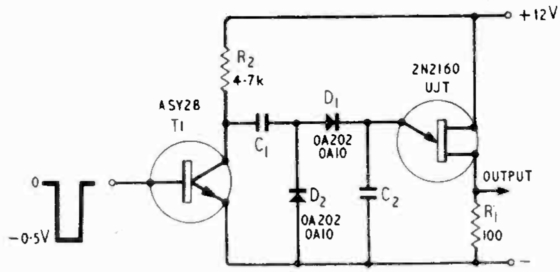


Fig. 10. Diode-pump counter using unijunction disharger. C_1 and C_2 are given by equation (7).

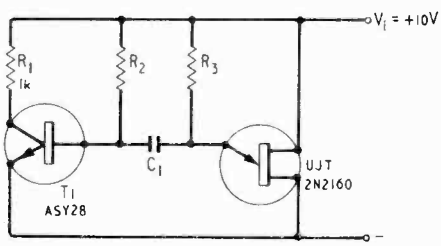


Fig. 9. Square-wave or pulse generator. C_1, R_2 and R_3 are determined by means of equations (5) and (6).

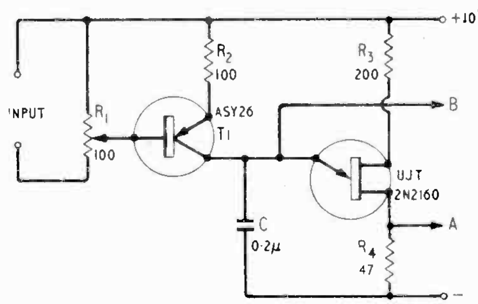


Fig. 11. Linear integrating counter giving, at output B, a linear staircase and at output A, a pulse.

setting the collector current of T1 between these limits the charging current to C may be varied and hence the p.r.f. An alternative circuit is that of Fig. 8, in which transistor T2 is connected in series with the charging resistor R_4. Here the oscillator p.r.f. is again controlled by the collector current and oscillations cease when this is below the value required by the unijunction to operate in the negative-resistance region. A resistor of approximately 3k Ω is placed in the collector of T2 to limit the maximum current for similar reasons.

Although the author has not yet tried it, it would seem feasible, using the equivalent transistor of Fig. 4, to vary the p.r.f., over a limited range by making the ratio $R_2/R_1 + R_2$ and hence η variable.

The unijunction may be combined with another transistor to form a square-wave generator Fig. 9. The load in this circuit may be replaced by a relay coil (or other load) the timing being unaffected by the output circuit. The period for which the transistor is conducting is given by:—

$$T_1 = R_1C_1\log_e \frac{V_1 - V_E}{V_1 - V_P} \quad \ldots\ldots\ldots\ldots \quad (5)$$

and the off period is given by:—

$$T_2 = R_2C_1\log_e \frac{V_1 + V_P - V_E}{V_1 - V_P} \quad \ldots\ldots\ldots\ldots \quad (6)$$

where V_E is measured at an emitter current of $I_E = V_1 (R_1+R_2)/R_1R_2$ and is obtained from the emitter characteristics.

Another interesting and useful circuit is the unijunction version of the integrating counter. Two forms are possible as shown in Figs. 10 and 11. The first uses a diode-pump circuit which charges the timing capacitor C_1 in steps until the emitter potential reaches V_P, when the unijunction fires and discharges C_1 and the process is repeated. It can be used as a frequency divider, the division ratio being given by

$$\frac{f_2}{f_1} = \frac{C_1}{C_1 + C_2} \quad \ldots\ldots\ldots\ldots \quad (7)$$

In the second circuit, Fig. 11, the capacitor is charged by the series transistor T1. Negative pulses at the base of T1 cause it to conduct and charge C_1 in steps. The amplitude of these steps may be conveniently controlled by the potentiometer R_1 at the input. A staircase waveform is available at the emitter of the unijunction and positive pulses at the end of each count at base 1, which may be used to trigger another stage. The staircase is quite linear and the number of steps may be varied from one to several hundred.

It is hoped that this has provided the reader with an insight into this interesting device. It has many applications and will doubtless find many more. They are readily obtainable from at least two leading manufacturers at reasonable prices. For many applications the equivalent circuit may be used, using germanium transistors and reducing the cost considerably. For more detailed information on the subject the reader is referred to the list of references below, to which the author is indebted for much of his information.

Finally, acknowledgements are due to the Engineer-in-Chief, G.P.O. for permission to publish this article.

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1. "Transistor Circuit Analysis", by Joyce and Clarke. Addison-Wesley.
2. General Electric Co. Transistor and Controlled Rectifier Manuals.

Wireless World OSCILLOSCOPE

8.—WIDE-BAND Y AMPLIFIER

IN the first article of this series, it was pointed out that the faster a voltage changes from one value to another, the higher the component frequencies contained in the waveform. For instance, in the new 625-line system of television, the spot must change from peak white to black in just over 70 nanoseconds (0.07 microseconds) to reproduce the allotted amount of detail. This means that any amplifier associated with the drive to the tube circuit must be capable of handling frequencies up to 5.5Mc/s and preferably more.

To display such a waveform on an oscilloscope without deterioration, a wider bandwidth is required, otherwise the oscilloscope amplifier rise-time apparently increases the rise-time of the signal. For the average television and radio experimenter, a bandwidth of 0-10Mc/s is sufficient, with a rise-time of 40 nanoseconds. Direct coupling should be used, as explained in the first article, and the deflection must be calibrated.

Attenuator

Each step of the input attenuator is of the same form as that used in the first amplifier. Instead, however, of " stacking " the sections, each one is a separate potential divider—a system which is easier to set up. Each section has a trimmer to enable the response to be adjusted. The values of the capacitors, together with the input capacitance of the first stage, are such that the attenuator is not dependent on frequency, and the input capacitance to the attenuator is kept at 20pF. Although the amplifier is directly coupled, it is sometimes convenient to reject a direct voltage which is large compared with the signal and which is outside the range of the y shift control. For this reason a large capacitor can be switched in series with the input to the attenuator. With this in circuit, the frequency response of the amplifier is about 2 c/s—10Mc/s at 3dB points.

Amplifier First Stage

The design of the amplifier is straightforward, except perhaps for the first stage. The requirements of direct coupling dictate that the voltage at the anode of VI must be at a suitable level to feed the grid of V3 ($V2_b$ is a cathode follower, and its cathode will be at the same potential as its grid, plus a volt or two).

One way of dropping the supply voltage to VI anode would be to use a large resistor in series with the anode load, decoupling the junction. This would be fine at all but the lowest frequencies, when the reactance of the decoupling capacitor would be comparable to the resistance of the dropper, and the effective anode load would increase. At zero frequency, the anode load would be R_{12} plus the dropper, and the response of the amplifier would show a large increase at zero and low frequencies. The solution to this problem is to use a triode valve (one of which conveniently happens to be spare) to drop the surplus voltage. This is in series with the anode load, but the impedance seen " looking into " the cathode of the triode is only about 200Ω, so that it is not necessary to decouple it. The response is therefore flat down to zero frequency.

The high-frequency response is improved by the combination of shunt inductive compensation and the reduction of cathode degenerative feedback at high frequencies by means of the small cathode by-pass capacitors. C_{15} and C_{16} do not begin to by-pass R_{13} until the frequency is about 7-8Mc/s, so that the gain up to this point is reduced to $g_m R_L/(1+g_m R_K)$. Above this frequency R_{13} is by-passed and the stage gain becomes $g_m R_L$. The 100kΩ resistor shunted by a 0.01μF capacitor at the input prevents excessive grid current if a large voltage is inadvertently

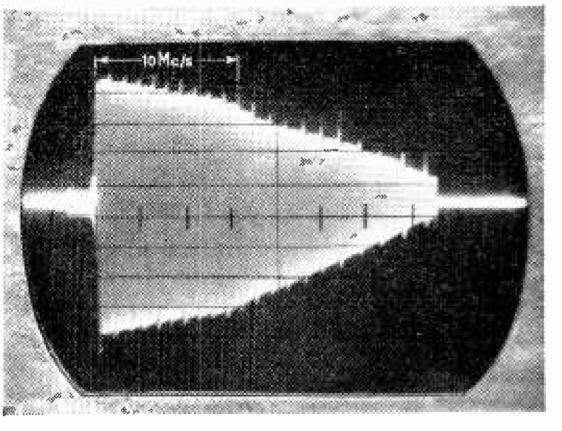
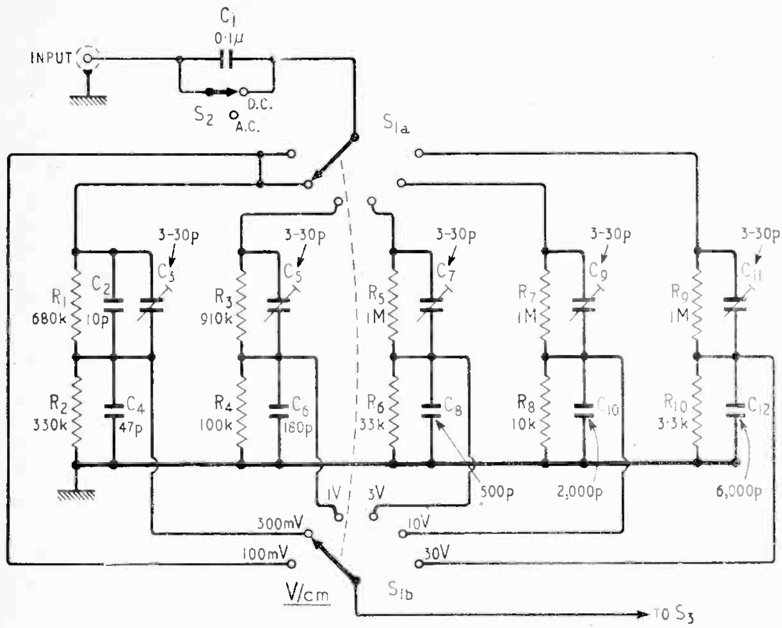
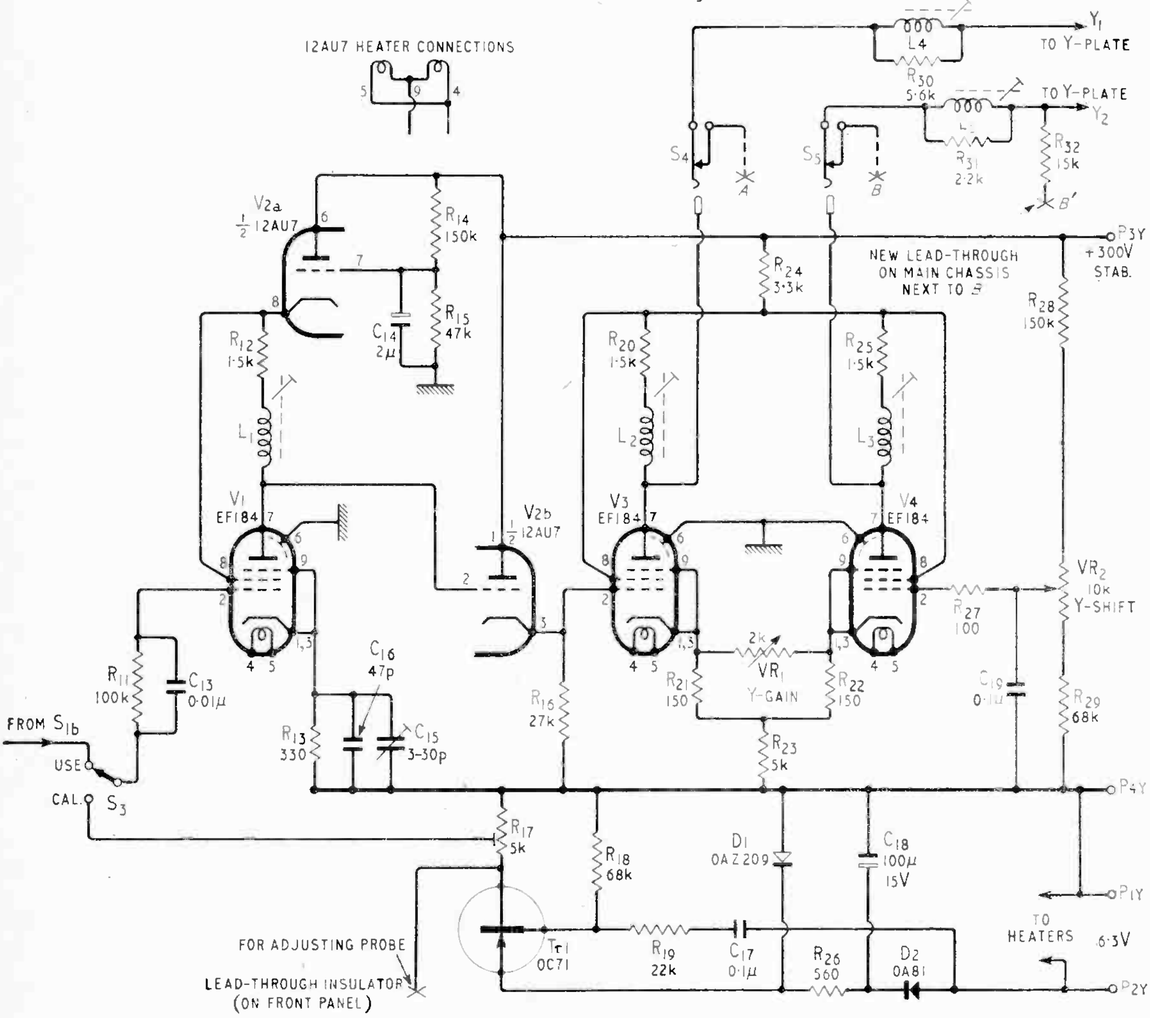


Fig. 1 Response of amplifier up to 20Mc/s shown on W. W. Oscilloscope. Frequency and amplitude axes are both linear. Pips are 1Mc/s apart.



Left:—Fig. 2 Frequency-compensated attenuator.



Below:—Fig. 3 Amplifier circuit diagram. A and B are existing feed-throughs on main chassis. C_4 in circuit of trigger stage (June 1963, p. 259) should be disconnected from S5Y and connected to B¹. L_1 is 50 turns 32g. d.s.c. L_2, L_3 60 turns 32g. d.s.c. L_4 and L_5 50 turns 32g. d.s.c.

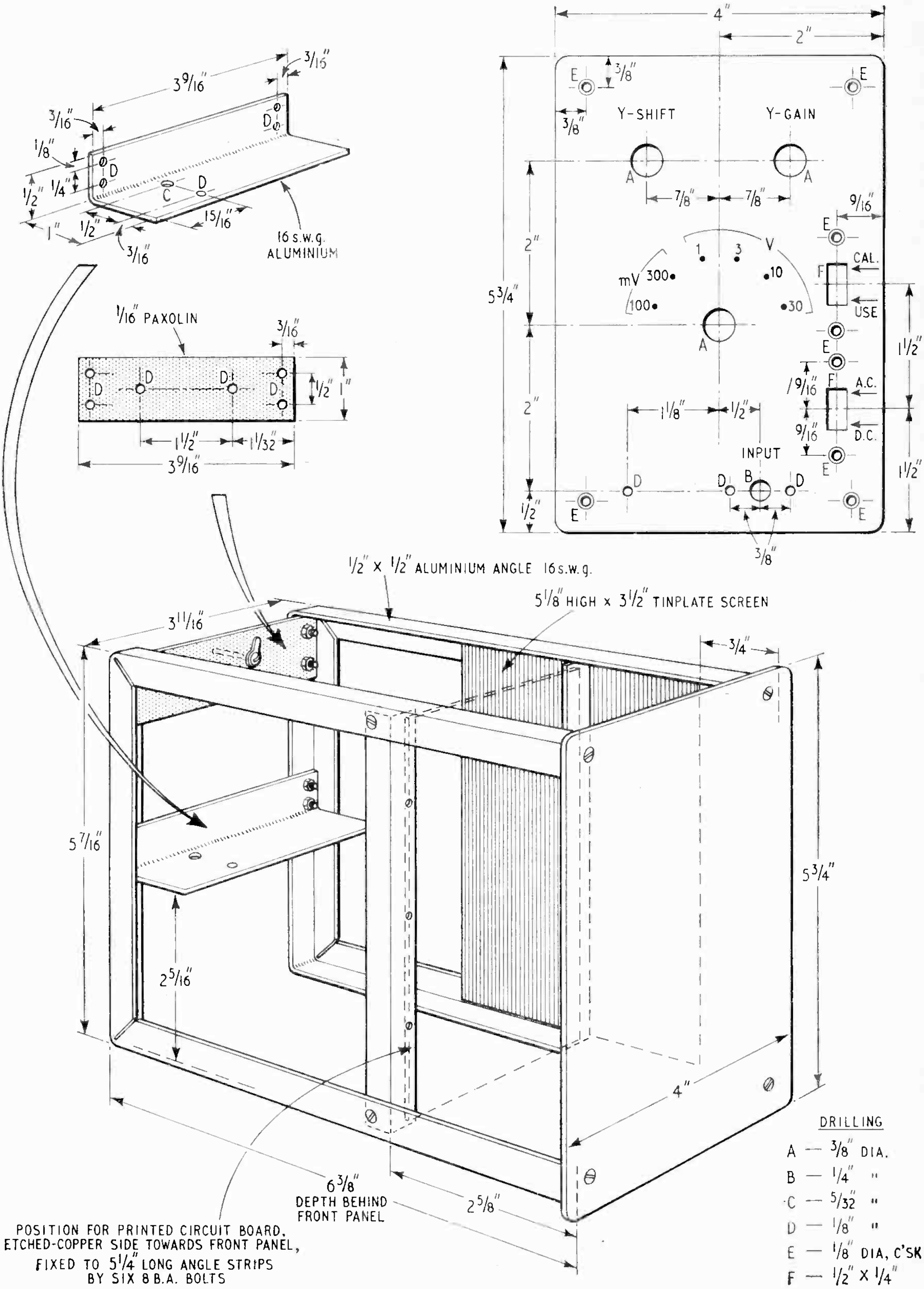


Fig. 4 Complete assembly diagram.

connected when the attenuator is switched to the most sensitive position.

Second Stage

A cathode follower is interposed between the input stage and phase-splitter to alleviate the effects of stray capacitance on the response of the input amplifier. The input capacitance of a typical cathode follower is of the order of 1.5-2pF. If a straightforward RC-coupled amplifier were used, with its attendant Miller effect, the input capacitance would be about 80pF, depending on the load. No gain is, of course, obtained from the cathode follower, but the reduction in stray capacitance is worth the effort. In addition, the low output impedance of the cathode follower means that the input capacitance of the next stage, which varies with settings of the gain control, is of less importance.

Phase-Splitter

To provide push-pull signals for the c.r.t. deflection plates, a long-tailed pair phase-splitter is used. It is similar to the circuit used in the first *y* amplifier with the exception of the h.f. compensation in the anode and the gain control in the cathode.

A combination of shunt and series compensation is used, the coils in series with the deflection plates being damped fairly heavily by resistors to avoid peaks in the response curve. This, together with the cathode feedback and anode correction in the first stage, gives a response which is less than 3dB down at 10Mc/s, and does not peak or roll off suddenly. The curve is a gentle one from low frequencies to many megacycles.

The gain control is similar to the one in the first amplifier, except that a common resistor is used as the "tail." The use of two resistors made rather odd things happen to the low-frequency response. The 100 Ω grid stopper is evidence of instability that beset the amplifier at one stage in its life.

Calibration

The calibrating voltage is a 500mV peak-to-peak square wave. The 50c/s sine wave from the heater line is used to over-drive a transistor, which alternately "bottoms" and cuts off. It is rather more useful to do this in a transistor than in a valve, because when a transistor bottoms, its collector voltage is only about 100mV negative to its emitter, and it does not change very much. When it cuts off, however, there are still a few micro-amps flowing—the leakage current—which means that there can be a few hundred millivolts less than the supply across the transistor. This is still sufficiently small not to be serious, and the output is a 50c/s square wave, with a nice flat top, at an amplitude of about 200mV less than the supply, which is held constant by the Zener diode, D_1. 500mV are tapped off by the preset potentiometer.

Construction

People are always asking us why we have not used printed circuits. We could see no particular advantage in previous units, but in this case, layout can make a vast difference to performance, and we have therefore made the amplifier on a printed board, or rather an etched board. We wanted to be sure that everyone would be able to repeat the construction, so we bought a kit of materials from a retailer and used that instead of more professional methods. The chief ingredient required is patience. After about an hour we began to think that perhaps the brown liquid was not ferric chloride but diluted treacle. At the end of 1¾ hours, happily, the unwanted copper disappeared and the board was finished, apart from a wash and brush up to get rid of the resist. No real problems cropped up, and the finished circuit performs well. Further diagrams and constructional notes will be given next month. For people who do not wish to buy a kit of materials, copper-clad board can be supplied by, for instance, Henry's Radio. Cellulose lacquer resist and thinners for resist removal are easily obtainable.

Setting-up

The response curves shown on the front cover and in the text were produced with the aid of a Marconi Instruments 20Mc/s Sweep Generator. We are well

COMPONENT LIST

Resistors		Capacitors	
All are ¼ types unless otherwise specified.			
R_1	680kΩ ± 5% Hystab	C_1	0.1μF 350V
R_2	330kΩ ,, ,,	C_2	10pF ± 5%
R_3	910kΩ ,, ,,	C_3	3–30pF
R_4	100kΩ ,, ,,	C_4	47pF ± 5%
R_5	1MΩ ,, ,,	C_5	3–30pF
R_6	33kΩ ,, ,,	C_6	180pF ± 5%
R_7	1MΩ ,, ,,	C_7	3–30pF
R_8	10kΩ ,, ,,	C_8	500pF ± 5%
R_9	1MΩ ,, ,,	C_9	3–30pF
R_{10}	3.3kΩ ,, ,,	C_{10}	2000pF ± 5%
R_{11}	100kΩ	C_{11}	3–30pF
R_{12}	1.5kΩ Hystab	C_{12}	6000pF ± 5%
R_{13}	330 Ω	C_{13}	0.01μF 350V
R_{14}	150kΩ Hystab	C_{14}	2μF 100V
R_{15}	47kΩ ,,	C_{15}	3–30pF
R_{16}	27kΩ 1W	C_{16}	47pF
R_{17}	5kΩ preset (Radiospares)	C_{17}	0.1μF 150V
R_{18}	68kΩ	C_{18}	100μF 15V
R_{19}	22kΩ	C_{19}	0.1μF 100V
R_{20}	1.5kΩ Hystab		
R_{21}	150 Ω		
R_{22}	150 Ω	**Miscellaneous**	
R_{23}	5kΩ 5W	V_1	EF184
R_{24}	3.3kΩ 1W	V_2	12AU7
R_{25}	1.5kΩ Hystab	V_3	EF184
R_{26}	560 Ω	V_4	EF184
R_{27}	100 Ω	Tr 1	OC71
R_{28}	150kΩ	D1	OAZ209
		D2	OA81
R_{29}	68kΩ	NEOSID 3510/8B.A. coil formers—5 OFF*	
R_{30}	5.6kΩ	NEOSID N4LT1 tag rings—5 OFF*	
R_{31}	2.2kΩ	NEOSID 199/1 screws—5 OFF*	
R_{32}	15kΩ	P490 "Domina" plugs Bulgin	
VR_1	2kΩ linear	McMurdo printed-circuit valveholders	
VR_2	10kΩ linear		

*Obtainable from Denco.

Miniature slide switches, 2-off (Radiospares).
Makaswitch shafting assembly (Radiospares).
Medium Makaswitch spacers (Radiospares).
Makaswitch wafer—1 pole, 12-way (Radiospares).

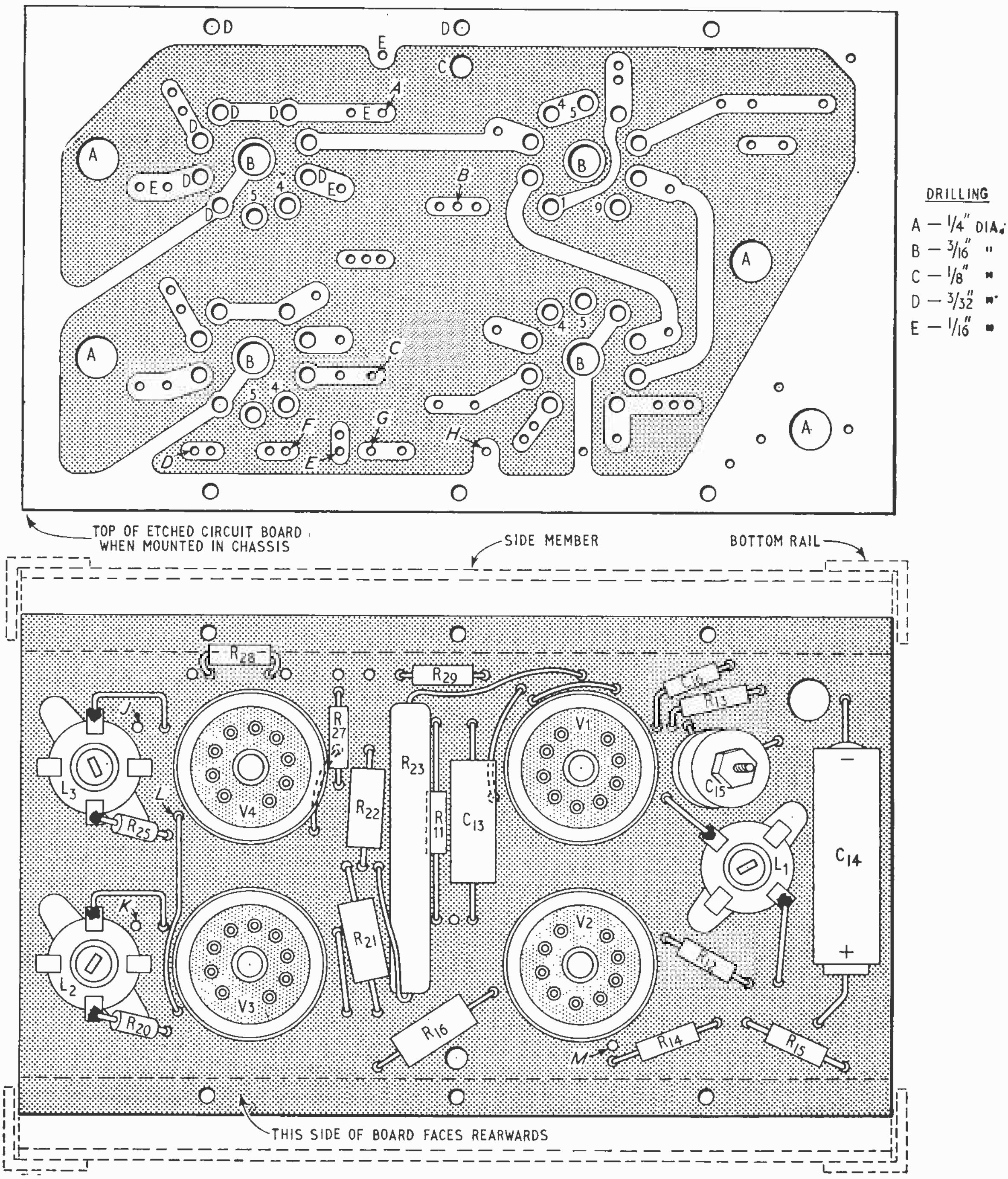


Fig. 5 Layout and wiring of printed-circuit board. Drawing is full-size. Connections to "A," "B," etc., will be shown later.

aware that we are in the minority in being able to use an instrument like this and have tried to find an easy way of adjusting the trimmers and coils. Unhappily, we are forced to the conclusion that there is no such method. The only way of doing it appears to be a succession of frequency-response checks with a signal generator, adjusting for the best shape of curve. Frequencies up to about 15Mc/s should be used, to check that there are no peculiarities in this region. Adjustment of the attenuator trimmers will be described next month.

Output Connectors

The plugs and sockets originally chosen for these units possess, it has been found, rather too much self-capacitance to be of much use at 10Mc/s. For this reason, the connections to the *y* deflection plates must be made via the auxiliary panel shown in Fig. 4. With the unit pushed home, the plates are automatically connected to the amplifier output and disconnected from the original sockets by means of the leaf switches.

Recent Developments in

AUTOMATIC ERROR CORRECTION

2.—RESULTS USING SELF-CHECKING CODES WITHOUT RETURN CIRCUITS

By P. R. KELLER,* M.B.E., B.Sc., A.M.I.E.E. *Concluded from page 66 of February issue*

THE first part of this article showed how an error detecting code, together with automatic repetition of detached errors, could be used to provide automatic error correction on radio teleprinter circuits. It also showed how an error correcting code could be devised for this purpose by adding parity elements to the information elements of character in the normal teleprinter code.

Some variants of the code construction described earlier will now be considered.

A Special Case:—In the special case where in constructing the error correcting code each of the check digits is chosen so that together with the appropriate elements of the original character the number of 1 elements is odd, the resultant 10-unit code simplifies to the original character followed by the character repeated erect when the number of 1 elements in the original character is odd, and the original character followed by the character repeated inverted when the number of 1 elements in the original character is even. As examples:

01101 becomes 0110101101
and 01100 becomes 0110010011

Similarly, if all the check digits are chosen to give an even number of 1 elements, the repeated half of the new character is inverted if the original 5-unit character had an odd number of 1 elements and is transmitted upright if the original characters had an even number of 1 elements. Then:

01101 becomes 0110110010
and 01100 becomes 0110001100

These special cases may be preferred, as the alternative logic approach may permit further simplification of equipment design. As the incoming 5-unit character is registered at the error correcting transmitting terminal the number of 1 elements can be counted to determine whether the total is odd or even, and the original character transmitted twice with the second transmission inverted if appropriate.

If the transmission is of this nature, an alternative approach can also be adopted at the receiver. In this case we may compare the first five elements with the second five, writing 0 for agreement and 1 where the elements differ, meanwhile counting the number of 1 elements in the first five elements to determine whether the total is odd or even. If odd parity is used in transmission, an unmutilated character gives rise to 00000 in the comparison register with an indication of an odd number of 1 elements in the odd/even register, or 11111 in the comparison register with even in the odd/even register. Characters with a single error affecting one of the first five elements will show only one 1 in the comparison register with even in the odd/even register, the position of the 1 indicating the element in error, or only one 0 in the comparison register with odd in the odd/even register, the position of the 0 indicating the element in error. Other combinations result from detected errors which cannot be corrected; these are arranged to cause an error symbol to be printed in the copy.

Equipment Design

In the design of the error correcting terminal the following points must be considered in addition to evident requirements such as reliability, compactness and simplicity of operation.

Synchronizing:—To permit operation with teleprinters transmitting a $7\frac{1}{2}$ unit start-stop signal at a nominal speed of 50 bauds, and allowing for the speed tolerance of the teleprinter, the synchronous 10 unit signal must be transmitted at a speed slightly greater than $66\frac{2}{3}$ bauds. The receiver must be synchronized to the incoming signal, and known methods[1] examining all transitions in the input signal readily permit the synchronizing to be accurate to about 1%, thus giving wide margin against distortion in the received signal. In common with all synchronous systems it is necessary to transmit an idle signal, containing at least one transition, when there is no traffic to be sent, so that syn-

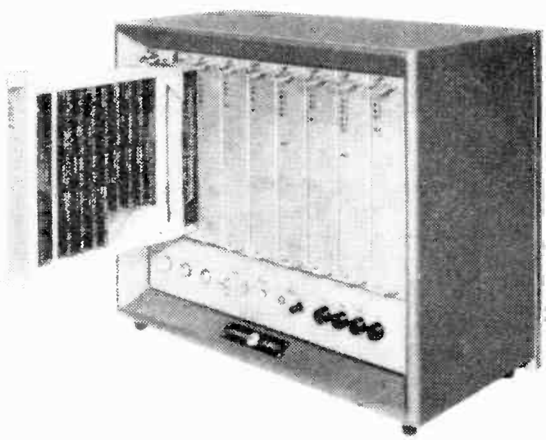


Fig. 2 Marconi "Autospec" showing transistorized modular construction.

*The Marconi Co. Ltd.

chronism can be maintained. Crystal oscillators may be used at the transmitter and receiver to permit synchronism to be maintained for reasonable periods in the absence of any input signal.

5-Unit Input Store:—If the input characters to be transmitted over the system are derived from punched tape using a pulsed 5-wire tape reader, new characters can be called in at synchronous rate every ten element periods.

If the input is from a start-stop apparatus, such as a teleprinter or free running auto-transmitter, the processing of received characters before retransmission as 10-unit synchronous characters can be simplified by converting characters in the sequential input signal to the 5-wire simultaneous form.

In the sequential input case characters may arrive at random times relative to the synchronous transmission. To allow for the consequent varying interval between the arrival of a 5-unit character and the commencement of the synchronous transmission of the corresponding 10-unit character, it is necessary to provide for each received character to be held in a 5-unit store for a period which will vary up to the clearance time of ten elements of the synchronous transmission. Since characters are transmitted out of the system faster than they can arrive, the store is always cleared before the next character is received and ready to come in. As a result, it sometimes happens that the store is empty when read, and this gives rise to the transmission of the 10-unit idle signal. The idle signal is therefore transmitted when there is no input traffic to be sent, and also in continuous traffic at intervals to allow for the nominal difference between the rate at which characters can arrive and are cleared. If the input device is running fast the number of idle signals is reduced, and if the input device is running slow the number of idle signals is increased. At the receiving terminal receipt of an idle signal gives rise to continuous stop polarity on the output to the teleprinter.

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Fig. 3. Comparative tests on an intentionally "bad" circuit showing (top) 5-unit traffic, uncorrected and (bottom) the same using "Autospec" at the receiving end. Tests carried out under controlled conditions.

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THE+TIME HAS COME,THE  WALRUS SAID,TO TALK OF MANY THINGS-

OF SHIPS AND SEAS AND SEALING-WAX, OF CABBAGES AND KINGS,

AND WHY THE S+A IS MADE OF INK, AND WHETHER PIGS HAVE WING+.

MARY MARY QUITE CONTRARY, HOW DOES YOUR GARDEN GROW?

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RYIRYIRYIRYIRYIRYIRYIRYIRYIRYIRYIRYIRYIRYIRYIRYIRYIRYIRYIRYI
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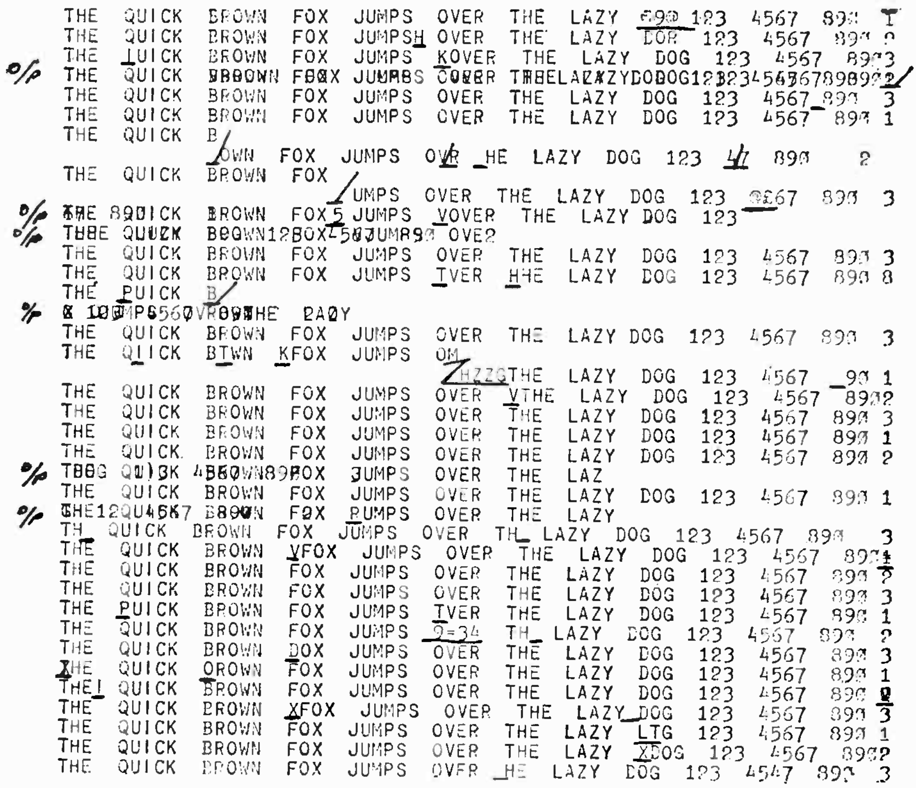
Phasing:—With a ten-unit code there are ten possible phase relationships between the receiver and the received synchronous signal. The correct phase relationship is, of course, that in which the receive register contains the ten elements of each character in their proper order. A phasing step can be taken by omitting one of the drive pulses to the receiver distributor, which has the effect of moving the receive register by one element relative to the signal. Correct phase can be established by taking the appropriate number of phasing steps. When the receiver is out of phase the frequency of (false) correction and the detected error rate both increase sharply relative to normal in-phase operation. Certain threshold values can be set for these functions, which when exceeded cause the phasing process to be initiated automatically. Phasing steps can then be taken automatically until phase is established, as indicated by the error rate falling below another threshold value, checking for correct phase after each step. During the phasing process the output to the teleprinter is held on continuous stop polarity.

Indication of Detectable but Uncorrectable Errors:—As we have seen, the majority of errors which cannot be corrected are detected. When this occurs the 5-unit combination containing five start-polarity elements (not normally used on the teleprinter) can be transmitted on the output circuit to cause a special error symbol to be printed on a suitably modified teleprinter. When modifications to the teleprinter are undesirable, the 5-unit combination corresponding to "space" can be transmitted, and an uncorrectable error is then indicated by a gap in the printed copy.

Comparison with ARQ Operation

In both systems all single element errors in a character are corrected. The 10-unit code system cannot correct multiple errors while the ARQ system can correct some. However, the 10-unit code detects multiple errors more effectively than the 7-unit ARQ code, and therefore gives rise to fewer wrongly printed characters.

An exact comparison would have to take account of a great many factors and different results would be obtained in different circumstances. In general, the performance of the two systems is comparable when the signal-to-noise ratio is above a certain figure. Below this threshold an ARQ system, if using tested RQ or tested repetition cycle facility, will go into a condition of almost continuous repetition



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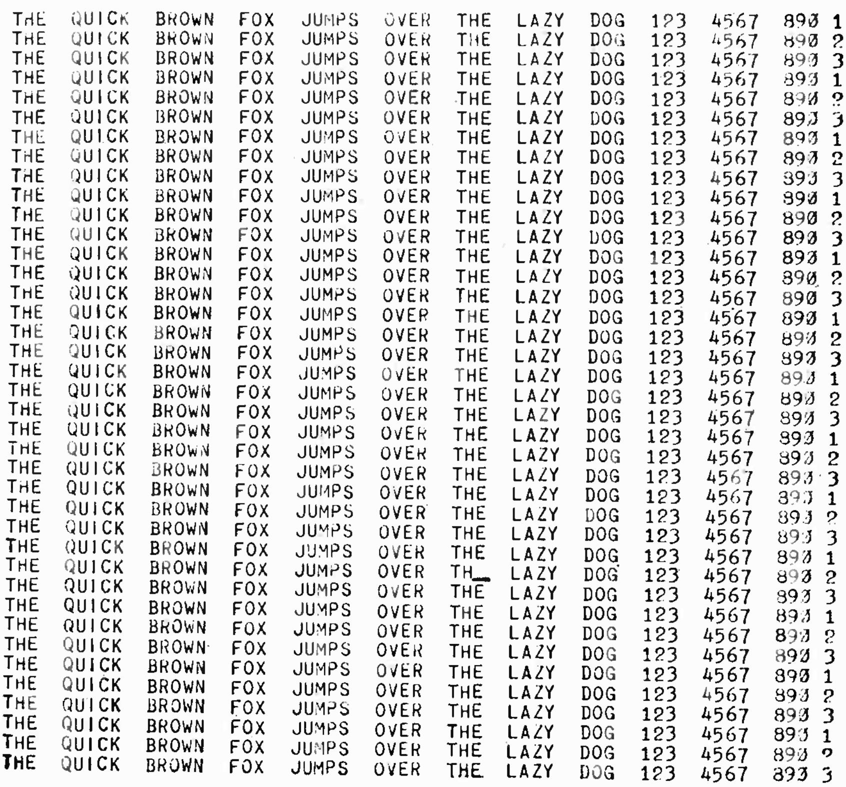
THE QUICK BROWN FOX JUMPS OVER THE LAZY LTG 123 4567 89Ø 1
THE QUICK BROWN FOX JUMPS OVER THE LAZY XDOG 123 4567 89Ø2
THE QUICK BROWN FOX JUMPS OVER _HE LAZY DOG 123 4547 89Ø 3

Fig. 4 Comparative tests on an intentionally "bad" circuit, showing (top) 5-unit traffic uncorrected and (bottom) the same message using "Autospec". Tests carried out under controlled conditions.



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cycling, so that few characters will be transmitted or printed[7], while the 10-unit code system, since it has no return circuit to prevent transmission, will result in characters being lost while error symbols are printed. For telex operation, for example, this would obviously not be permissible, but it could be acceptable for many applications as the performance is considerably better than that of a plain 5-unit code.

TABLE IV

Element Error Rate	Printed Character Error Rate		
	5-unit Start-Stop Tele-printer Code	10-unit Synchronous Error Correcting Code	
		Undetected	Detected but uncorrectable (Error symbol printed)
1 in 100	1 in 3	1 in 8,500	1 in 80
1 in 1,000	1 in 30	1 in 8,500,000	1 in 7,500
1 in 10,000	1 in 300	1 in 10^{10} approx.	1 in 700,000

Table IV shows the character error rates, corresponding to given element error rates, for systems using 5-unit start-stop teleprinter code and 10-unit synchronous error correcting code. The error rates given in the table assume that the probabilities of any elements being in error are the same, and allowance has been made for the loss of synchronism of the receiving teleprinter which will occur for a proportion of the errors.

Test Results

The following results were obtained in tests using the Marconi "Autospec" equipment shown in Fig. 2. This equipment uses the transistor logic modules first employed on the "Autoplex" ARQ equipment.

Test 1

In this test message blocks were transmitted alternately in direct 5-unit start-stop code and via "Autospec". The test was carried out in the laboratory between a double on-off VF channel modulator and a demodulator, with noise added; an HF receiver was used as the noise source. A sample of the received printed text is shown in Fig. 3. Detected but uncorrectable errors are shown by a + sign.

Test 2

In this test the same message was transmitted in 5-unit start-stop code and "Autospec" code simultaneously over two channels of a V.F.T. system applied to a 1 kW s.s.b. mobile transmitter operating on reduced power with whip aerials. The frequency was about 8 Mc/s and the range 15 miles. A sample of the received printed text is shown in Fig. 4. In this case detected but uncorrectable errors are shown by spaces; O/P in the margin indicates lines which have been over-printed due to the loss of a "line feed" character or to a false "carriage return".

Conclusions

Error detecting and correcting equipment, using the ARQ principle of repetition of detected errors to provide automatic error correction, has now been in use for some years on the more important HF telegraph circuits. The increasing usage of such systems is an indication of their value in improving the error rate, particularly of bad circuits. Their use is however confined to circuits where a return channel is available for requesting repetitions.

The great majority of HF telegraph circuits, however, do not operate with a "protected" code system for one reason or another; because the traffic capacity does not justify an elaborate terminal or, in the case of broadcast applications, that the return circuit requirement cannot be fulfilled. Error correcting terminals employing a 10-unit error correcting code can provide a relatively inexpensive and operationally simple means of reducing the error rates of these circuits.

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3. P. R. Keller and A. J. Wheeldon: "Recent Improvements in Automatic Error Correcting Systems for HF Telegraph Networks," *Point-to-Point Telecommunications*, Vol. 6, No. 2 (1962).

4. Recommendation No. 242 C.C.I.R. Green Book (Los Angeles 1959), Vol. 1, p. 130.

5. Report No. 108 C.C.I.R. Green Book (Los Angeles 1959), Vol. 3, p. 70.

6. R. W. Hammings: "Error Detecting and Error Correcting Codes." *Bell System Technical Journal*, April, 1950.

7. A. C. Croisdale: "Automatic Error Correcting Systems used on HF Radio Links," *I.E.E. Convention on HF Communication*, March 1963, Fig. 15.

CLUB NEWS

Dorking.—An informal discussion on "Aerials and methods of coupling" will be held by the Dorking & District Radio Society on March 10th at 8.0 at the "Wheatsheaf."

Eltham.—"DF expeditions" is the title of the talk to be given by A. J. Gould (G3JKY) at the meeting of the Cray Valley Radio Society on March 5th at 8.0 at the Congregational Church Hall, Court Road, London, S.E.9.

Halifax.—Members of the Northern Heights Amateur Radio Society are to visit the Tape Recorder Centre, Halifax, on March 18th.

Heckmondwike.—The March meetings of the Spen Valley Amateur Radio Society include a talk by S. Marsden entitled "Moon Bounce" on the 5th and another on silicon semiconductors by a representative of Standard Telephones and Cables on the 18th. Meetings are held at 7.15 at the Grammar School, High Street. The programme also includes a lecture on communication satellites at 3.15 on Saturday March 7th at the Griffin Hotel.

Melton Mowbray Amateur Radio Society is holding an open evening on March 26th to discuss beginners' problems. Monthly meetings are held at 7.30 at the St. John Ambulance Hall, Asfordby Hill.

New Cross.—On March 6th R. Steverson (G3JEQ) will talk to members of the Clifton Amateur Radio Society on portable transmitting equipment. The inter-club quiz with the Crystal Palace Amateur Radio Society will be held on March 21st and April 3rd. Meetings are held each Wednesday and Friday at 8.0 at 225 New Cross Road, London, S.E.14.

Plymouth.—At the March 3rd meeting of the Plymouth Radio Club R. P. Ellis (G3SN) will give a talk on high fidelity with demonstrations. Weekly meetings are held at 7.30 on Tuesdays at Virginia House, Bretonside.

MANUFACTURERS' PRODUCTS

NEW ELECTRONIC EQUIPMENT AND ACCESSORIES

Switch Kit

UP to 25 multi-section, OAK rotary switches can be constructed from the switch kit announced recently by N.S.F. Ltd. of 31-32 Alfred Place, London, W.C.1. The kit is supplied complete with eyeletting tool, blade-filing template and assembly instructions. The switches than can be assembled are the 12-position JK-type, with single-ball positive indexing and up to 22 contact positions. Two stops are provided for each switch, one fixed in the 12th position and another which is readily adjustable to act in any position from 2 to 11. An ancillary kit can be supplied to enable the construction of dual-concentric switches.

6WW 301 for further details

Beat Frequency Oscillator

MANY notable features are exhibited by the Type HO32 b.f.o. manufactured by Radiometer of Denmark. The total frequency coverage of the instrument is 0 to 21kc/s (0 to 20.5kc/s on the main dial and 0 to 500c/s on an incremental scale). The maximum power output of the oscillator is 4W which is available from a calibrated attenuator (300μV to 100V) via an output transformer which has tappings for impedance matching of various loads. The harmonic distortion is less than 0.1% for attenuator outputs below 10V. From 20c/s to 21kc/s the output remains level within 0.3dB.

After a warm-up period of 15 minutes the drift is less than 15c/s during the first hour and less than 2c/s per hour after the first hour of continuous use. A mains voltage variation of 5% will cause a frequency drift of 1c/s.

The instrument can be used as an a.f. amplifier. The cost is £106 (exclusive of duty) and the instrument can be obtained in the U.K. from Livingston Laboratories.

6WW 302 for further details

Sub-miniature Switch

TWO sub-miniature switches have been developed by Miniature Electronic Components Ltd., Woking, Surrey, for on/off switching applications where space is limited. Both types are single-pole change-over switches and both are intended for panel mounting. The toggle-operating pressure is nominally 60gm and the working temperature range is stated by the makers to be 0°C to 85°C. (In "dry" conditions the switches can be operated down to −40°C.) The Type TS70 switch has silver internal contacts and is rated at 1A (resistive) at 50V, direct, or 0.25A at 125V alternating. Switch Type TS71 has gold-plated contacts and the rating is 100mA at 1V, direct. Apart from the internal contacts and the associated contact resistances both switches are similar. The switches weigh 1.5gm each and the overall length from toggle tip to end of terminals is 1.31in. The switch body, however, is only 0.5in long The diameter is 0.25in.

6WW 303 for further details

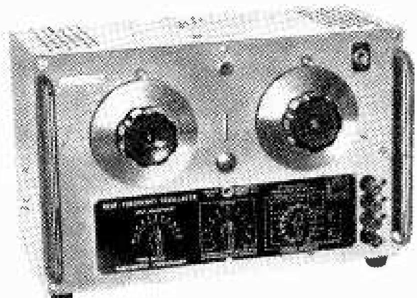
Pre-set Timers

THE existing range of Haydon timers has been increased by a new series of low-cost timers. Two basic models are available. The Type DA1003 delay timer employs a Haydon clutch motor and has a maximum delay time of up to 8.5 minutes. When the motor is energized, the clutch engages and the motor drives a cam, which, at the end of a set-time delay actuates a switch. The Type CA 1004 cycle timer employs a single adjustable cam. Standard time cycles available range from 1/60 to 8 r.p.m. in 14 values. The switches used on both units are rated at 110/240V 50/60 c/s and are 5A change-over types. Haydon timers are manufactured by Ether Ltd., Stevenage, Herts.

6WW 304 for further details

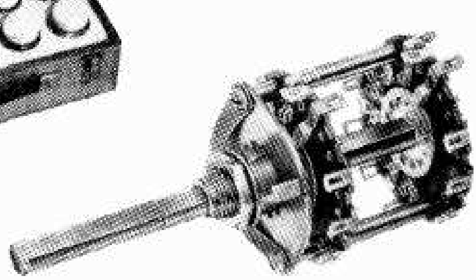
Carrier Modulation Amplifier

TWO MODULATED carrier outputs with a crystal-controlled carrier frequency of 10kc/s can be obtained from the Derritron dual-phase carrier modulation amplifier, the phase relation of the two modulations being 180°. The amplifier was designed for use with very low frequency vibration techniques and the modulation system consists of a stage capable of modulating the carrier with fre-



▲

The Type HO32 beat frequency oscillator, manufactured by Radiometer, can also be used as an audio amplifier.



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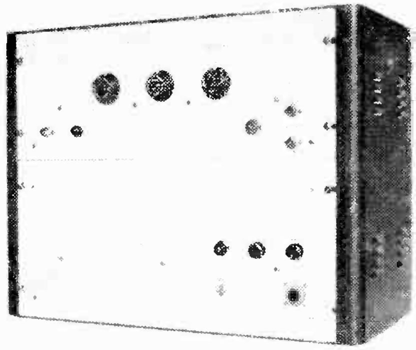
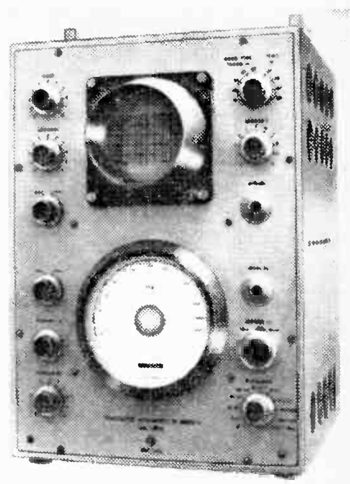
Type JK OAK switch and kit of parts supplied by N.S.F. Switches.

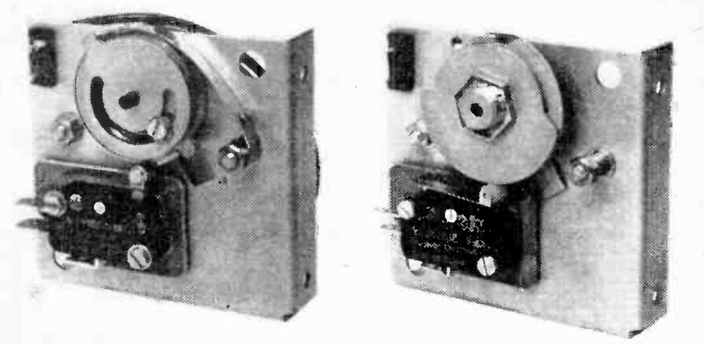
Switch from the T.S. Series manufactured by Miniature Electronic Components. (Compared in size with 1d.)



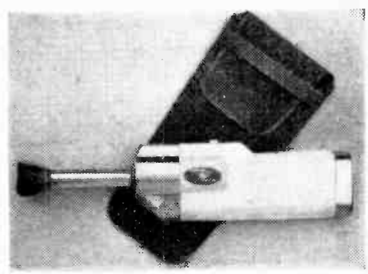
Derritron dual-phase carrier modulation amplifier with power-supply unit. The equipment can be installed in a 19-in rack.



C.R.B. automatic frequency tracer Type TAR/61. Provision is made for connection of a compression amplifier in the oscillator section to compensate for non-linearity in secondary transducer equipment.



Type DA1003 delay timer and Type CA1004 cycle timer (Haydon division of Ether).



UN "Auto Brush" miniature vacuum cleaner. (Distributed in the U.K. by Henri Picard & Frère Ltd.)

quencies between 1c/s and 130c/s. Up to 90% modulation depths can be obtained with less than 4% second harmonic and 2% third harmonic distortion. Modulation levels in excess of 90% are limited by a clipper stage and an indicator lamp indicates over-modulation. For 90% modulation, the input signal required is less than 2V r.m.s., the impedance being 50kΩ. A stabilized power supply requiring a 200/250V alternating mains supply is incorporated in the equipment which is constructed in a 19-in rack.

6WW 305 for further details

Automatic Frequency Response Tracer

FREQUENCY response tests and adjustments of amplifiers, filters, microphones and other audio frequency equipments may easily be made with the Type TAR/61 automatic frequency response tracer manufactured by C.R.B. of Ancona, Italy. Essentially the instrument is an audio-frequency spectrum analyser consisting of a low distortion (less than 1.5% for 1W output) beat-frequency oscillator, power amplifier and a tracer unit with cathode ray tube. The oscillator is swept repetitively over the range 20c/s to 20kc/s by a motor drive. The c.r.t. graticule is calibrated vertically in terms of decibels and milliwatts and horizontally in terms of frequency. The trace persistence is sufficiently long to permit superimposition of successive sweeps for comparison purposes. The instrument weighs 96lb and the dimensions are 21×15×18in. Available from Claude Lyons Instrument Division, Old Hall Street, Liverpool 3, the cost is £490 exclusive of duty.

6WW 306 for further details

Miniature Vacuum Cleaner

A MINIATURE vacuum cleaner, manufactured in Japan, which can remove dust by brushing combined with either suction or blowing is being distributed in the U.K. by Henri Picard and Frère Ltd. The tool is powered by two Type UM/3, or equivalent, dry batteries (pen-torch size). The cleaner resembles a hand torch to either end of which a brush can be fitted. The internal air filter can be removed for cleaning purposes. The overall length including a $2\frac{1}{4}$in removable brush is 7in; the diameter is approximately 1in. The cost is 29s 6d.

6WW 307 for further details

Power Transistors

TWO power transistors intended mainly for the output stages of servo-amplifier circuits have been introduced by SGS-Fairchild, Ruislip, Middlesex. Packaged in $\frac{7}{16}$in hexagonal power cans they are designated Types 2N2892 and 2N2893. They are also available in TO-5 cans when they are designated 2N2890 and 2N2891. Both types feature a flat gain characteristic from 100mA to 2A and usable characteristics from 1mA to 5A. Collector saturation voltage is 0.35V at 2A and collector cut-off current is typically 0.002mA at 60V. The minimum h_{FE} at 1A is 50 (2N2893 and 2N2891) and 30 (2N2892 and 2N2890). The transistors are silicon planar epitaxial types and the 2N2892 will deliver 12W at 20 Mc/s with 55% efficiency as an amplifier with a 33V supply. Inverter circuits can be operated above 10kc/s using these transistors.

6WW 308 for further details

Coaxial Reflectometers

USERS of v.h.f. and u.h.f. equipment may be interested in a new range of coaxial reflectometers suitable for permanent installation in coaxial lines for monitoring incident and reflected power. Notable features of the reflectometers, which are produced by A. T. & E. of Bridgnorth, are their high-power handling capacity and low insertion loss. At present, the types available cover a frequency range of 50 to 500 Mc/s. One designed for use over the range 150 to 300 Mc/s has a minimum directivity of 40dB and the maximum primary line standing wave ratio is better than 1.05:1. The power handling capacity is limited to 300W. The coupler sensitivity is 500μA for 10W incident power.

6WW 309 for further details

Component Bins and Trolley

SMALL components can easily be stored and transported from stores to bench, etc., by the Kabi "Plastibox" series of plastic component trays. The contents of the storage boxes are immediately visible and the accessibility is good. The trays are mounted on trolleys with rubber-tyred castors. The manufacturers are Kabi Electrical and Plastics Ltd., Potters Bar, Middlesex.

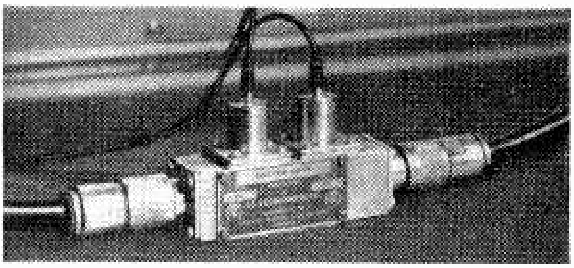
6WW 310 for further details

Digital Phase Meter

PHASE angles from 0 to 360 degrees may be measured directly between any two alternating voltages from 20c/s to 500kc/s by the digital phase meter Type 524A manufactured by Ad-Yu Electronics. A 4-digit indication system is used, the last digit indicating tenths of one degree.

Measurements may be made irrespective of fluctuations in amplitude of either or both waveforms over the range 0.3 to 50V r.m.s. The input impedance of both channels is 3MΩ shunted by 30pF. Output signals in both digital and analogue form can be made available for recording or system programming. Between 20c/s and 20kc/s the accuracy of measurement is maintained to within the limits of ±0.3 of one degree. The instrument can be obtained in the U.K. from B. & K. Laboratories, Park Lane, London, W.1.

6WW 311 for further details

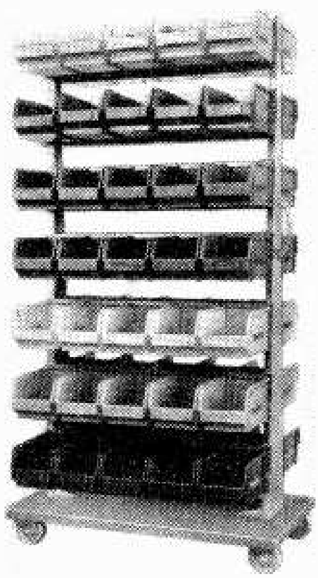


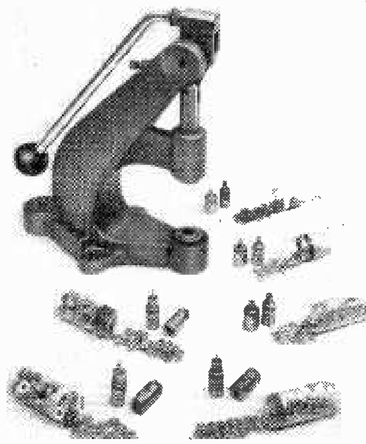
◀ *V.h.f./u.h.f. coaxial reflectometer manufactured by A. T. & E. Bridgnorth will handle powers up to 300w.*

"Prestincert" Tool Kit

A PORTABLE Prestincert insertion press can now be obtained from Belling-Lee of Enfield, Middlesex, together with six pairs of insertion tools, colour coded to the appropriate Prestincert component, three sizes of threaded brushes and three types of terminal posts. The components are inserted into sheet metal and many synthetic insulation materials without the necessity of having to drill holes before insertion or riveting after. The push-fit, paired insertion tools are retained in the press by a spring clip. The kit is supplied in a robust transit case. Additional supplies of threaded brushes and terminal posts are readily available.

6WW 312 for further details





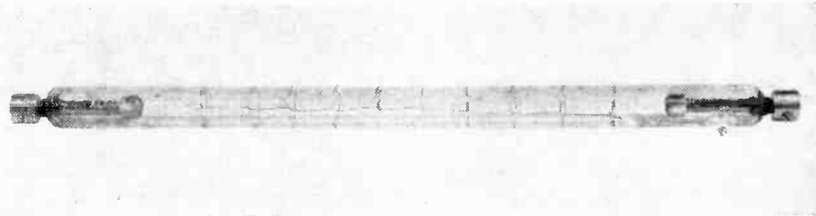
▲ *"Prestincert" portable kit supplied by Belling-Lee. The insertion tools are colour coded to conform with the coloured band on the component containers.*

◀ *Kabi "Pastibox" trolley and component storage trays.*

Insulation Measurement

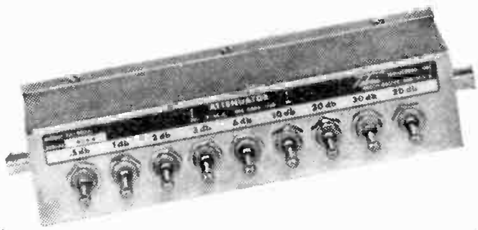
THE insulation meter, Type 190, manufactured by Comark Electronics, Littlehampton, Sussex, is battery powered and insulation resistances of up to 1,000MΩ may be determined with test voltages of 100, 250 and 500V. Indication is by meter with a 3½in scale length and a push-to-read button switches the instrument on. The maximum current is limited to 50μA, the limiting circuit reduces the test voltage proportionately from its full value under open circuit conditions to zero resistance at full scale. In addition to the resistance scale, a current scale (0-50μA) permits leakage-current measurements of semiconductors, diodes, etc. The faceplate of the unit is plastic and the case is an alloy and p.v.c. laminate. The test voltages are produced by an inverter from a mercury cell which can be replaced by unscrewing

(*Continued on page* 125)

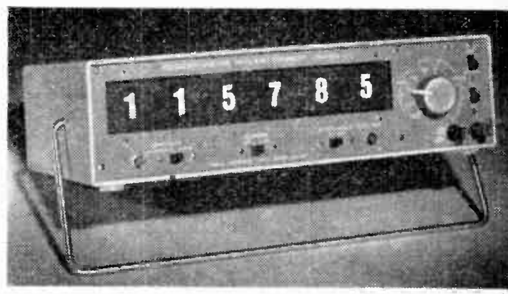


▲ *Type XL605 quartz flash tube manufactured by English Electric Valve Company.*

▲ *Comark insulation meter Type 190.*



▲ *TG-9050 r.f. attenuator for use over a frequency range of 0 to 300 Mc/s (Telonic Industries).*



▲ *Electronic counter/timer Type TSA 3436 manufactured by Venner Electronics.*

a small cover plate. The instrument measures $6\frac{1}{4}\times5\times3\frac{1}{2}$in and weighs 2.5lbs. It can be operated over the temperature range 0 to 35°C. The cost is £27.

6WW 313 for further details

R-f Attenuator

A TOGGLE - SWITCH operated attenuator permitting attenuation from 0 to 82.5dB in steps of 0.5dB over a frequency range of 0 to 300 Mc/s is being manufactured by Telonic Industries of Beechgrove, Indiana. Precision carbon-film resistors are used in the π pads and each pad is individually shielded. The attenuator is double shielded to minimize leakage. The insertion loss is quoted as less than 1dB at 100 Mc/s and less than 3dB at 300 Mc/s. B.N.C. connectors are used for both input and output and the attenuators are rated at 0.5W. The 50Ω version is designated Type TG-9050 and the 75Ω version TG9075.

6WW 314 for further details

Ruby Laser Flash Tubes

TWO quartz flash tubes, Types XL604 and XL605, have been introduced recently by the English Electric Valve Company, Chelmsford, Essex. The linear tubes, intended for ruby laser excitation, are filled with a gas mixture which, when triggered, gives a light output spectrum similar to the absorption characteristics of ruby laser crystals.

The maximum input energy, per flash, of the Type XL604 is 1,250 joules with a nominal duration of 1msec. It has an arc length of 5.5in and the flash rate is 2 per minute. The maximum input energy of the XL605 tube is 5,000 joules per flash with a nominal duration of 3msec. The flash rate of this tube is one every two minutes and length of arc of 6.5in. The maximum operating voltage of both tubes is 3kV.

6WW 315 for further details

Timer/Frequency Meter

FREQUENCY measurement up to 1.2 Mc/s and time measurement from 1 μsec to 100,000 sec is possible with the Venner Electronics TSA3436 general-purpose counter timer. Transistors are used throughout and indication is given by a 6-digit, in-line readout. The oven-controlled crystal oscillator has a stability of ±1 part in 10^6 and the accuracy of frequency measurement is claimed to be ±1 count, $\pm$ crystal stability. With the input switch in the "A.C." position, the input impedance is 70 kΩ (25 pF). The minimum input is 100 mV, the maximum being 50 V r.m.s. In the "D.C." position the impedance is 1 kΩ shunted by 500 pF; the input voltage range being 1 to 50 V peak. Three gating times, 0.1, 1.0 and 10 sec, are provided. Positive-going pulses of 5 to 10 V amplitude with rise times of not more than 0.2 μsec and widths of not less than 0.5 μsec are required for driving the gating circuits. The counter measures $14\frac{1}{4}\times3\frac{7}{8}\times10\frac{1}{2}$in and weighs 13lb. Power supplies of 100 to 125V or 200 to 250V 40-60 c/s are required. Alternatively the instrument may be powered by a 12V direct-current source. The manufacturer's address is Kingston By-Pass, New Malden, Surrey.

6WW 316 for further details

Mains Failure Alarm

USING four 1.5V dry cells as a power source, the Thorn M.F. alarm is a detector unit giving both audible and visual warning signals in the event of a power supply failure. Facilities are provided for giving alarm signals more than a mile away from the monitoring point. The equipment is housed in a metal case measuring $6\times4\times3$in. The alarm bell and red signal lamp are operated by a relay when the alarm mechanism is triggered off. The unit can be obtained from Thorn Electronics Ltd., Judd Street, London, W.C.1.

6WW 317 for further details

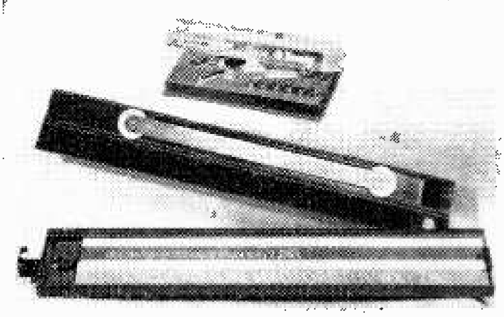
Silicone Grease

SILICONE grease M.494, produced by the Nobel Division of I.C.I., is inert and stable over a wide temperature range. Over the range

−50 to 200°C it is claimed to remain essentially unaltered. Being highly water repellent, the grease may be used for the protection of surfaces against moisture, for sealing electronic equipment, as a wide-temperature, light-duty lubricant and as a release agent. M.494 Dispersion has been introduced to aid application by spraying, brushing or dipping.

The grease complies with the provisional specification TS.379 of the War Office Chemical Inspectorate. The colour of both grease and dispersion is light grey. The specific gravity of the former is 1.0, that of the latter being 1.2. The electric strength of the grease (0.05in gap) is greater than 300V/mil, the dielectric constant less than 2.9 and the power factor is less than 0.0025. The dispersion fluid upon which the grease is based is non-inflammable and has an extremely low level of toxicity. The Nobel Division Silicones Department of Imperial Chemical Industries is located at Stevenston, Ayrshire, Scotland.

6WW 318 for further details



Copiograph lettering set manufactured by Tecnostyl of Italy and distributed in the U.K. by Westwood Stationery.

T.S.L. "Continental"-type audio plugs and sockets manufactured in the U.K.

"Continental" Audio Connectors

FOLLOWING recent attempts to standardize input and output connections on audio equipment, Technical Suppliers, Goldhawk Road, London, W.12, can now supply British multi-pole plugs and sockets manufactured to D.I.N. standards. A typical plug consists of a moulded non-conducting outer sleeve under which is found the screening sleeve which extends to beyond the limits of the conductors. A locking ring and multi-pole contact unit completes the assembly.

6WW 319 for further details

Magnetic Tape Copying

UP to 25 copies of 1,200ft tapes can be produced in an eight-hour day by a single operator using the new Ampex PD-10 tape duplicator. The copying machine can also be used to record, simultaneously, up to three master tapes of the same source material from microphone or line inputs. The standard PD-10 equipment consists of one master and three slave recorders which will produce up to three duplicates at a time. Master and duplicate recordings can be either mono or stereophonic. The standard speeds provided are $1\frac{7}{8}$, $3\frac{3}{4}$, $7\frac{1}{2}$ or 15in/sec. Copies may be decreased in speed from the master by one standard speed.

When recorded for replaying at speeds at $7\frac{1}{2}$ and 15in/sec the maximum deviation of frequency response of copy from master is +2 to −4dB over a frequency range of 50 to 15,000 c/s. The equipment will not introduce more than 3dB noise on duplicates and the percentage wow and flutter introduced is not more than 0.25% r.m.s. (measured to A.S.A. standards).

The DP-10 equipment can be obtained from Ampex Great Britain Ltd., Reading, Berks, and the cost is claimed to be less than half that of previous copying equipment.

6WW 320 for further details

INFORMATION SERVICE FOR PROFESSIONAL READERS

To expedite requests for further information on products appearing in the editorial and advertisement pages of *Wireless World* each month, a sheet of reader service cards is included in this issue. The cards will be found between advertisement pages 16 and 19.

We invite readers to make use of these cards for all inquiries dealing with specific products. Many editorial items and all advertisements are coded with a number, prefixed by 6WW, and it is then necessary only to enter the number(s) on the card.

Readers will appreciate the advantage of being able to fold out the sheet of cards, enabling them to make entries while studying the editorial and advertisement pages.

Postage is free in the U.K., but cards must be stamped if posted overseas. This service will enable professional readers to obtain the additional information they require quickly and easily.

Lettering Equipment

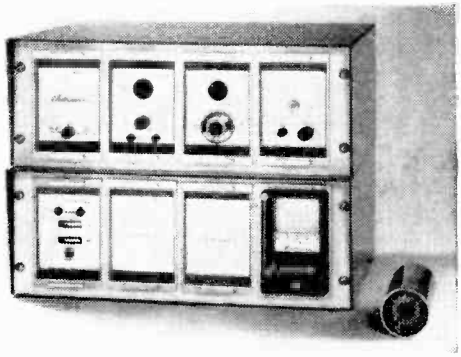
LABELLING in a variety of sizes can be obtained by the use of one stencil and a pantograph scriber unit. The Copiograph lettering set comprising a template set and the scriber unit allows the user to produce upright or sloping characters, in different thicknesses, from the same template. The pantograph device can be used for ink or pencil lettering. The four templates are supplied in a plastic box, the lid of which serves as a holder and straight-edge for the stencil in use. The scriber unit includes five interchangeable pens and a lead holder. Costing £8 8s, the equipment is available from Westwood Stationery, Islington Park Street, London, N.W.1.

6WW 321 for further details

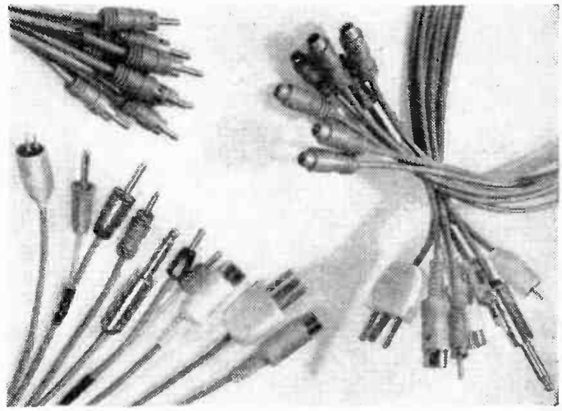
Nuclear Instrumentation

BASED on a modular design, the new series of Victoreen Instrument

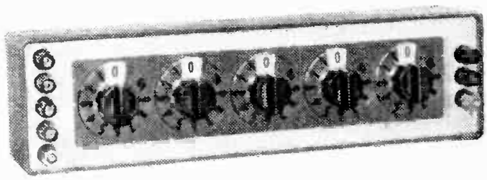
▲ *Electro Instruments digital deviation ohmmeter Model 6202.*



▲ *Single channel analyser/ratemeter from the 830 series of Victoreen nuclear instrumentation.*



▲ *Complete set of input and output connecting leads for audio equipment (Tape Recorder Maintenance).*



▲ *Model DT58 alternating-voltage divider available in the U.K. from Livingston Laboratories.*

nuclear instrumentation is available in the U.K. from A.E.P. International Ltd., Hounslow, Middlesex. Component instruments of this 830 Series include recording log alarm ratemeter, log or linear count ratemeter and scalers. Solid state printed circuitry is used throughout.

6WW 322 for further details

Digital Deviation Ohmmeter

THE Model 6200 digital deviation ohmmeter manufactured by Electro Instruments will measure and indicate, on a 3-digit Nixie-tube readout, resistance deviations from ±5% to ±0.01% of a given value. Resistances may be compared with an external standard resistor or with a resistance decade unit Model 6203 which can be supplied as an accessory and provides measurement ranges from 1Ω to 10MΩ. The average readout time is 1 second, thus the equipment can be used for fairly rapid sorting or grading of resistors in large quantities. Automatic temperature-coefficient measurements may also be made. An unusual feature of the in-line readout is that it can be tilted and locked into any one of three positions. The readout includes a positive or negative sign which automatically indicates the direction of deviation. Except at the range extremities, where the accuracy of measurement is within 0.1%, the general accuracy is of the order of 0.01%, ±1 digit. The equipment may be rack mounted. The cost of the complete equipment, exclusive of duty, is approximately £1,520 (including power supply and the Model 6203 resistance decade unit). The U.K. agents are Livingston Laboratories Ltd.

6WW 323 for further details

Interconnecting Leads

THE lack of standardization of input and output plugs and sockets on audio equipment often causes a great deal of time wasting during servicing, or during usage. With this in mind, Tape Recorder Maintenance of 323 Kennington Road, S.E.11, have produced a series of leads divided into two groups, input and output, such that any output lead may be linked to any input lead via a "phono" connection. The other ends of the leads are fitted with different plugs such as 0.125in wander plugs, 6mm banana plugs, jack plugs of varying diameter, "phono" and Philips p.u. plug, etc. In all, ten output types are provided, which, with the ten input varieties effect a 100 interconnection combinations. A 6ft extension lead permits the length of any pair to be increased from 6ft to 12ft. The leads may be purchased individually and a complete set of 20 leads costs £6 6s.

6WW 324 for further details

Alternating Voltage Divider

AMONG the applications of a new series of decade-transformer voltage dividers are turns-ratio measurement, impedance comparison and divider calibration. Manufactured by Electro Scientific Industries and available in the U.K. from Livingston Laboratories the Model DT58 from the series is a 5-decade alternating voltage divider with a terminal linearity of 5 p.p.m. over the frequency range 50 c/s to 1 kc/s. The frequency range of the divider is 50 c/s to 10 kc/s and the maximum input voltage is 350V r.m.s. above 1 kc/s decreasing to 35V r.m.s. at 100 c/s. The maximum division ratio is 1.1111.

Gapless torroidal cores are used in the transformers which are encapsulated. The switches are arranged so that a 10% overlap is provided between decades. The instrument is housed in an aluminium case and the total weight is 9.5lb. Excluding duty, the Model DT58 costs £118.

6WW 325 for further details

Elements of Transistor Pulse Circuits

3.—TRANSISTOR ASTABLE MULTIVIBRATORS

By T. D. TOWERS,* M.B.E.

IN pulse electronics, a common requirement is for a circuit to give abrupt transitions between two different electrical states (usually high and low voltage). There are three main types of such two-state circuits:

(a) *astable*, i.e. switching continuously between the two states at a constant repetition rate without external excitation.

(b) *monostable*, i.e. normally lying in one state, but, when suitably triggered by an external signal, passing into the other, remaining there for a pre-set time, and then returning to the first state of its own accord without further triggering.

(c) *bistable*, i.e. capable of remaining indefinitely in either of two states, passing from one to the other only when externally triggered.

The astable two-state circuit is often referred to as "free-running," and the monostable and bistable circuits as "triggered." This may perhaps be found a little ambiguous, because the astable circuit can also be triggered by a series of synchronizing pulses of a higher frequency than its natural one.

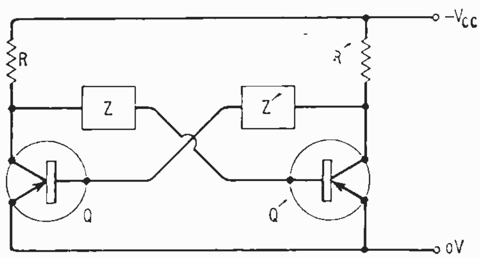


Fig. 32. Basic transistor multivibrator circuit.

The Multivibrator Family

The most widely used two-state circuit is probably the "multivibrator." This is a two-stage amplifier with phase inversion over each stage and with the output heavily coupled back to the input. The feed-back is thus large and positive. Due to regeneration the circuit can then be made to pass very rapidly from one to the other of its two possible limiting states.

The multivibrator first made its appearance (with valves) in April 1918, in a report by H. Abraham and E. Bloch, "Notice Sur Les Lampes-Valves à 3 Electrodes et Leurs Applications" (Publication No. 27 of the French Ministère de la Guerre). In this form the multivibrator was free running, but W. H. Eccles and F. W. Jordan soon reported a bistable version (in the *Radio Review*, 1919, Vol. 1, page 143).

In one form or another, the multivibrator has proved to be a ubiquitous tool in pulse circuitry. Over the half century since its discovery it has been much analysed and discussed. It has been used under many different names. The convenient colloquial abbreviation "multi" has become firmly accepted and we will use this for its brevity. Other terms that will be found in the literature are listed below.

(a) *Astable*: astable multi, multi (by itself), Abraham-Bloch circuit, free-running multi, square-wave generator, unstable multi, AMV.

(b) *Monostable*: monostable multi, monostable (by itself), univibrator, monovibrator, delay multi, one-shot, single-cycle, single-step multi, gating multi, MMV.

(c) *Bistable*: bistable multi, bistable (by itself), flip-flop, trigger, Eccles-Jordan, binary, toggle, scale-of-two, BMV.

The basic operating principle of the transistor multi family is illustrated by Fig. 32. It is the transistor equivalent of the anode-coupled multi originally developed with valves. The output from the collector of a transistor Q is fed through an impedance Z to the base input of another transistor Q′. This second transistor gives out from its collector a corresponding amplified and phase-inverted output which is fed back through an impedance Z′ to the input of the first transistor, Q. The signal is now further amplified and phase-inverted through Q, so that an initial signal at the collector of Q reappears at the same point greatly amplified and in the same phase. The circuit will therefore tend to go into violent oscillation. What actually happens depends upon the nature of the cross-coupling impedances Z and Z′. If they are both capacitances, the multi will be astable. If one is a capacitance and one a resistance, the system will be monostable. If both cross-coupling impedances are resistances, the system is bistable. This article deals with the first of these circuits.

The Astable Multivibrator

The astable multi is a self-driven oscillator which generates a train of rectangular waves, and, since it requires no triggering signals, it is widely used as a primary source of pulses. The basic transistor circuit is illustrated in Fig. 33 (note that both cross-coupling impedances are capacitances). Other astable multis using different feedback circuits are

*Newmarket Transistors Ltd.

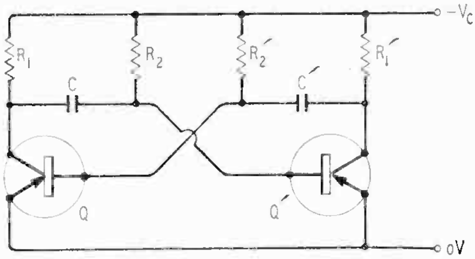


Fig. 33. Elementary astable multivibrator.

possible, but the collector-coupled version is by far the commonest and so we use it to illustrate the features of the basic circuit.

Operating Principle of Astable Multi.—To understand how the circuit of Fig. 33 works, the waveforms given in Fig. 34 are needed (with negative voltages upwards for p-n-p transistors). The sequence of operations is as follows. When the circuit is first switched on, both transistors tend to conduct because current is supplied to the bases through R_2 and R'_2. The positive feedback from output to input takes the circuit into oscillation between states where one transistor is on and the other off. At the end of period (1) in Fig. 34, the base voltage of the left-hand transistor Q is rising towards zero volts. As the base passes through zero and rises negatively, Q starts to conduct and causes the collector voltage of the transistor to drop towards zero. This voltage drop is transmitted to the base of the other transistor Q′ via the coupling capacitor C and causes a rise in Q′ collector voltage. This rise is applied back to the base of Q via the coupling capacitor C′, so causing a further increase in the collector current in Q. The action develops cumulatively and causes the base voltage of Q to rise rapidly to a small negative value and its collector voltage to drop close to zero. At the same time the base of Q′ drops to a large positive value (well beyond the Q′ base cut-off value), and its collector rises close to the supply voltage. Note that the base of Q cannot rise above the small negative value because the flow of base current in the transistor input makes the base-emitter resistance small and limits the voltage developed across it. In this rapid switch over, the circuit is said to " flip."

The regenerative switching stage is now complete and the circuit is then said to " relax " during period (2) in Fig. 34. (This is the origin of the description " relaxation oscillator " sometimes applied to this multi). During this period, two things happen. First, C′ *charges* via R'_1 and the low resistance base-emitter path of Q, thus causing the base of Q to return towards zero with a time constant $C'R'_1$ and the collector of Q′ to rise towards the rail voltage V_{cc}, with the same time constant. Secondly, C *discharges* through R_2 and the base voltage of Q′ rises towards zero with a time constant CR_2.

As soon as Q′ base rises through zero at the end of period (2), Q′ starts to conduct, the sudden regenerative action takes place all over again and the circuit " flops " through the unstable transition state once more. Regeneration ceases at the beginning of stage (3) when Q is cut off by the base going positive. Stage (3) now sees a further quiet or relaxed period when C *charges* via R_1 and the low resistance base emitter path of Q′, causing Q′ base voltage to drop towards V_{BE} with a time constant CR_1, and Q collector voltage to rise towards V_{cc} with the same time constant. Also during stage (3), C′ discharges through R'_2 and the base voltage of Q rises towards zero with a time constant $C'R'_2$. When Q re-conducts, sudden amplification and regeneration take place again, the circuit flips through the unstable transition stage once more and the cycle repeats itself.

To make the rise in collector voltage to V_{cc} rapid, the time constants CR_1 and $C'R'_1$ should be short. For this, it is usual to make the collector load resistors R_1 and R'_1 fairly low values, and to keep C and C′ as low as possible. The capacitor values cannot be selected without restriction, however, as they are also dependent on the repetition rate (oscillation frequency) desired.

Oscillation Frequency of Astable Multi.—The frequency at which the astable multi oscillates is set principally by the time constants CR_2 and $C'R'_2$ in Fig. 33, although it is also affected slightly by other factors such as the collector leakage current, I_{cbo}, and the base-emitter drive voltage, V_{BE}, of the transistors used. Also for high frequency operation, transistor internal and circuit stray capacitances become significant. To a first approximation, however, at relatively low frequencies it can be shown that the period of oscillation is expressed by

$$T(\text{seconds}) = 1/f = 0.7(CR_2 + C'R'_2).$$

Square Wave Generator.—In the circuit described above, the duration of the negative and positive going parts of each collector waveform is unequal, i.e. the circuit is " asymmetrical." It is

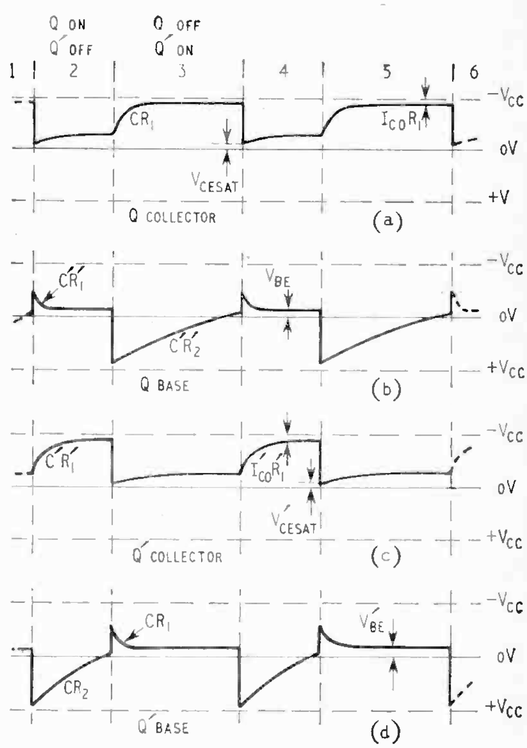


Fig. 34. Waveforms of astable multivibrator of Fig. 33.

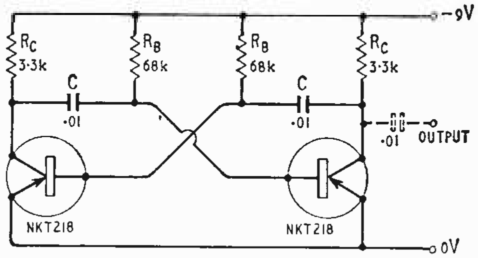


Fig. 35. Simple 1kc/s astable multivibrator or square-wave generator.

possible, however, to make the two parts of equal duration, if the time constants CR_2 and $C'R'_2$ are made equal. Most commonly the circuit is made completely symmetrical with $C = C'$, $R_1 = R'_1$ and $R_2 = R'_2$. The circuit is then known as a "symmetrical" multi or "square wave generator" because of the collector waveform. The period of oscillation becomes 1.4CR and the frequency 1/(1.4CR).

Practical Design of Astable Multi.—A precise paper design of an astable multi is quite complex, but the simple practical 1kc/s square wave generator shown in Fig. 35 can be used to illustrate at least the more important design points.

The voltage ratings of the transistors can be worked out from the waveforms of Fig. 34. They must have a V_{ce} rating at least equal to the d.c. supply voltage. Also the bass-emitter junction sees a peak reverse voltage equal to the supply voltage and the collector-base junction nearly twice this. In the circuit of Fig. 35 this means V_{ce}, V_{cb}, V_{eb} ratings of 9V, 18V,.9V respectively. The NKT 214, a conventional p-n-p germanium audio transistor, has ratings better than this.

The battery voltage is selected at 9V in Fig. 35 because this is fast becoming a practical semi-preferred value for transistor low level circuits and a wide range of standard dry batteries is available at this voltage.

The value of the collector resistor, R_c, is decided by the current to be switched. Now the current gain of most modern germanium audio transistors tends to fall off somewhat below 1mA. We have therefore chosen a collector load resistor of 3,300 ohms, because this means that when a transistor is switched hard on and its collector is down nearly at positive rail voltage, the full rail voltage dropping across 3,300 ohms gives a collector current of just under 3mA. (This is, incidentally, the mean current taken by the circuit from the supply, since at any point in time either one or other transistor is switched on.)

The base resistor values are then selected to ensure that the lowest gain transistor is switched firmly on. Now the NKT 214 has a minimum current gain of 30, so that if we take a base resistance some twenty times the collector resistance, we will ensure that the transistor bottoms firmly when switched on, because the actual base current will be more than one thirtieth of the desired collector current. The preferred value of 68,000 ohms is therefore used.

For a frequency, $f = 1{,}000$ c/s, the timing capacitor values, given by $1/(1.4fR_B)$, where R_B=base feed resistance, work out at approximately 0.01μF.

The output from an astable multi can be taken from either collector. The load resistance is then in parallel with the collector resistance, but it has only a second order effect on the repetition frequency because the collector resistor does not appear in the approximate frequency formula. In Fig. 35, the output can be taken off from the right hand collector (through a 0.1μF d.c. isolating capacitor if desired), and this simple circuit makes a useful 1kc/s square wave test oscillator, with an output impedance of 3,300 ohms.

High Frequency Limitations.—The simple astable multi circuit shown cannot be made to operate above a certain repetition rate. Up to about 20 kc/s a conventional audio transistor such as the NKT 214 can be used satisfactorily. Up to 100 kc/s an alloy r.f. transistor can be used. Above this frequency recourse must be made to alloy diffused or other u.h.f. types, but precautions are necessary to ensure that the emitter-base voltage ratings of these are not exceeded because they are usually somewhat limited. In the audio and supersonic range the transistor is usually the limiting factor in speed of operation. It is only when we get into the r.f. range that circuit strays become significant compared with the transistor limitations.

The switching speed of the transistor itself is limited by three things—hole storage, interelectrode capacitances and fall-off of current gain with frequency. Special techniques such as non-saturated switching (e.g. diode clamping of transistor collectors) can be used to increase the available repetition rate, but in general it is difficult, with any given transistor, to increase the repetition rate more than two or three times in this way.

Low Frequency Limitations.—In the low frequency direction, the repetition rate of a simple astable multi circuit of the type shown is also limited. Since the repetition rate is proportion to $1/CR_B$ to get very low frequencies we must increase the CR_B product as far as possible. Now R_B cannot be increased above a certain value fixed by R_C and the current gain of the transistors. If we want to reduce repetition rate beyond a certain point, we can do this only by increasing the cross coupling capacitors, C. Unfortunately, to do so in practical circuits we are compelled to use electrolytic capacitors, and above a certain value of these we find the leakage currents upset the timing constants. This prevents reducing the repetition rates any further. Transistor leakage currents, too, become significant and make it difficult to get very low repetition rates. However, one effective way exists of reaching lower frequencies;

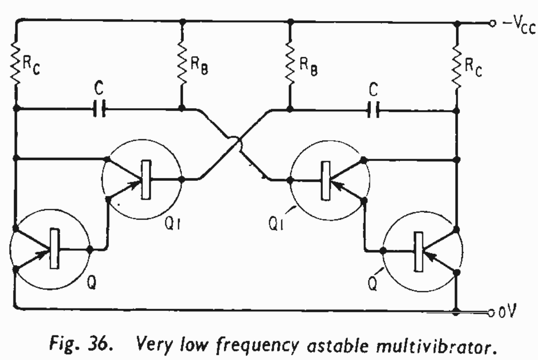


Fig. 36. Very low frequency astable multivibrator.

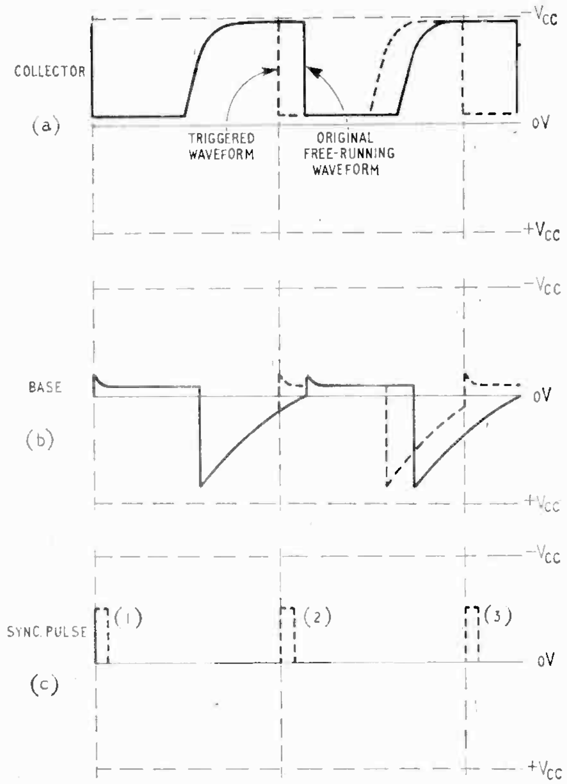


Fig. 37. Wave-shapes of synchronized astable multivibrator.

this is to increase R_B rather than C. This we can do if we can get transistors with sufficiently high current gain. Single transistors with current gains in excess of a hundred are not freely obtainable commercially, but a simple Darlington pair such as shown in Fig. 36 gives a compound current gain of the order of a thousand. This makes possible base resistors an order of magnitude higher than feasible with single transistors, and thus extends the lower frequency limit of the simple multi by a factor of 10 at least.

We have been illustrating the principles only of the astable multi by the simplest possible circuit, but in practice real circuits are much more complex. Frequently, to define the voltage levels accurately, and to give the fastest possible rise and fall times, the circuit is operated in a non-saturated mode. This means that the transistor is not allowed to switch hard into bottoming, with resultant long hole-storage and switch-off times. Another variant often found is to supply the direct voltage to the bases from a separately controlled rail. By varying this base supply voltage it is possible to vary the pulse repetition rate easily. Finally, we have shown only one version of the basic multi circuit, i.e. with collectors cross-coupled by capacitors. Other circuits such as the emitter-coupled equivalent of the cathode-coupled valve circuit will also be found.

Astable multis are not only used as rectangular or square wave pulse generators, but they also feature as frequency dividers in the form of the triggered astable multivibrator.

Synchronized Astable Multivibrator Frequency Divider.—Free-running multis possess rather poor frequency stability since changes in supply voltage, capacitances, resistances and the characteristics of transistors affect the controlling time constant. However, the multi can be locked in step with an external signal is injected into one of the transistor bases and the multi adjusted to run at a slightly slower frequency than the applied signal.

The resultant waveforms from such a procedure are shown in Fig. 37. Negative going sync. pulses are applied to the base of one transistor (say Q of the simple astable circuit of Fig. 33) at a faster repetition rate than the free-running frequency of the circuit which is indicated by the continuous line in (a) and (b). If pulse No. 1 arrives at an instant when Q is already switching on, pulse No. 2 will arrive at the transistor base when the voltage there is rising towards zero, but has not quite reached a level to switch the transistor on by itself. The negative pulse takes it immediately over to a negative level and so accelerates the transition of Q into its conducting state as shown by the dotted traces, coinciding with the leading edge of pulse No. 2. In effect this causes Q to conduct before it would have done under the normal CR discharging conditions. As each successive sync. pulse causes this to happen, the astable multi locks in with the sync. pulses.

Instead of making every sync. pulse switch the free running multi, it is possible to arrange for it to be switched by every *n*th pulse. This means that the multi frequency locks in at 1/*n*th of the input frequency. For example, an input with a repetition rate of 1 kc/s can cause the multi to oscillate at 200 c/s by arranging for it to be switched by every 5th pulse. Frequency division thus takes place, and by careful design, it is possible to divide reliably up to as much as ten times. To do this, the astable multi is designed asymmetrically so that one transistor conducts for less than the repetition time of the sync. pulses and the other for longer than the time of (*n*-1) pulses, the overall time being longer than *n* times the period of the sync. pulses. Fig. 38 illustrates how division then takes place. Negative sync. pulses are supplied to the base of the transistor with the short conducting time. At the fifth pulse, the transistor is prematurely switched on and thus the circuit brought into synchronism with a frequency 1/5th of the sync. pulse repetition rate. It will be noted that the amplitude of the sync. pulse is critical. If it varies significantly, the switching can be early or late and the frequency division becomes uncertain.

One convenient fact is that either a sine wave or a

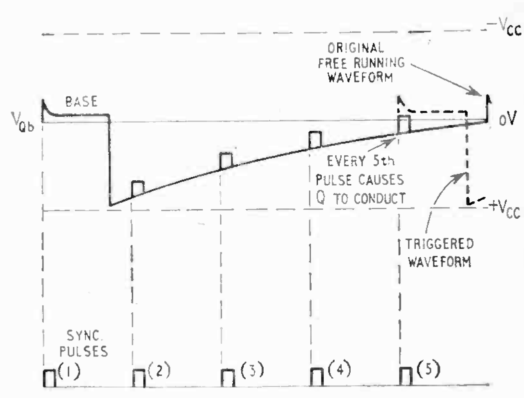


Fig. 38. Frequency division by astable multivibrator.

square wave can be used as the sync. signal and flat-topped square or rectangular output pulses obtained.

The example shown has been for an unsymmetrical output. If a symmetrical output is required at the lower frequency, it will be necessary for sync. pulses to be applied to both transistors. This can conveniently be done by including a small resistor between the commoned emitters and positive earth in Fig. 33 and applying the sync. pulses across this resistor.

Conclusions

As one of the basic building blocks of pulse circuit work, the astable multi deserves deeper study than is possible within the confines of this article. For a fuller and more rigorous treatment, readers are recommended to consult "Junction Transistors in Pulse Circuits" P. A. Neeteson, Cleaver-Hume Press 1959.

WHAT DO METERS MEASURE?

DISCUSSIONS at the I.E.E. are sometimes on post-graduate topics which are difficult to understand, and sometimes on elementary ideas which are much worse. But that introduced by Mr. A. Felton, B.Sc. (Eng), M.I.E.E., under the title "Peak, Mean, R.M.S. and All That" was comparatively lucid, certainly his introduction was. He began by drawing attention to reasons why sinusoidal waveforms are the basis of a.c. theory; they are easy to manipulate mathematically and resemble those presented to us by the C.E.G.B. Generally we have been interested in effects which depend on the square of current or voltage, and it has been convenient to quote r.m.s. values.

But the pattern is changing. Moving-coil instruments have advantages over moving-iron, and great improvements have taken place in rectifiers. Moving-coil rectifier instruments are mean-sensing, but some engineers, especially those concerned with telemetry, find mean values more helpful than r.m.s. There is no point in their using moving-coil rectifier instruments calibrated in r.m.s. values on a sine-wave source when they may be interested in the mean value (or the rectified mean value) of a non-sinusoidal source.

An instrument ought to state (a) whether is senses mean, mean-square or peak values, and (b) how it is calibrated. If it is a voltmeter it may be calibrated in r.m.s., peak or (rectified) mean volts; even though it may be a moving-coil rectifier voltmeter, sensing the rectified mean value, it may be calibrated in r.m.s. volts on a sine-wave source. By way of short-hand for this phase, Mr. Felton suggested "sine volts."

Standard symbols are required. Mr. Felton suggested the symbols shown below to indicate the response of different instruments.

For the information required in (b) Mr. Felton suggested conventional phases such as "r.m.s. volts" or "peak volts." Later speakers tried to find abbreviations such as $\bar{V}$, V and $\sqrt{V^2}$ for mean, peak and r.m.s. volts. But there was no agreement on these.

Mr. Felton condemned the practice of some manufacturers of valve voltmeters who mark the scale in r.m.s. volts when the instrument senses the mean or peak value. This compels manufacturers of instruments which sense the r.m.s. value to mark the scales "true r.m.s. volts." One cannot help feeling sorry for them. They are driven into a position similar to that of a detergent manufacturer who claims that his miracle-formula product with ingredient PQ washes whiter than his competitors miracle formulæ product with ingredient XY. Any sensitive manufacturer of valve voltmeters is entitled to resent this. As Orwell might have said in a similar context, all volts are born r.m.s. but some are more r.m.s. than others.

In the discussion which followed Mr. Felton's introduction, someone suggested that the dial should state the response of the instrument as a function of the current or voltage measured by the instrument. Several thought that this would baffle many technicians. It seemed to be the general opinion that technicians rarely understand the difference between mean-sensing and mean-square sensing even when this is not expressed mathematically.

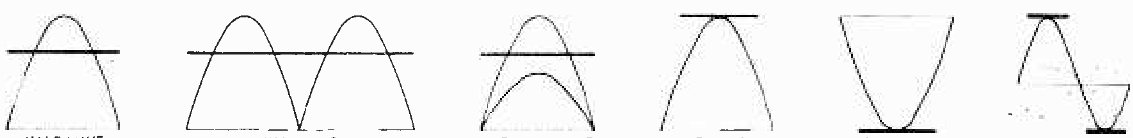
The discussion ranged over associated topics. In his opening speech Mr. Felton had asked us to forget "effective" as a synonym for "r.m.s."; it is not helpful in circuits in which resistance is not constant throughout the cycle. He also expressed distaste for "voltage"; "tension" seemed better, and many agreed with him. He, and others, took a particularly poor view of "a.c. voltage."

It was interesting to discover that the meeting was not sure of the definition of "mean value." Are negative values to be treated as though they are positive, or as though they are different from positive values? Pages of glossaries were turned and one hint was discovered, but a comprehensive definition was not found. It is odd that the B.S.I. Glossary of Electrical Terms should define so much, but not "mean value."

Since mean values are becoming more important, one wonders whether there is any possibility of moving-iron instruments being calibrated in mean values (or rectified mean values) on a sine-wave source. No one mentioned an instrument calibrated in this way, so perhaps we are lucky in being saved from this particular source of confusion by the disadvantages at present associated with moving-iron meters.

Perhaps one of the most important purposes of the discussion was to test the reaction of the meeting to the symbols Mr. Felton had suggested. Most speakers liked them.

T. P.



HALF-WAVE MEAN SENSING — FULL-WAVE MEAN SENSING — MEAN-SQUARE SENSING — SENSING POSITIVE-GOING PEAK — SENSING NEGATIVE-GOING PEAK — SENSING AVERAGE PEAK

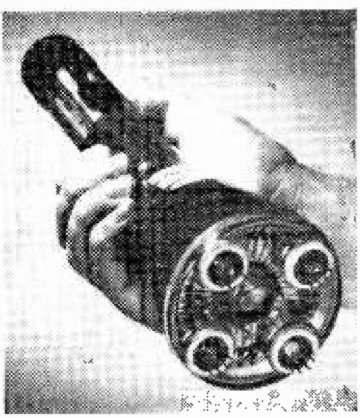
RECENT TECHNICAL DEVELOPMENTS

Coloured Test Fabrics

The problem of deciding whether a colour television channel is reproducing colours correctly has usually been tackled by using a standard test scene containing detergent packets, flowers, etc. The trouble is that these colours do not necessarily represent a complete test of the system's capabilities, in respect of colour range. Coloured gelatine filters lit from the rear have also been used, but are inconvenient and expensive. With these points in mind, the Television Society asked several colleges and Courtauld's to investigate the possibility of producing woven fabrics to close chromaticity, purity and reflectance specifications. This was done, the resulting fabrics being dyed to colours near the N.T.S.C./PAL/SECAM reference stimuli. Both acetate and mercerized poplin fabrics are produced, the different reflectance values being useful in varying scenes. The fabrics are available at 7s 6d per yard from the Society, Colour Television Fabrics Department, 166, Shaftesbury Avenue, W.C.2.

Cathode-ray Multiplexer

A variety of applications are envisaged for the Raytheon CK1378 cathode-ray tube. The electron beam produced by a normal gun is deflected into one of thirty-six sectors on the "screen" of the tube, each sector being electrically isolated from the rest. Output-leads from the sectors are taken to four E9 nine-pin bases mounted on the tube face, which is also made fluorescent in the normal way, so that the position of the beam can be seen. The tube can be used for multiplexing, frequency multiplication, analogue-to-digital conversion and many other applications. A complete specification can be obtained from Raytheon-Elsi, S.p.A., Villagrazia, Palermo, Italy.



Raytheon CK1378 radial resolution tube.

I.L.S. Monitoring

The use of an instrument landing system for automatic landing depends on the possibility of maintaining extreme accuracy of alignment. To this end, Dawe Instruments have introduced, and exhibited at the Physical Society Exhibition in January, an instrument based on phase-sensitive detection. Normally, filters are used in the aircraft to extract the 90c/s and 150c/s modulating tones, and the difference in depth of modulation is obtained. In the Dawe instrument, filters have been rejected and a different method employed. The two tones are assumed to be the upper and lower sidebands of a 120c/s suppressed carrier, modulated at 30c/s. The amplitude of one signal is the sum of the two tones, and of the other, the difference. A quadrature component is also present. A reference signal at 120c/s is fed, together with the two receiver signals, to a phase-sensitive detector, from which a 30c/s signal with an amplitude proportional to the difference in amplitudes of the two tones is obtained. This signal is nulled, the operation required to do this giving the difference in amplitudes, which can be as small as 0.005 per cent.

Self-healing Conductors

Electronic wiring that will automatically repair hair-line cracks as they occur is being developed by the Aeronautical Division of Honeywell Controls at Minneapolis. Two types of healing process have been tried and show promise of success. In the first type, the surfaces of a crack in printed wiring or welded miniature circuits grow a number of "whiskers" which bridge the crack. The whisker growth is obtained by alloying hard metals with soft ones, faster growth rate and greatest density being observed in an alloy of tin, aluminium and magnesium. The whiskers only grow at stressed points, and it is possible to inhibit them if necessary. Several days are needed for the repair, which can be repeated several times. A rather quicker process is termed "ohmic resoldering." The increased resistance of an incipient crack causes heat to be developed, which melts a low-melting-point gallium-indium alloy coating on the conductor. The alloy, which remains semi-solid over the normal operating range (up to 250° F), fills the crack and maintains continuity.

Medical Computing

In a lecture before the Radar and Electronics Association, Dr. L. C. Payne drew attention to the possibility of diagnosis by the correlation of many contributory factors. A typical spool of computer recording tape has been used by Elliott Medical Automation to store up to 100 pieces of information on each of 50,000 patients, the access time for any patient being less than 5 minutes. A complete statistical analysis of all the patients can be carried out in less than an hour. An additional possibility is that of providing automatic library facilities for a vast amount of medical knowledge, which can be interrelated with the patients' data.

Triode Laser

A gas laser which can be modulated has been announced by Bell Telephone Laboratories. Developed by P. K. Tien, D. MacNair and H. L. Hodges, the laser is normal in construction except for the inclusion of a cathode, grid and anode structure in the form of three eight-inch parallel strips running along the main laser axis. The laser is excited by the collision of electrons in the triode path with active gas atoms. As the band of energies produced in normal excitation is wide, and the band used very narrow, the normal process is fairly inefficient. In the triode laser, on the other hand, the band produced is less than 1eV, which means that many more of the emitted electrons are at useful energies. The laser oscillation can be modulated or switched by varying the triode grid voltage, the upper frequency limit of the modulation being limited by the lifetimes of the laser states and by electron transition times between the triode electrodes.

WORLD OF WIRELESS

Satellite Communications

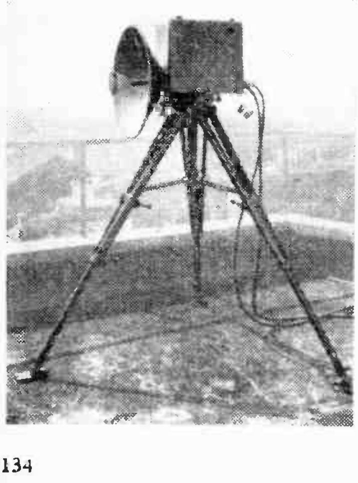
"THE United Kingdom favours the creation of a single global system of satellite communications, with European and Commonwealth countries participiating with the United States in the design of the system, having a share in its management and control and, in due course, an opportunity to provide some of the equipment." This was stated by the Postmaster General when speaking at the annual dinner of the Telecommunication Engineering and Manufacturing Association, although it was obvious that this view was not shared by many of the 250 telecommunication engineers present.

The chairman of the Association—Mr. C. Riley, vice-chairman of G.E.C. Telecommunications—spoke ot the fears that had been expressed of the possibility of American domination in this field. He put forward the view that the research and development effort required to evolve successful satellite systems will almost certainly produce technological advances which could have important applications in other fields of telecommunications. "It would be most unfortunate," he said, "if we were to lose ground because of the inadequacy of our efforts in the field of satellite communications, worse still if a combination of technical, political and financial considerations made it more difficult for us to participate in the extensions to overseas networks."

Development Contracts for Computer Research

FOUR new contracts for research and development into advanced computer techniques have been awarded by the D.S.I.R. Two of the contracts have been placed with Standard Telephones and Cables Ltd. The first is to investigate means of obtaining increased reliability in computers and to consider the possibilities of applying automatic maintenance to computers, with only a minor increase in costs. The other is for the development of a spark-machining process for the production of the accurate and complex masks required when using thin film techniques; for instance, in the manufacture of cryotrons.

The other two contracts are with the Plessey Company, for work on integrated transistor digital circuitry, and Elliott Bros. for work on tunnel diode logic. Mullards were awarded a contract for the development of a cryogenic store last September. The value of the five contracts has been put at just over £300,000.



S.H.F. Television Link.—*One of a pair of portable wideband television O.B. links the B.B.C. has purchased from Mullard Equipment Ltd. These units operate in the 11Gc/s band and using the attached 4ft parabolic aerial have a bandwidth of 8 Mc/s. The associated control units can be operated at distances of up to 500ft from the head. The weight of each installation is 108lb.*

Balance of Trade

WHILE exports of electronic and radio equipment during 1963 rose by some 25% to nearly £77M, imports increased almost 40% to a value of £36M. The main increases in imports were of domestic receiving equipment which rose from £2.5M to £7.3M. The value of imported transistor sets included in these figures rose from £2M to over £4M. There were also marked increases in the imports of valves and c.r. tubes (£6M compared with £4.7M) and semiconductors (£3.4M compared with £1.6M). Imports of "capital goods"—transmitting equipment, navigational aids, etc.—increased by £1.6M to £13.6M. Comparative export figures for the last two years are tabulated below.

Components are no longer listed as a separate item in the Board of Trade Accounts, from which the export figures are culled, but are given under the specific "end product" in which they are used—receivers, transmitters, etc.—and this has been done in the table. The total value of parts exported was nearly £17M.

	1962	1963
Sets & parts		
Television	3,462,792	3,944,652
Sound	1,344,253	6,015,881
Audio equipment	1,268,023	1,776,014
Transmitters, Navaids, etc. & parts ...	27,135,721	37,892,636
Valves & c.r. tubes	10,689,504	10,176,687
Semiconductors	977,563	2,024,259
Electronic control gear	2,378,953	2,341,527
Instruments	13,569,762	12,594,265
	60,826,571	76,765,921

Audio Fair

THE international aspect of the Audio Festival and Fair, which is being held at the Hotel Russell, London, W.C.1, from April 2nd-5th, is extending annually. Some 30% of the record number of nearly 90 exhibitors at this year's Fair will be showing imported audio equipment. Most of the exhibitors will have demonstration rooms as well as stands in the main exhibition.

Tickets are now available free from this office and applicants are asked to send a stamped addressed envelope (tickets measure 5in × 3in). Each ticket admits two. The Fair will open daily at 11.0 but admission before 4.0 on the first day is restricted to invited guests. It closes at 9.0 (Sunday 8.0).

I.Q.S.Y. Investigations

RESEARCH grants have been made by the D.S.I.R. to nine universities and colleges for investigations during the International Years of the Quiet Sun (1964/5). Of the total of £100,000 in grants Professor W. J. G. Beynon, of the University College of Wales, receives nearly £33,000 for ionospheric studies, some of which will be carried out in Antarctica. Other recipients include Sir Bernard Lovell who is to receive £18,840 for moon-ionosphere and Jupiter experiments, Dr. T. R. Kaiser (Sheffield University) who receives £18,874 for upper atmosphere studies and radio-echo investigations of the Auroa and Dr. F. W. Chapman (Kings College, London) who receives £3,500 for ionosphere and l.f. radio investigations.

In addition the D.S.I.R. Radio Research Station is carrying out ionosphere investigations at Halley Bay, Antarctica; Port Stanley, Falkland Islands; Singapore; Lerwick, Scotland; and Slough, Bucks.

Radio Telescope for D.S.I.R.

TO ENABLE the Radio Research Station of the D.S.I.R. to study space radiation in the 10 Gc/s band, a steerable radio telescope is to be built on the old Chilbolton airfield near Stockbridge, Hants, by the Ministry of Public Building and Works. The angle of inclination of the dish-shaped aerial will be variable through 125 degrees—starting 5° below the horizontal—and in azimuth it will be able to rotate the full circle. It will be possible to operate the telescope either manually or automatically by a system of punched tape.

The Ministry has awarded a contract to Associated Electrical Industries Ltd., of Trafford Park, Manchester, for the manufacture and the erection of the telescope. The estimated cost is about £275,000.

Telecommunications Research.—In answer to a Parliamentary question on how much is being spent from public funds on telecommunications research; and whether he will name the organizations undertaking the research, Mr. Hogg, the Lord President of the Council and Minister for Science, replied: "Government expenditure on civil research into telecommunications was just over £1 million in 1962-3, and is now running at about the same level in 1963-4. This research is undertaken by the General Post Office and by the Department of Scientific and Industrial Research."

T.E.M.A. Awards.—At the tenth annual dinner of the Telecommunication Engineering & Manufacturing Association in London on February 11th the awards were presented to winners of the competition for final year apprentices of the member firms of the Association. The recipients were N. W. Horne, B.Sc., graduate in training (G.E.C. Telecommunications), K. Lillie, Dip. Tech., student apprentice (A.T. & E.), and T. A. Johnson, technician apprentice (Ericsson Telephones).

The Council of the Royal Society, having received a bequest under the will of the late S. G. Brown, F.R.S., has established a fund, the income from which will be used to offer annually an **S. G. Brown medal and award.** The award will be for an outstanding contribution, based on work carried out during the preceding five years, "to the promotion and development of mechanical inventions." The Councils of the Institutions of Civil, Mechanical and Electrical Engineers have agreed to select the candidate by rotation.

The Netherlands second television service is to be introduced on October 1st. The first transmitter for the new service—at Lopik-IJsselstein—is now ready and is to start testing in March. It will operate in channel 27 with horizontal polarization and a vision e.r.p. of 250kW. The Netherlands is to use the same 625-line standards (5Mc/s vision bandwidth, negative vision modulation and f.m. sound) for Bands IV and V as are employed for Bands I and III.

Receiving Licences.—During 1963 the number of combined television and sound licences increased by over 550,000 to 12,789,483. The number of sound only licences, which includes those issued for car radio, dropped by over 250,000 to 3,092,161. Licences for sets fitted in cars rose from 526,549 to 568,804.

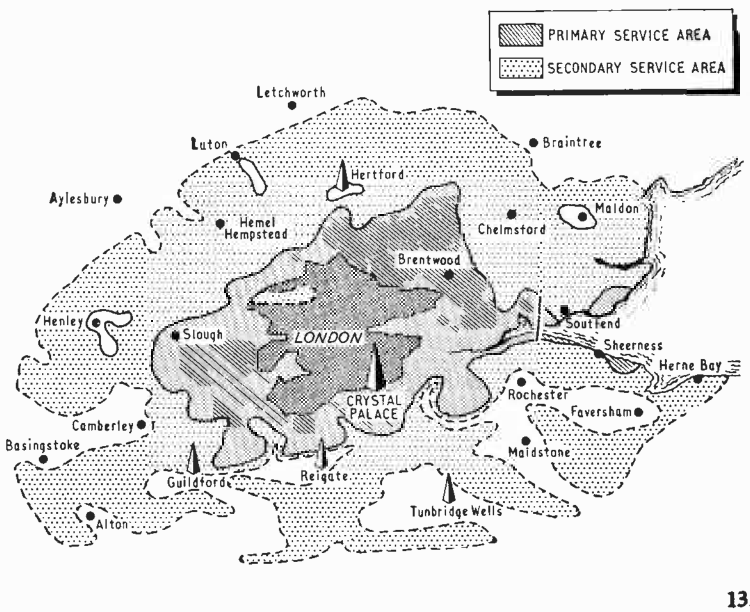
With the international introduction of 50kc/s channel spacing for **airborne equipment** all transmitters installed after January 1st this year must conform to a frequency tolerance of better than 50 parts in 10^6. The Ministry of Aviation has announced that after January 1st, 1966, all transmitters must conform to this standard.

Educational Television.—In a survey following a five-week tour of the United States at the invitation of the Ford Foundation to study television in education, L. Marsland Gander, of the *Daily Telegraph*, reported that there are now 80 purely educational television stations in the U.S.A. Most of them are run by local education authorities. In addition there are over 400 closed-circuit educational television systems.

A new B.B.C. television and v.h.f. sound relay station on Brougher Mountain, nine miles north-east of **Enniskillen,** Northern Ireland, is being brought into service on February 24th. The television service is on Channel 5 (vision 66.75 Mc/s, sound 63.25 Mc/s) with vertical polarization and the three sound programme frequencies are 88.9, 91.1 and 93.3 Mc/s.

National Mobile Rallies are being organized by the Radio Society of Great Britain for Sundays 5th April, 24th May and 13th September. They will be held, respectively, at Texas Instruments Ltd., Bedford; S.A.F. Base, Wethersfield, Essex; and Woburn Abbey, Bucks. Further details are obtainable from C. L. Fenton (Niarbyl, Gay Bowers, Danbury, Chelmsford, Essex) chairman of the Society's Mobile Committee.

BBC-2 Fill-in Stations.—*As can be seen from this sketch map of the predicted service area of the London BBC-2 transmitter there are several fairly large "shadow" areas. The B.B.C. has announced the localities (Reigate, Tunbridge Wells, Guildford and Hertford) in which the first four fill-in stations are to be built and these are shown on the map. The B.B.C. states that viewers in these four areas who have difficulty in receiving BBC-2 from the Crystal Palace station may find it worthwhile to wait until the fill-in stations are available rather than to install elaborate aerials to receive Crystal Palace direct. Fill-in stations will, of course, work on different channels from the main station. Some 95% of viewers in the primary service area should obtain a satisfactory service and about 70% in the secondary area.*



An **International Conference on Magnetic Recording** is to be held at the Institution of Electrical Engineers, London, during the week beginning 6th July. Its scope has been provisionally divided into audio recording, video recording, digital applications, analogue applications, recording media and general problems. A technical exhibition will be arranged as part of the conference and it is hoped to arrange a programme of technical visits. Further information and registration forms for the Conference, which is jointly sponsored by the I.E.E., Brit.I.R.E. and the I.E.E.E. European Region, will be available in due course from the I.E.E., Savoy Place, London, W.C.2.

C. R. T. Design.—A one-day colloquium on "Recent advances in the design and use of cathode-ray tubes" is to be held at the I.E.E., Savoy Place, London, W.C.2, on 16th April. Contributions, presented by rapporteurs thus allowing time for a discussion, will cover electron optics and the construction and uses of display tubes (excluding "entertainment" tubes and storage devices). Registration for non-members costs 10s 6d.

A convention, of three-and-a-half days' duration, on **advances in automatic control** is to be held at the University of Nottingham in April next year. It is being conducted jointly by the Institutions of Mechanical, Electrical, Chemical and Production Engineers, the Royal Aeronautical Society, the Society of Instrument Technology and the Brit.I.R.E.

The annual report (1963) on the work of the **Tin Research Institute** makes reference to recent work on soldering and to methods of determining the wetting *time* rather than the area of spread as a criterion of solderability. This factor is of importance in the automatic soldering of printed circuit boards.

The Institute of Physics and the Physical Society is holding a two-day conference, starting on 1st October, on **electron emission,** in the University of Keele. Further details are available from 47 Belgrave Square, London, S.W.1. During the conference Professor Martin Ryle, F.R.S., Professor of Radio Astronomy, Cambridge University, will give the 1964 Guthrie lecture.

The I.E.E./Brit.I.R.E. joint group on **medical and biological electronics** is planning to hold a day's demonstrations of experimental electronic techniques and instrumentation in medicine and biology. The proposed date is June 5th at Savoy Place, London, W.C.2.

A two-day symposium on "**Lasers and their applications**" is being planned by the I.E.E. for the late autumn.

A course of six evening lectures on **medical electronics and biological engineering** is starting on Tuesday, 7th April, at the Norwood Technical College, Knight's Hill, London, S.E.27. The lecturer is W. J. Perkins, president of the International Federation for Medical Electronics and Biological Engineering. (Fee 15s.)

R.F.C.W.O.O.C.A. Dinner.—The Royal Flying Corps Wireless Operators Old Comrades' Association is to hold its annual dinner in London on March 14th. Details are obtainable from E. J. F. C. Hogg, 57, Hendham Road, London, S.W.17. (Tel.: BALham 6963.)

"**Electronics and Power**" is now the new title of what was the *Journal of the Institution of Electrical Engineers.* The three quarterlies containing papers published in the *Proceedings* are now entitled *Electronics Record, Power Record* and *Science & General Record.*

PERSONALITIES

W. H. Penley, C.B.E., B.Eng., Ph.D., A.M.I.E.E., has been appointed Deputy Controller of Electronics at the Ministry of Aviation in succession to **Air Vice-Marshal T. U. C. Shirley,** C.B., C.B.E., M.I.E.E. Dr. Penley, who joined the Telecommunications Research Establishment in 1940, has held several senior appointments in the Ministry including those of superintendent and senior superintendent, guided weapons, at R.R.E., and director-general of electronics research and development, M.o.A.

Graham Phillips, A.M.Brit.I.R.E., Assoc.I.E.E., a senior engineer of the B.B.C.'s headquarters staff in London, has been seconded to take up the position of director of engineering to the Instructional Television Trust (The Rothschild Group). Mr. Phillips recently returned from East Africa where he had held the post of chief broadcasting and television engineer to the Kenya Broadcasting and Television Corporation since 1958. He held a similar post in Uganda from 1952-56.

W. Philip Rowley, M.B.E., M.Brit.I.R.E., is the new manager of the telecommunications division of the Ultra Electronics Group of Companies. Mr. Rowley was formerly assistant managing director of W.S. Electronics Ltd., which has now been absorbed by the Ultra telecommunications division. During the war, he was secretary of the Combined Signals Board and the Joint Signals Board and also Staff Officer, Radio, Supreme Headquarters Allied Expeditionary Force. Immediately after the war he became secretary of the Multipartite Signals Board. **Major-General E. S. Cole,** C.B., C.B.E., who joined Ultra as operational manager of the telecommunications division in 1961 and a year later became divisional manager, has been appointed defence consultant and will be concerned with the co-ordination of military projects, and liaison with associated overseas companies.

W. Philip Rowley

T. H. Pritchard, who became managing director of Garrard Engineering last year, has joined the board of Plessey Overseas Limited, the organization responsible for co-ordinating the manufacturing activities of the Plessey Group throughout the world. Mr. Pritchard joined Plessey in 1951 as chief inspector (Swindon Region) and became divisional manager of the Company's mechanical products division, Swindon, before being appointed production director of Garrard Engineering in 1962.

George W. Tillett is joining Wharfedale Wireless Works Limited on 2nd March as technical director. Since 1958 he has been chief engineer of Daystrom Ltd., manufacturers of Heathkits, prior to which he was for three years chief audio engineer with Decca. From 1951-55 he was with the Armstrong Company as chief engineer and later as a director.

Frank Poperwell, Assoc. Brit. I.R.E., technical director of Reslosound Ltd., is the president-elect of the Association of Public Address Engineers for 1964. He has been a member of the council of the Association for the past 13 years. Prior to joining the Derritron group of companies, of which Reslosound is a member in 1961, he had been with the G.E.C. for 35 years.

For reasons of ill-health, **Sir Arthur fforde** resigned his post as chairman of the B.B.C. at the end of January. The vice-chairman of the Corporation, **Sir James Duff,** is to be chairman for the time being.

G. R. Watson, A.M.I.E.E., has joined English Electric Valve Company to become sales engineer, responsible for television camera tube products. Mr. Watson was previously a design engineer with E.M.I. Electronics.

Geoffrey E. Chambers, B.Sc., has been appointed to the board of Electrical Remote Control Company, of Harlow, and its associated companies Equipment & Services Ltd. and Elremco Sales Ltd. Mr. Chambers, who is 40 and graduated in physics and radio engineering at Bristol University, recently joined Electrical Remote Control Company after spending ten years with Londex Ltd.

W. A. Neat, who has been with the Ultrasonoscope Co. (London) Ltd., since its formation in 1951, has been appointed technical manager. In this position he will be responsible for development and production matters.

C. J. W. Hill, A.M.I.E.E., A.C.G.I., who joined the B.B.C. in 1936 as an engineer in the research department and became the first engineer-in-charge of the Monitoring Service in 1939, has had to relinquish his post because of ill health. He is succeeded by the assistant e.-in-c., **F. Masterman,** who also joined the B.B.C. in 1936. Mr. Masterman spent several years on technical advisory duties related to schools broadcasting and in the sound studio department before transferring to the Monitoring Service in 1943.

Dr. Carlo L. Calosi has been appointed managing director of Cossor Electronics Ltd. in succession to **Frank F. Oddi,** who is returning to the United States to take up an appointment outside the Raytheon Group. Dr. Calosi, who is a vice-president of the Raytheon Company, of which Cossor is a subsidiary, was at one time Professor of Electrical Engineering at the University of Genoa. He was appointed to the board of Cossor Electronics last year.

Dr. Carlo Calosi

H. J. Bird, head of the accounts section and administrator of seagoing staff of A.E.I. Marine Communications Department, has retired after completing 41 years' service with the company. Mr. Bird was one of the original members of the Radio Officers Panel of the National Maritime Board is at present Joint Secretary. His successor at A.E.I. is **E. F. Weatherhead** who joined Siemens Brothers & Co. Ltd. (now part of A.E.I.) in 1928 and spent 13 years as a seagoing radio officer before joining the shore staff of the Marine Communications Department. Mr. Weatherhead is also on the Radio Officers Panel of the N.M.B.

R. E. Ridsdale, a member of the B.B.C.'s staff at Daventry, prior to emigrating to Canada in 1950, has joined the staff of the British Columbia Institute of Technology. Since 1959 he has been head of the electronics division of the British Columbia Vocational School, Vancouver.

Four executive appointments have been made within Welwyn Electric Ltd. The company's technical director **R. H. W. Burkett,** B.Sc., A.M.I.E.E., becomes director and general manager; **C. W. Martin,** previously general manager, becomes a member of the board as director of manufacture; **J. Browning,** M.A., chief engineer, becomes a member of the board and **R. Steven,** B.Sc., sales manager of the board, becomes commercial director.

F. E. Jones, M.B.E., B.Sc., Ph.D., managing director of Mullard Ltd. has been elected to the Council of the Institution of Electrical Engineers to fill the vacancy created by the death of **G. F. Peirson.**

OUR AUTHORS

M. Bronzite, B.Sc., who describes a d.c. amplifier in this issue, is a graduate of Reading University where he obtained his degree in physics and chemistry in 1958. He was a graduate apprentice with B.T.H. at Rugby for two years after which he joined Plessey's telecommunications group where he was investigating transistor circuitry for aircraft instruments. He went to Israel in 1962 where, after a short time in the Weitzman Institute, he worked in the Hebrew University on the design of equipment for meteorological studies. Mr. Bronzite, who is 26, is now with Kelvin Hughes.

Henry H. Henly, author of the article on page 110, joined the Post Office as a youth-in-training in 1951 and is at present an assistant engineer in the Engineering Department where he is engaged on electronic development work associated with postal mechanization.

J. H. Willis, Assoc.I.E.E., contributor of the article on a car transistor coil ignition system in this issue, has been with the B.B.C. since 1940, although the subject of the article is in no way connected with his work in the Corporation. During the war he was a maintenance engineer at the long-wave overseas station at Ottringham, near Hull. Mr. Willis, who is 47, is now concerned with the technical maintenance and operation of B.B.C. transmitters in general.

OBITUARY

Harry Melville Dowsett, M.I.E.E., F.Inst.P., who retired 25 years ago from Marconi's W/T Company, died on January 27th in his 85th year. He joined the company in 1899 as an assistant to Marconi and was closely associated with much of the early development work. He was for many years in charge of the company's testing department and in 1931 was appointed research manager. When the *Marconi Review* was started in 1928, Mr. Dowsett was appointed technical editor and later became editor. From 1935 until his retirement in 1939 he was principal of what is now Marconi College. Mr. Dowsett was joint author of "Handbook for Wireless Telegraphists" and author of "Wireless Telegraphy and Telephony."

NEWS FROM INDUSTRY

Malaysian 300-mile TV Link.—Standard Telephones and Cables Ltd. have received an order, valued at £250,000, to provide a 300-mile microwave link to interconnect television studios and transmitters based in Singapore, Kuala Lumpur and Ipoh. The existing buildings and aerial masts, erected five years ago, for the S.T.C. telegraph microwave link will be used to carry the new equipment. Four of the repeater stations, which are included every 30 to 40 miles, are to be provided with demultiplexing equipment to feed additional television transmitters. At present the television transmissions, in Malay and Chinese, are restricted to the Kuala Lumpur and Singapore areas. However, four new television stations are being built and when the system is completed later this year, it will link all the stations covering the west coast of Malaya.

Group profit of **Muirhead & Co. Ltd.** in the financial year ended 30th September totalled £936,710 and showed an increase of nearly £200,000 on the previous year's results. The net profit, after taxation and profit retentions for subsidiaries, amounted to £402,457; as against £259,791 in 1961/62.

Police "Walkie-talkies."—A contract to provide every constable on the Lancashire beat with pocket v.h.f. three-channel f.m. transceivers has been awarded to G.E.C. (Electronics) Ltd., of Wembley, Middx., by the Lancashire County Constabulary. Known as the Lancon transmitter-receiver, it has been developed by radio engineers at Preston police headquarters and is now in production at G.E.C.'s radio communications division at Coventry. The Lancon weighs less than 2lb and is claimed to be the smallest unit to receive Home Office and G.P.O. approval for police and commercial applications. The dimensions of the case, which houses the transmitter-receiver and its power supplies (a 12 volt rechargeable battery), are $8 \times 4\frac{1}{4} \times 1\frac{3}{8}$in. These transceivers are carried in an inside pocket of the policeman's uniform.

Plessey Overseas Limited, formed last year to co-ordinate and expand the manufacturing facilities of Plessey's overseas factories, is now responsible for nearly 20% of the Group's net assets. The latest of its acquisitions, for £1,250,000, is the Instrument Manufacturing Corporation of South Africa Ltd., makers of industrial and scientific instruments and communications equipment. Plessey previously had an interest in the Corporation, which was formed in 1957 to commercially exploit the Tellurometer, an electronic distance measuring instrument developed by the South African Council for Scientific and Industrial Research. The number of subsidiaries under the wing of Plessey Overseas Ltd. is now 40; with 12 in Australia, 3 in Brazil, 2 in Canada, 1 in Ireland, 3 in New Zealand, 1 in Portugal, 16 in South Africa and 2 in the U.S.A. Six of these subsidiaries are not wholly owned.

Sealectro Ltd.—The Sealectro Corporation, of Mamaroneck, U.S.A., has decided to change the status of its British branch to that of a British limited liability company. It will remain a wholly owned subsidiary and operate under Mr. G. S. Westbrook as managing director, with Mr. A. D. Zemenides as general manager, on the Hersham Trading Estate, Walton-on-Thames, Surrey. Sealectro Ltd., the new subsidiary, is to build an additional factory, covering some 20,000 sq ft, on a two-acre site at Portsmouth. This is planned to be completed by the end of the year and will be primarily concerned with the production of a new range of programming devices.

The I.T.A. has placed a contract, worth £120,000, with **EMI Electronics Ltd.** to supply and install an aerial, mast and feeder system at Rumster Forest, Caithness, to transmit the Grampian programme on Channel 8. The maximum e.r.p. of the new aerial will be 30 kW and it is scheduled to be completed by next spring. The 750 ft mast, which carries the vertically polarized aerial, is to be supplied and erected by B.I.C.C. as sub-contractors.

Redifon Ltd., of Wandsworth, London, have signed an agreement with the Hughes Aircraft Company, of California, to enable them to manufacture, under licence, the Hughes HC-162 Manpack 15-watt s.s.b. transceiver. These units, which weigh 20 lb, operate in the 2-20Mc/s band and employ a novel frequency synthesizer which enables an operator to select any one of 10,000 channels. The British subsidiary of the Hughes Aircraft Company is Hughes International (U.K.) Ltd. of Hounslow, Middlesex.

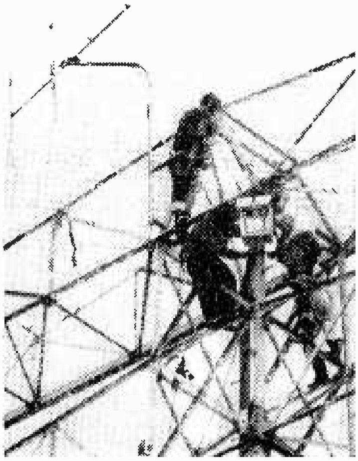
Following successful trials of **two-tone telegraph equipment** with automatic error correcting facilities on two tankers, Shell International Marine Ltd. have asked the Marconi International Marine Company to provide a further twelve installations. These will be used in conjunction with a Creed tape reader and the ship's main h.f. transmitter to send day-to-day hull data and engine performance figures to Shell's central office in London. The signals from the ship will be received at either the G.P.O.'s radio station at Bearley, Warwickshire, or the Dutch P.T.T. station at Scheveningen and then passed to the Shell central office by land line, where complementary receiving equipment has been installed.

Another M.I.-I.R.C. Venture.—Metal Industries Ltd. has acquired from Fiat of Turin, Italy, a 50% interest in International Rectifier Corporation Italiana S.p.A., the manufacturers of semiconductors. The other 50% interest in the Italian company, which has a 25,000 sq ft factory, near Caselle airport, Turin, is owned by the International Rectifier Corporation, of Los Angeles, U.S.A. This is the second joint venture in Europe between I.R.C. of Los Angeles and Metal Industries. The first was the establishment of International Rectifier Company (Great Britain) Ltd., which has a factory at Oxted in Surrey. Mr. Waldo Thorn, director and general manager at Oxted, has been appointed managing director of the Turin company.

Submarine Cables Limited, owned jointly by A.E.I. and B.I.C.C., have received contracts, valued at £2M, for three wideband (5Mc/s) submarine telephone cable systems for North Sea routes. The systems, which will link the U.K. with Norway and with Holland, and also Norway with Denmark, will employ 76 transistor repeaters and each provide 480 telephone circuits of 4kc/s bandwidth.

The South African Marine Corporation, of Capetown, one of South Africa's major deep-sea shipping companies, has ordered **A.E.I. radio equipment** for four new refrigerated cargo vessels. Each vessel will carry a Triton 300-watt transmitter, a general-purpose receiver, emergency radio equipment, direction-finder, lifeboat equipment, and a 28-channel v.h.f. transceiver.

Keyswitch Relays Ltd.—In some copies of our January 1964 issue an incorrect address was given in this firm's advertisement. Their address is 120/132 Cricklewood Lane, London, N.W.2. (Tel.: GLAdstone 1152.)



A solar-powered v.h.f. radio alarm system being installed on a high-voltage transmission line tower. The system employs a crystal-controlled transistor transmitter operating in the 68-88 Mc/s band and receives its power from a battery of nickel cadmium cells, which are kept charged by a bank of solar cells. The equipment has been developed by British Telecommunications Research Ltd., in collaboration with the Central Electricity Research Laboratories, Leatherhead, and is being produced by A.T. & E. (Bridgnorth) Ltd.

Telemax-Southern Ltd. have obtained an order from the communications branch of the Home Office for over £10,000 worth of frequency meters and generators.

N. Saunders Metal Products Ltd. have opened an additional factory and offices at Enessa Works, Edwin Road, Twickenham, Middx. (Tel.: TWIckenham 2261.) Dumatic printed circuit board drilling machines and other special purpose machinery will be manufactured at the new Twickenham factory and the rest of the Company's work will continue at its premises in Munster Road, Fulham, London, S.W.6. All correspondence should be sent to the Twickenham address.

Oddie Bradbury & Cull, of Southampton, manufacturers of **Oddie fasteners,** have been acquired by Ross, Courtney & Co. The Southampton works are closing on March 1st and the business will become the Oddie Fasteners Division of Ross, Courtney, and will operate from Ashbrook Road, Upper Holloway, London, N.19. (Tel.: ARChway 0551.)

Decca Radar has just received its 15,000th marine radar order—an installation for the Palm Lines 8,440 ton cargo liner *Africa Palm*.

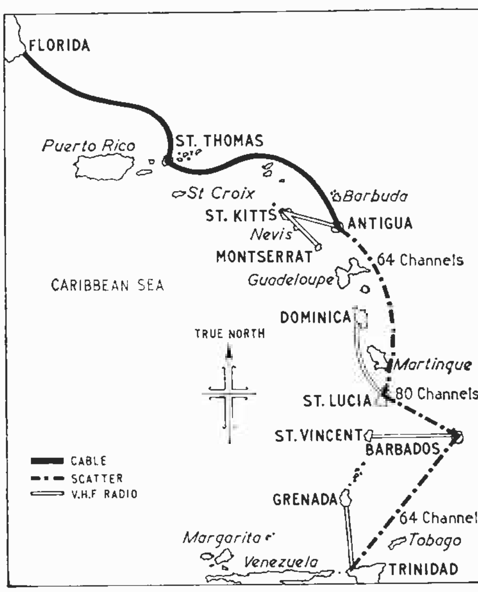
Ericsson Telephones Ltd., a principal operating company of the Plessey Group, has sold its (49%) holding in Bendix Ericsson U.K. Ltd., to the Bendix Corporation. The company, under its new name **Bendix Electronics Ltd.,** will operate from High Church Street, New Basford, Nottingham, and use the trade mark "Bendix" instead of "Benderic."

U.H.F. aerials for three more BBC-2 stations have been ordered from Marconi's. They are to be erected on existing masts at the B.B.C. stations at Rowridge (Isle of Wight) and Pontop Pike (Durham) and the I.T.A. station at Black Hill (Lanarks). These aerials and those to be supplied by Marconi's for the Sutton Coldfield and Wenvoe stations are designed to radiate up to four programmes simultaneously.

Storno-Southern Ltd. are supplying a frequency-modulated **u.h.f. mobile radiotelephone system** to the Eastern Electricity Board, for use in the North Met. Sub Area. The system employs selective calling techniques with a 20-watt base station, linked to their private telephone exchange, and 5-watt mobile installations. This is stated to be the first private mobile system in the U.K. to operate in the (450-470Mc/s) band.

SASCO, Stewart Aeronautical Supply Company Ltd., are moving, on 1st March, from Redhill, Surrey, to Gatwick Road, Crawley, Sussex. (Tel.: Crawley 28700.) From the same date, the new address of the associate companies, Radionic Products Ltd. and Electrocon Ltd., will be Stephenson Way, Three Bridges, Crawley, Sussex.

Cable and Wireless (WI) Ltd. are establishing a multi-channel tropospheric scatter system between Barbados and Antigua via St. Lucia, with a cable link from Antigua to Florida, U.S.A., via St. Thomas. A multi-channel tropospheric scatter system between Trinidad and Barbados together with certain inter-island v.h.f. links in the Leeward and Windward Islands were introduced three years ago. The new and the existing links will be integrated. The v.h.f. radio links each provide six telephone channels with the exception of that between Granada and Trinidad which provides twelve. The cost of the latest project has been put at £3M sterling. Marconi's have been appointed equipment contractors.



The scientific and medical division of **Honeywell Controls Ltd.** is moving its manufacturing facilities from Kennington, London, to Newhouse, Scotland, and to Hemel Hempstead, Herts. The division's administrative offices will be at Ruislip Road, Greenford, Middx. (Tel.: WAXlow 2333.) Incidentally, Honeywell Controls Ltd. have moved their Manchester office from Northenden Road to the Civic Centre, Wythenshawe, Manchester 22. (Tel.: Mercury 3214-20.)

British Relay Ltd. has acquired **Antiference Installations Ltd.,** a subsidiary of Antiference. It will in future be known as British Relay (Installations) Ltd. Enquiries should be sent to 172-3 New Road, Croxley Green, Herts. (Tel.: Rickmansworth 2142.)

Painton and Co. Ltd., component manufacturers of Kingsthorpe, Northants, announce the formation of an Italian company to be known as **Painton Italiana S.p.A.** This company will commence local manufacture immediately at a new factory in Padua.

Carrion Television Systems Ltd., who are agents for the closed-circuit television tape recorders produced by Precision Instruments, of California, have moved to Boulton Road, Reading, Berks. (Tel.: Reading 82732.)

Pinnacle Electronics Ltd. (formerly Pinnacle Electronic Products Ltd.) have moved from their West End premises to Achilles Street, New Cross, London, S.E.14. (Tel.: TIDeway 7285.)

BOOKS RECEIVED

Transistor Amplifiers for Audio Frequencies by Thomas Roddam. Up-to-date guide to the design of transistor small-signal and power amplifiers including class B and complementary pair circuits. There is a chapter on temperature effects and cooling methods, and concluding sections deal with pulse modulation systems, frequency-selective amplifiers and negative impedance converters. Pp. 255. Iliffe Books Ltd., Dorset House, Stamford Street, London, S.E.1. Price 45s.

Electric Filter Circuits by Emrys Williams, Ph.D., B.Eng., M.I.E.E. M.Brit.I.R.E. Provides a new and simplified approach to lumped-constant networks in which the use of hyperbolic functions is included for completeness but is not required in the main body of the work.

Based on courses given in the University of Wales to students with only one year's experience of steady-state a.c. theory and elementary complex algebra. Separate chapters are devoted to constant-k, lattice-section and m-derived filters. Pp. 162. Sir Isaac Pitman & Sons Ltd., Parker Street, London, W.C.2. Price 25s.

Technical Dictionary of Radio and Telecommunication Installations, compiled by H. Plöhn, W. Preikschat and M. Schwertner. English, German, French and Russian equivalents of approximately 12,000 terms. Pp. 1001. Pergamon Press Ltd., Headington Hill Hall, Oxford. Price £10.

Loudspeakers, by E. J. Jordon, deals with the radiation of sound from vibrating surfaces, design of magnet systems, cones and suspensions, loudspeaker enclosures, crossover networks, etc. There is a separate chapter on electrostatic loudspeakers. Pp. 227.

Tape Recording and Reproduction, by A. A. McWilliams, deals not only with the theory of magnetic recording and reproduction but with mechanical problems of tape transport, microphone techniques, tape editing and other aids to the intelligent use of tape recorders. Pp. 287.

Both the above form part of a series of volumes "The Technique of Sound Reproduction" published by Focal Press Ltd., 31, Fitzroy Square, London, W.1. Price 42s each volume.

Acoustics, Noise and Buildings, by P. H. Parkin and H. R. Humphreys. Revised paperback edition of this broad treatise on architectural acoustics including high-quality sound reinforcement systems. Pp. 331. Faber & Faber, 24, Russell Square, London, W.C.1. Price 18s.

Das Fischer Lexikon Technik 4, Elektrische Nachrichtentechnik. Volume 4 of a series of paperback encyclopædias contains a high density of information on selected aspects of communications including aerials, automation, picture telegraphy, high-frequency techniques, information theory, measurements, mathematical tools, computers, etc. Pp. 351, Fischer Bücherei K.G., Frankfurt am Main, Germany. Price DM 3.80.

The Effect of Disturbances of Solar Origin on Communications, edited by G. J. Gassmann. Twenty-six papers and discussions presented at the Symposium of the Ionospheric Research Committee of the Advisory Group for Aeronautical Record and Development, N.A.T.O., Naples 1961. Pp. 349. Pergamon Press Ltd., Headington Hill Hall, Oxford. Price £5.

A Guide to the Design and Construction of Electronic Equipment. Summary of considerations involved in the design of industrial, ground mobile and fixed, shipborne and airborne equipment. Current practice in environmental testing, an index of specifications and many other facts which might form the basis of mutual understanding between manufacturer and customer are contained in this 88-page compendium which costs £1 to members and 2gns to non-members of The Electronic Engineering Association, 11, Green Street, London, W.1.

Propagation of Radio Waves by B. Chatterjee, Ph.D. Concise survey, including the relevant mathematics, of the whole subject, based on post-graduate lectures at the Indian Institute of Technology, Kharagpur. Chapters deal with surface waves, space waves, sky waves, the ionosphere and scatter propagation. References are included at the end of each section for students wishing to specialize. Pp. 115. Asia Publishing House, 447, Strand, London, W.C.2. Price 25s.

Handbook for Science Masters and Lecturers, by I. L. Muter, B.Sc., A.M.I.E.E., A.Inst.P., and K. B. J. Bowden, B.Sc. The second edition of this 150-page book, which is sponsored by Advance Components and deals with circuit theory, laboratory experiments and demonstrations, and measurement problems, now contains a section covering semiconductors. Intended primarily for distribution to science masters and lecturers, it is available also to those outside the teaching profession, price 12s 6d, from Advance Components Ltd., Roebuck Road, Hainault, Ilford.

Electromagnetic Scattering, edited by Milton Kerker. Proceedings of the interdisciplinary conference held at Clarkson College of Technology, Potsdam, N.Y., in Aug. 1962. There are six parts covering particle scattering, light scattering in the atmosphere and space, microwave scattering in the atmosphere, light scattering in solutions, interaction in solids and liquids, and multiple scattering. Pp. 592. Pergamon Press Ltd., Headington Hill Hall, Oxford. £5 5s.

B.B.C. Engineering Monograph No. 51. Radiophonics in the B.B.C. by F. C. Brooker, M.I.E.E. Description of the equipment of the Radiophonic Workshop at the Maida Vale Studio which synthesizes background sound effects for both radio and television plays. Pp. 18. B.B.C. Publications, 35, Marylebone High Street. London, W.1. Price 5s.

Westinghouse Silicon Controlled Rectifier Designers Handbook. Edited by Robert Murray, Jr. Comprehensive guide to Westinghouse s.c.rs. their characteristics and applications in inverters, oscillators, switches, car ignition systems. A chapter is included on the design of heat sinks. Pp. 280. Westinghouse Brake and Signal Company Ltd., 82 York Way, Kings Cross, London, N.1. Price 16s.

Fundamentals and Components of Electronic Digital Computers by G. Haas. Valuable overall introduction to the subject covering the basic numerical systems used, programming and the electronic components of arithmetical units and logic circuits, bistable and monostable circuits, decade counters, stores and registers. Typical component values are given as a basis for design. Pp. 247, Philips Technical Library and Cleaver-Hume Press Ltd., 10-15, St. Martins Street, London, W.C.2.

PARIS COMPONENTS SHOW 1964

NOW firmly established as one of the most important international electronic exhibitions in the calendar, the *Salon Internationale des Composants Electroniques* was held this year from 7th to 12th February in the 25,000sq.m. ($6\frac{1}{4}$ acre) halls near the Porte de Versailles. Successive extensions have failed to keep pace with applications for space, and although close on 800 firms (300 from outside France) were accommodated, there is still a growing waiting list. There was this year, however, an extension of duration of the exhibition for one more day.

To try, in the space available, to describe the whole of this vast exhibition is completely out of the question. At most, we can only mention briefly a selection of the exhibits that attracted our attention.

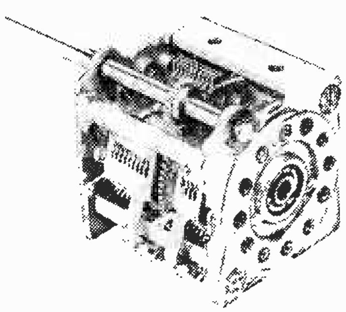
Components

Although the Salon nowadays includes a large proportion of measuring instruments, it was the *pièces détachées* which founded the exhibition in 1934. The large numbers of competing firms manufacturing each type of component indicate the vast scale of the world electronics industry today and its importance in industrial control, communications and military applications.

Resistors:—The technique of loose winding, developed by Alma to reduce stresses due to thermal cycling in wire-wound components, attracted considerable attention. Long-term stability of, typically, $\pm 0.005\%$ for the first 1,000 hours at temperatures up to 70°C are claimed.

Ten-turn helical potentiometers with neat two-pointer decade clock dials set in the knob itself were shown by many firms, including Bourns, Colvern and Ultrapot; settings can be made to 1 part in 1,000.

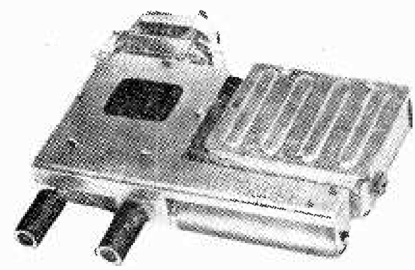
Capacitors:—Among fixed capacitors one of the most interesting developments was the multi-layer "monolithic" form of construction seen on the T.C.C. stand, which gives a high capacitance/volume ratio in ceramic capacitors (typically 2.2 μF in $12.7 \times 10.5 \times 7.1$ mm or 0.01 μF in $9 \times 5.1 \times 3.8$ mm). Working voltage (steady) is 25. Like most other small capacitors, including miniature electrolytics, leads are from one end only, suitably spaced for 0.1-inch grid printed circuit boards.



Arena tuning capacitor, Series 16000.

A new variable condenser (Series 16,000) from Arena makes use of a mixed air and solid dielectric to reduce both size and microphony. It is driven by a built-in reduction gear.

Tuners:—Alternative versions (valve or transistor) are being offered for most types of u.h.f. and v.h.f. tuners (e.g. Arena and Oréga). A new integrated u.h.f./v.h.f. unit, Model 260 50, has been developed by Hopt. It uses two AF 139 and two AF 106 transistors, requires a 12 V, 8 to 16 mA supply, has a gain of >18 dB, noise factors of <8 dB v.h.f. and <13 dB u.h.f., and image rejections of >40 dB and >60 dB respectively. Dimensions overall are approximately $95 \times 85 \times 55$ mm. A new departure for Hopt, incidentally, is their entry into the field of numerical position control for machine tools.

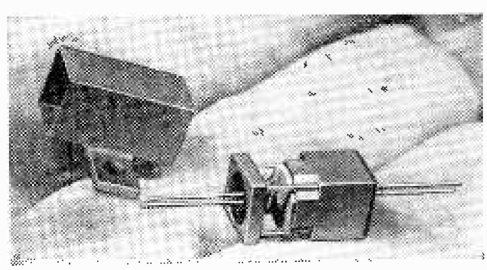


Hopt integrated u.h.f./v.h.f. tuner.

Relays

Two of the smallest relays seen were by G.E.C. and Servo-Contact. The G.E.C. sub-miniature type occupies only 0.04 cubic inches and is designed for printed-circuit use. It has a single changeover contact of solid precious metal, and gives a life expectancy of 50 million operations at 24 V, 0.5 A. Coils are offered for 1.5, 6, 12 and 24 volt working and operating power is less than 200 mW.

The Servo Contact SCE relay has a sensitivity of about 0.25 mW and will break 1 A at 220 V. Depending on the coil voltage, the contacts will respond to frequencies corresponding to 200 bauds.



Sub-miniature G.E.C. relay.

Solid-state relays by Leach use magnetic counting techniques to obtain delays of from 50 msec to 3 years. Depending on the accuracy required, unijunction, magnetic or crystal oscillators are used, feeding pulses to a magnetic scaler. Reset is automatic or externally provided, and the maximum contact set is 6 poles—two ways at 10 A.

A bistable relay by Chauvin-Arnoux uses a permanent magnet to retain the armature in the "ON" position after the signal has ended. Two coils are used, one to magnetize the pole-piece and hold the armature, and one to demagnetize the pole-piece and allow the armature to spring back.

An r.f. switch that is really in the "battleship" class was shown by Radio-Selection. For transmitter use, the two-pole make-and-break switch is capable of handling 20 kV at 2 Mc/s, breaking a current of 125A.

Audio

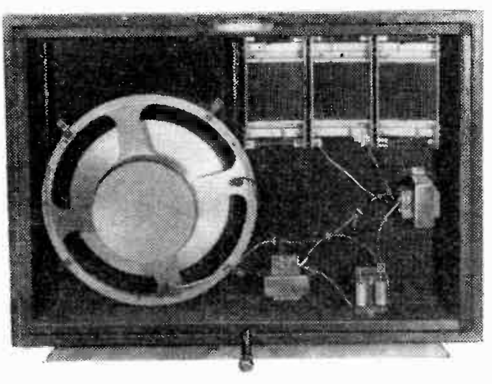
With the *International Festival du Son* due to take place in Paris from 12th to 17 March the volume of audio participation in the components exhibition was somewhat reduced, but not the quality.

Loudspeakers:—The Gé-Go Orthophase unit, working on the blattnerphone principle which was reported two years ago and which created a very good impression, is now offered at a comparatively lower price in combination with a "woofer" unit using a conventional coil drive and a shallow metal-coated cellular plastic diaphragm. Two types are available, one with three Orthophase units for 1920 NF (£140) and with one unit for 1120 NF (£82). In its thin cabinet it looks very like an electrostatic unit.

Combinations of conventional moving coil units of different sizes continue to hold their own against all comers, typical examples being shown by Peerless and Isophon.

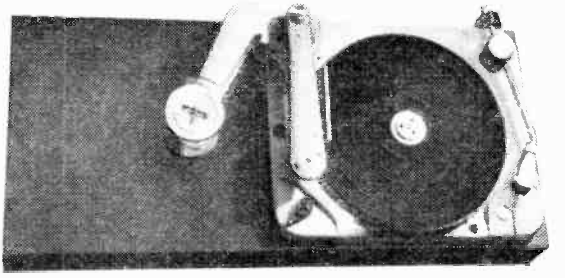
Cabasse courageously demonstrated on an oscilloscope the linearity of response of one of their larger m.c. units at 2 c/s. The sine wave looked too good to be true, but was proved to be genuine by a surreptitious gentle flick of the edge of the diaphragm which immediately showed as a ragged edge on the trace.

Audax showed an artificial reverberation unit consisting of a system of five parallel coil springs with their centre points coupled mechanically to a 5-inch moving coil unit. Energy exchanged between the diaphragm and the springs gives reverberation effects up to 10 seconds. No additional amplifier is required.



Gé-Go Orthophase loudspeaker with three h.f. cellules and bass "woofer".

Turntables and Pickups:—The automatic record changer, TD224, shown by Thorens, goes far to remove the prejudice harboured by hi-fi enthusiasts against the conventional types. In some respects the new design resembles some of the earliest methods, for each disc is taken from, and returned to, piles at the side, only one disc is on the turntable at a time and there are no problems of vertical alignment.



Thorens professional turntable with record changing mechanism.

On the Acos (Cosmocord) stand a retractable mounting for the protection of ceramic cartridges against accidental downward pressure was shown. This is unique in that the stylus is lifted clear of the groove through a link mechanism, with nylon hinges, operated by a feeler stud which is set to just clear the surface under normal playing conditions. The system is gravity controlled and suitable for playing weights from 3 to 6 gm.

Semiconductors

No great strides seem to have been made during the year; power dissipations and gain-bandwidth products continue to increase, and several more firms are producing integrated circuits inside one transistor can.

An indication of progress is given by the COSEM PR168 television line output transistor, which can dissipate 30W. I_c maximum is 20 A, V_{CE} 160 V, and the current gain is constant at 20 over a large range of collector currents. Saturation voltage at $I_C = 15$ A is 0.5 V.

For low-noise applications, Ferranti have the ZT2857, which is a u.h.f. type. The noise figure is 4.5 dB and power gain is 17 dB at 450 Mc/s. The gain-bandwidth figure f_T is greater than 1,000 Mc/s and 200 mW maximum is dissipated.

Thyratrons and thyristors are often likened to mechanical switches, but in one important particular, the resemblance fails; they only conduct in one direction. After much research, the Compagnie Générale d'Electricité, have produced a device which conducts in both directions when appropriately gated. A symmetrical p-n-p-n-p unit always presents two reversed junctions, and prevents switching. In the C.G.E. five layer unit (p_t-n-p-n-p_t), the outer junctions are inverse diodes (or unitunnel diodes). In such junctions the reverse current is as great as the forward current. In this way, as each junction is polarized in the reverse direction, it becomes an extremely low resistance in series with an ordinary thyristor. The direction of current is then determined by the sense of the applied voltage at the moment of switching.

Connections can be made to one or both of the n regions, to provide the gating in either direction.

Valves

New domestic television receiving valves on ten-pin bases were shown by Telefunken. These have two sections with entirely separate cathode systems and include a triode-pentode mixer-oscillator (PCF200), a triode-heptode sync separator (PCH200) and a double pentode (PFL200) which includes a video power output stage.

For use as the final stage in transistor mobile equipments, Eimac were showing a 500 Mc/s, 100 W tetrode (4CS100L) with a remarkably short heating-up time (0.1 sec).

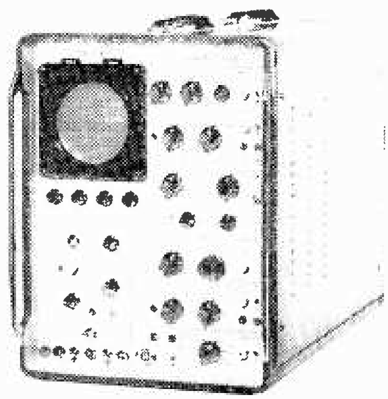
New valve developments are to be found these days mostly in gigacycle frequency bands where solid-state devices have not yet produced comparable powers. E.M.I. were showing a new klystron (Type R9653) for electron spin resonance, materials research and scaled aerial experiments. It produces a power in excess of 10 mW in the range 65 to 85 Gc/s. Also on the E.M.I. stand was a 4-stage image intensifier (Type 9694), believed to be the first commercially available. Giving a picture of 2 in diameter the tube gives a light gain of 10^6. Ferranti were exhibiting an X-band klystron (SZ31) with an associated power amplifier (SY41) for Doppler radar giving an output of 2 kW with a tuning range of ±20 Mc/s. The coaxial magnetron (SYM4328) made by Sylvania International for airborne radars is hydraulically tunable at 240 c/s over the range 16 to 16.4 Gc/s. It is claimed that this method gives better stability and a wider tuning range than vane and strap tuning. Thomson-Varian showed a high-power (10 MW peak) klystron (Type TV2019) working in the S band (2.5 to 4 Mc/s) for particle accelerators, and Thomson-Houston made a feature of the TH290 u.h.f. tetrode which is being used in the Eiffel Tower transmitter of the French *deuxième chaîne* and of the 25 kW, TH491 ceramic Vapatron which will be used in the Bouvigny transmitter.

A new h.f. tetrode (E3033) by the M-O Valve Company delivers 17 kW in class AB1, s.s.b. linear amplifiers, and can be used for power audio amplification in push-pull.

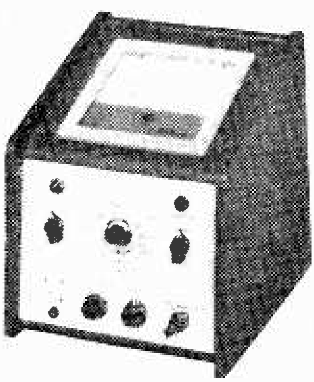
The Marconi Company showed new developments in high-power isolators, including a 500 W air-cooled type for No. 12 waveguide, and a wide range of stable oscillators and (for the first time) crystals in the range 1 kc/s to 80 Mc/s.

Instruments

Oscilloscope design is probably the most rapidly developing field of measuring instrumentation. A large number of comparable oscilloscopes are making their appearance, having *y* amplifiers giving a 0-20 or 0-30 Mc/s passband, with two beam-switched traces, extreme sweep speed when expanded of about 10 or 20 nsec/cm and *y* sensitivities of 50 mV/cm. The C.R.C. (Constructions Radioélectriques et Electroniques du Centre) OC586 has the rather higher pass band of 50 Mc/s, and a correspondingly higher sweep rate of 10 nsec/cm. To obtain a sufficiently bright trace while still retaining adequate sensitivity, the extremely high e.h.t. of 17.3 kV is applied. The Philips PM3236 is unusual in its class in having two separate horizontal amplifiers each with

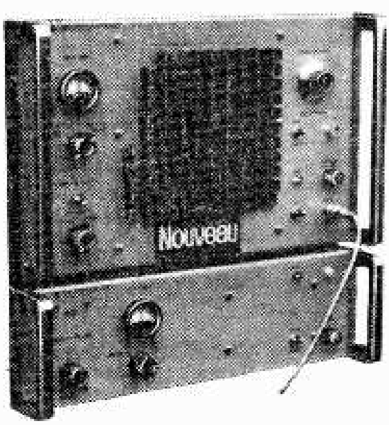


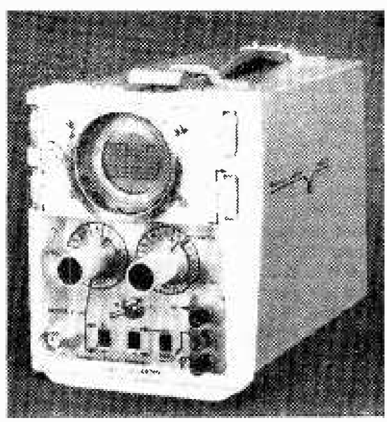
50 Mc/s C.R.C. oscilloscope using 17kV on final anode to give adequate brightness at 10nsec/cm.



Tacussel VE-7 electronic multimeter.

50 Mc/s Hewlett-Packard frequency synthesizer.





Transistor oscilloscope by Ribet-Desjardins is about 6in high.

its own shift and gain control. Thus, although a common time-base is used, a waveform can be displayed in its entirety on one trace, and a portion of itself or another waveform expanded and "windowed" on the other.

Transistor oscilloscopes are still not very numerous, but one extremely compact example was shown by Ribet-Desjardins. It is intended for maintenance work, having the fairly narrow passband of 1.5 Mc/s at a sensitivity of about 25 mV. The input stage—a transistor—presents an impedance to the source of 1 MΩ. Automatic sync is provided, the fastest sweep being 20 μsec. An internal calibration oscillator delivers a high-frequency, 1-Vpp square wave. As only a 1-in tube can be used, a lens is used, integral with a viewing hood.

A larger instrument by Katji uses Nuvistors to obtain 1 MΩ input impedance and employs two 0-15 Mc/s *y* amplifiers, giving 50 mV/cm. Two 200 nsec delay lines are provided.

The a.f. response curve tracer by Bruel & Kjaer does not rely on the linearity of a frequency-modulating device to obtain precise correlation between *x* and *y* axes. Instead, the frequency sweep is obtained from a motor-driven generator, the *x* deflection being derived by a frequency discriminator. Two plug-in units enable the instrument to cover 20 c/s-20 kc/s or 200 c/s-5 kc/s, and log. or linear *y* deflection is provided.

At the other end of the scale, two extremely wideband instruments were exhibited by Ribet-Desjardins and Férisol. Both accept the fact that with present-day devices, oscilloscope amplifiers are not able to operate at signal frequencies of 1 Gc/s or more. One answer is to use the sampling oscilloscope, but this requires a recurrent waveform to build up the trace. For single-shot phenomena, the only answer is not to amplify, and Férisol have a 3,500 Mc/s passband at a sensitivity of 10 V/cm. Ribet are limited to 1000 Mc/s, achieving useful traces for recording by using a blue phosphor and an accelerating voltage of 24 kV.

High input impedance is the main feature of the Tacussel VE-7 electronic multimeter. Infinite impedance is claimed up to 3 V input level, after which the attenuator is in circuit giving an impedance of 1,000 MΩ. Input current on the low range is less than 0.01 picoamps. Sensitivity on direct volts is 100 mV f.s.d., on direct current 0.1 mA, and on resistance 1 million megohms.

Two frequency synthesizers were on view, the Solartron FS1 covering the range 0-1.2 Mc/s in steps of 1 c/s with an error of less than 1 part in 10^8. Spurious synthesis outputs are better than −80 dB relative to the wanted signal.

Hewlett-Packard's 5100A covers 0.01 c/s to 50 Mc/s in 0.01 c/s steps with less than 2 parts in 10^{11} error. Selection is by push-button, and a "sweep" switch on each decade allows continuous control of frequency on that and subsequent (smaller) decades. The instrument can be remotely programmed, as only contact closures are needed for selection of frequency.

LETTERS TO THE EDITOR

The Editor does not necessarily endorse opinions expressed by his correspondents

Hi-Fi by Numbers

I AM very sympathetic towards Mr. Hodgson's plea for better B.B.C./G.P.O. landlines and would like to repeat here his request for people to complain in large numbers to the B.B.C. I myself have written on several occasions to the B.B.C. but, however, have met with the same frustrating complacent attitude expressed in Mr. Turner's reply and, I am afraid, in your leading article. Only sheer weight of numbers will, I feel, have any effect.

It is all very well people like yourself and Mr. Turner making references to antediluvian conditions such as 78 r.p.m. shellac records, broadcasting in pre-war days and the desire to put maximum interference-free radio coverage before frequency range—you are enjoying a range of up to 15 kc/s from the Wrotham transmitter and can well afford to sit back and feel happily complacent.

In the provinces we are not in such a happy position. Here are the quoted upper limits transmitted by Holme Moss v.h.f. transmitter, the programmes originating in London in each case—Home Service, 10 kc/s; Third Programme, 9.5 kc/s; Light Programme, 8 kc/s. The area served by Holme Moss is enormous, probably the largest slice of the country's population served by any transmitter and I can see no logical reason why such a large body of people should be treated in such an off-hand manner.

As Mr. Hodgkinson says, more and more people are spending large sums on high-quality sound equipment and if the B.B.C. cannot provide land lines of good quality for these people when it is already providing lines covering an enormous frequency range for TV, then it is high time it did so. Remarks about international standards cut no ice*—this country once led the world in radio transmission and can and should do so now, and as for saying that expenditure would have to be reduced in other directions to pay for better land lines—this expenditure would be as a mere drop in the ocean compared with the enormous current spending on B.B.C.-2 TV transmitters.

This is a highly technological age and the present state of affairs in sound broadcasting is just not in accord with the wonders of Telstar, the new Commonwealth cable link, etc.

Sheffield. P. R. HARWOOD

* They should, because without agreement on channel allocations and sideband limitation, interference would be intolerable.—ED.

MR. C. C. V. HODGSON reopens the question of B.B.C. "quality" transmissions. On the TV channels we can see test card "C." Why not audio tones on all sound channels covering the actual bandwidths normally transmitted. This would enable thousands of enthusiasts to check their equipment.

Cheadle. D. A. WATSON

TELEVISION engineers are given proof of performance through the medium of test card "C," also, the fact that the B.B.C. conduct frequent pulse and bar tests on video transmission ensures the TV engineer that they are very concerned about his picture quality. What then is to prevent the B.B.C. from transmitting a "frequency run" from their London studios on all sound transmitters, perhaps just once per week? Surely the audio enthusiast also merits some proof of performance and this would enable him to check the response of the whole proverbial chain to which Mr. Hodgson made reference in your January issue.

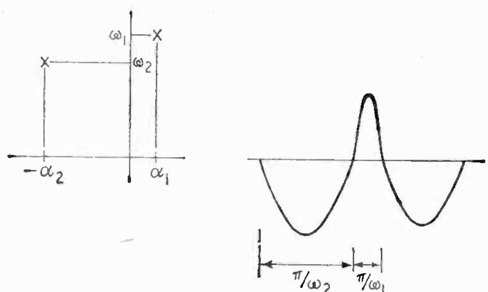
Newcastle upon Tyne. H. B. THOMPSON

Bridge Oscillator

THE common screen connection, to which Mr. J. P. Crean refers on page 73 of the February issue, was described in *Electronics* in about 1950. It provides positive feedback and can be easily understood if the screen of the first valve is regarded as a control electrode while the screen of the second valve is an output electrode. The usual object is to avoid the use of decoupling capacitors while preventing loss of gain due to the negative feedback produced by individual screen resistors.

The common anode resistor, R_1, provides negative feedback, and circuits of this form used in feedback pairs have been described in *Wireless World,* about 1954-5.* Here, to make matters more complicated, there is also a feedback component to the screen of the first valve.

Unfortunately, the screen feedback trick does not work very well, because the screen characteristics are normally not sufficiently linear. The increase of distortion is greater than the increase of gain and the overall



(a) (b)

performance is degraded. In consequence, this circuit is rarely mentioned in the reference texts.

We can assume that in Mr. Crean's circuit the amplifier proper has rather over infinite gain, so that with the feedback path through RV_4 he gets a pair of points on the signal excursion where the gain is just $1/\beta$. When RV_4 is correctly set this suits the RC network.

Amplitude limiting may be produced by the screen non-linearity, which will knock down the gain at the extreme excursions. On the other hand, there is a large signal at the screen of V2, which means that this valve is driven quite hard, and the amplitude control may be produced by grid rectification driving this variable-mu valve down its slope characteristic.

I do not understand the involuted cycloid: the waveform sounds to me as though it contained a good deal of second harmonic, or as though the circuit pole was being swept from $(-\alpha_2, \omega_2)$ to (α_1, ω_1) by the large-amplitude signal varying the gain and thus generating the waveform shown in simplified form as (b). If this is so, we should not expect the frequency to be particularly stable. In any event the internal distortion suggests this, if we follow Groszkowski. We should expect the output distortion to be reduced because of the filtering effect of the RC network combined with the feedback.

The great disadvantage of this circuit is that it is not designable, for we do not know enough about screen characteristics, and there are too many interacting factors. An infinite-gain inner amplifier is more easily produced using a double triode in a capacitively coupled Schmitt circuit. This will give a very low source impedance for feeding the network and will thus improve the calibration. If amplitude control by limiting is permitted, and we avoid it normally to keep the stability high, clipping diodes built out with resistance to maintain a finite, though reduced, forward gain should be satisfactory. A torch bulb is so cheap that I really cannot see the point of avoiding the use of a slow-speed control, with all its advantages.

London, W.8. THOMAS RODDAM

* "Feedback I.F. Amplifiers for Television," by H. S. Jewitt. Dec. 1954, p. 609.—Ed.

Problems of Presbyotia

IF only the problem of solving old age deafness was as easy as "Free Grid" would imply (January, 1964 issue) there would be many thousands of elderly people who would welcome such a solution.

The real problem is that while there are hearing aids which do boost the frequency range up to 4,000 c/s, the type of hearing loss involved is not a straightforward attenuation, but one which involves the perceptive mechanism of the ear. Consequently it is possible to overcome the attenuation, but it is not possible to replace the perception which the ear originally had. Hearing aids are made which fit entirely in the external ear, if not within the auditory meatus. These have a limited frequency response, but a head-worn, behind-the-ear aid normally will have a considerably improved frequency response than the in-the-ear aid. The limit on the frequency response is, of course, the transducers and the normal bandwidth for a hearing aid is not greater than 500 c/s to 4,000 c/s.

"Free Grid's" solution is, therefore, being used at the moment, but what is really required is something which will restore the clarity as well as the level of hearing.

London, W.C.1.

M. C. MARTIN,
Technical Officer,
Royal National Institute for the Deaf.

Public Address Show

THE 16th annual exhibition organized by the Association of Public Address Engineers opens on March 4th for two days at the King's Head Hotel, Harrow-on-the-Hill, Middlesex. A record number of firms are exhibiting and it is understood several more applied to participate, but all available space is allocated. In addition to the 36 manufacturers and organizations listed below, several journals, including *Wireless World*, are exhibiting.

During the show, which will be open from 10.0-6.0 each day, several manufacturers and the B.B.C. are staging demonstrations of sound equipment.

Admission is by ticket, obtainable free from exhibitors, or by trade card.

A.K.G. (Politechna)
Audix
Ampex Great Britain
B.B.C.
B.T.S. Productions
C.T.H. Electronics
Clarke & Smith
E.M.I. Electronics
E.M.I. Records
Ficord
Film Industries
Goodmans Industries
Grampian Reproducers
Hird-Brown
Jennings Musical Industries
Kelly Acoustics
Lockwood
Lustraphone
Magneta BVC
Pamphonic Reproducers
Philips Electrical
Post Office
Pye Telecommunications
Rendar Instruments
Reosound
Reslosound
Rola Celestion
S.T.C.
Shure Electronics
Sound Coverage
Tannoy Products
Trix Electronics
Vitavox
Vortexion
Warren PA Equipment
Westrex

COMMERCIAL LITERATURE

Semiconductors.—A new short-form catalogue (SFC-3) giving the essential ratings, characteristics and dimensions of over 400 different silicon rectifiers, Zener diodes, thyristors and other semiconductor devices is now available from International Rectifier Company (Great Britain), of Hurst Green, Oxted, Surrey. Details of several new products, including 50-watt, 10-watt and 1-watt diffused Zeners with voltage ratings up to 200 volts; 400 mW all-glass Zeners; and 70 A 1500-volt epitaxial thyristors are included together with details of a wide range of standard and custom built rectifier assemblies.
6WW 326 for further details.

Detailed information of facsimile radio **transmissions of weather maps,** including the times of broadcasts, from stations all over the world has been compiled and published by Muirhead & Co. as a loose-leaf book. It is available, free, to those interested in the broadcasting and reception of weather maps, from Muirhead & Co. Ltd., Beckenham, Kent.
6WW 327 for further details.

A 20-page catalogue describing the **Heathkit range of constructional kits** is now available from Daystrom Ltd., Gloucester. The kits listed cover the audio, domestic radio, test equipment and amateur radio fields.
6WW 328 for further details.

A short-form catalogue covering **magnetic core and memory test equipment** is now available from the Computer Test Corporation, Route 38 & Longwood Avenue, Cherry Hill, New Jersey, U.S.A. Programmed pulse generators, solid-state current pulse drivers and voltage/current calibrators, for measuring core signals and for calibrating drive pulses, are included. (Bulletin No. 63-G.)
6WW 329 for further details.

Miniature Lamp Bulbs.—Indicator and instrument panel bulbs and sub-miniature lamps are included in catalogue No. 63 now available from Vitality Bulbs Ltd., Neville House, Neville Place, London, N.22.
6WW 330 for further details.

The Government and Industrial Valve Division of Mullard Ltd., Torrington Place, London, W.C.1, have produced a booklet describing the **electrical behaviour of quartz crystal units.** Entitled "Mullard all-glass crystal units," it deals with their behaviour as individual components and as oscillators. A glossary of terms and the specifications laid down for crystal units are included.
6WW 331 for further details.

A **low-distortion oscillator,** complementary to the Radford distortion measuring set, is described in a leaflet obtainable from Radford Electronics Ltd., Ashton Vale Estate, Bristol 3. This instrument, which generates frequencies from 5 c/s to 250 kc/s, has an in-built valve voltmeter for output monitoring and measurement. A technical specification is included.
6WW 332 for further details.

"Silcoset" room-temperature-curing silicone rubbers are described in a publication now obtainable from Imperial Chemical Industries Ltd., Nobel Division, Silicones Department, Stevenston, Ayrshire, Scotland. Technical details are included together with general information on its uses which include potting terminal connections, sealing or encapsulating electronic equipment and repairing silicone rubber piece-parts.
6WW 333 for further details.

The 1964 **EEV Abridged Valve Data** book is now available from the English Electric Valve Company, Chelmsford. The first part of the publication comprises an equivalent index and lists all EEV types, their applicable CV numbers, and other manufacturers' types which they may replace. The second part gives abridged data for the EEV range of valves and accessories.
6WW 334 for further details.

The capacitor division of Standard Telephones and Cables Ltd. has produced a publication, **Quality Control,** which deals with the methods used, from the intake of raw materials to the final stage of "quality assurance sampling." Copies are available from the company's offices in Brixham Road, Paignton, Devon.
6WW 335 for further details.

A preliminary leaflet entitled "**Thorn-A.E.I. Semiconductors**" is now available from Thorn-A.E.I. Radio Valves & Tubes Ltd., 155 Charing Cross Road, London, W.C.2. It includes technical details together with prices and equivalent data, on their l.f. transistors, diodes and silicon rectifiers.
6WW 336 for further details.

Newmarket Transistors Ltd. have produced a leaflet listing their **equivalent transistors** to other British types. Some 250 are included, and copies of the leaflet are obtainable from Exning Road, Newmarket, Suffolk.
6WW 337 for further details.

A catalogue giving details of the **electronic measuring instruments** manufactured by the American company Waveforms Incorporated is now available through the U.K. agents Livingston Laboratories, 31 Camden Road, London, N.W.1.
6WW 338 for further details.

An abridged catalogue listing the major features and characteristics of **Tektronix oscilloscopes** and companion instruments is now obtainable from Tektronix U.K. Ltd., Beaverton House, Station Approach, Harpenden, Herts.
6WW 339 for further details.

INFORMATION SERVICE FOR PROFESSIONAL READERS

To expedite requests for further information on products appearing in the editorial and advertisement pages of *Wireless World* each month, a sheet of reader service cards is included in this issue. The cards will be found between advertisement pages 16 and 19.

We invite readers to make use of these cards for all inquiries dealing with specific products. Many editorial items and all advertisements are coded with a number, prefixed by 6WW, and it is then necessary only to enter the number(s) on the card.

Readers will appreciate the advantage of being able to fold out the sheet of cards, enabling them to make entries while studying the editorial and advertisement pages.

Postage is free in the U.K., but cards must be stamped if posted overseas. This service will enable professional readers to obtain the additional information they require quickly and easily.

By

"CATHODE RAY"

NO HIDING PLACE—

—from the Law (Lenz's)

ADVERTISERS devote their remarkable talents towards trying to impress indelibly on our minds crisp statements which may be profitable to their clients but cannot be relied upon for universal validity. Some of the rules handed out to us by teachers are little better. " Never end a sentence with a preposition," for example. " Like poles repel; unlike poles attract." This is often true, but *can* be the reverse. The fact that it is so often true makes it all the more misleading when the exceptions turn up. The moral of all this is to concentrate our attention on the genuinely general laws.

Lenz's is one of these. Looking it up, I was surprised to find that it dates from 1834—only 3 years after Faraday's discovery of electromagnetic induction, to which it refers. Like most of these laws it can be put in various ways. A direct translation from the original German is rather involved and restricted, but broadly it means that when a current is magnetically induced its field opposes the inducing field. This is an application, to one particular activity, of the still more general law of conservation of energy. If Lenz's law were reversed one would be able to get energy for nothing. Any induction started would increase itself. It is its generality that makes the law applicable to situations undreamed of by Lenz, and therefore so valuable to us.

Faraday's experiments, of course, were performed with coils of wire. In one experiment the coils were stationary, like transformer windings, and a momentary current was indicated in one of them whenever a current through the other was switched on or off. In another experiment currents were induced by moving a magnet in and out of the coil in circuit with the current indicator. Either a permanent or electro magnet would do.

The lines of force or flux suggested by Faraday are imaginary and unnecessary, but most of us find them a useful mental aid. We say that when the magnetic flux enclosed by a loop is varying, an e.m.f. is generated around the loop, proportional to the rate of change of flux. The loop need not be material; it can be an imaginary line. But if it is a conductive circuit the current driven along it by the e.m.f. creates a magnetic field which (in accordance with Lenz's law) is in the opposite direction to the inducing field.

Earlier still, Ampère showed the equivalence of a current-carrying coil and a magnet, and suggested that all magnetism was due to currents, permanent magnets being energized by currents on an atomic scale. And Rowland demonstrated convincingly that moving a " static " charge creates an electric current. Next, J. J. Thomson discovered electrons, which proved to be the charges whose motion constituted most electric currents. They were also found to constitute the outer parts of all atoms. Along came Bohr with his theory that they revolve around the positive nucleus like planets round the sun, except that only certain orbits are possible, but they can jump from one orbit to another with absorption or emission of energy. These allowable orbits were linked with the quantum theory by h, Planck's constant, which connects the sizes of packets of radiation (photons) with their frequency by the fundamental formula

$$\delta E = hf$$

According to Bohr, the orbits were such that the angular momentum of the electron in them was 1, 2, 3, etc., times $h/2\pi$.

Angular momentum, by the way, is the product of (a) mass, (b) its velocity, (c) its distance from the axis around which it revolves. It is one of those things that are conserved. So if you whizz yourself around in a well-constructed revolving chair, holding a brick at arm's length in each hand, and then hug them to your bosom, you will find yourself going faster. Factor (c) being reduced and (a) remaining constant, (b) must increase.

The electron has angular momentum around the nucleus by virtue of its mass (m) and orbital speed. It also has negative electric charge, e, and this charge moving around the orbit is an electric current, which creates a magnetic field. So the electron in its orbit is a combination of a tiny flywheel and a tiny magnet. Because the ratio e/m is constant, the amount of magnetism is directly proportional to the angular momentum.

More recently still it has been shown that the way an electron moves is nothing like so simple and mechanical as just described and the electron itself is not a definitely locatable particle but is more like a standing-wave system. However, fortunately for those of us who find these modern concepts difficult,

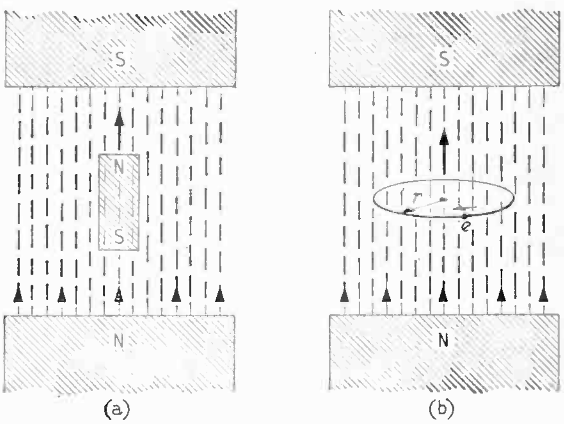


Fig. 1 How a small bar magnet (a) and an elementary electromagnet (b) would tend to lie in a uniform magnetic field, with their own internal fluxes in line with that of the main field.

the calculated results often turn out to be the same as those derived from the planetary model by fifth-form applied maths. So let us assume simple circular orbits.

Fig. 1(a) shows how a little bar magnet would tend to set itself in an upward magnetic field as shown. Note that the bar magnet's own internal flux would also be upward, so as to emerge from its N pole as convention has it. The electronic equivalent is shown at (b). The orbit is horizontal and the electron is circulating clockwise as seen from above, which is the same as conventional positive current clockwise from below. The resulting flux through the orbit is upward, as indicated by the corkscrew rule.

Let us now calculate the speed at which the electron is rotating in an orbit of given r, before the surrounding field is switched on. For r to remain constant there must be an exact balance between the centrifugal force, tending to make the electron fly out, and the centripetal force, tending to draw it in to the nucleus. Because the nucleus is 1836 times as heavy as the electron there is very little error in assuming (as we are going to do) that it is a fixed point. The centrifugal force, due to the mass of the electron tending to continue in a straight line in accordance with Newton's first law, is mv^2/r. The centripetal force, due to the electric attraction between opposite charges is, in m.k.s. units, $e^2/4\pi\epsilon_0 r^2$, ϵ_0 being the permittivity of the vacuum in which the electron is moving, 8.854×10^{-12}.

Since these are equal,

$$\frac{mv^2}{r} = \frac{e^2}{4\pi\epsilon_0 r^2}$$

$$\therefore\ v = \sqrt{\frac{e^2}{4\pi\epsilon_0 mr}}$$

From this we can, if we want, find the electron's angular velocity, $\omega_0 = v/r$, or revs per sec, $f_0 = v/2\pi r$. Because current is reckoned as the charge passing any point per second, around the orbit it is ef.

Next, let us suppose the field is switched on. There are various ways of considering what should happen as a result. According to Faraday (in modern terms) the flux now made to link with the orbit will generate an e.m.f. around it and, because an electron is available for "flowing", the e.m.f. will drive a current round the orbit. According to Lenz, the field due to that current will oppose the field that caused it and so reduce the linked flux.

There is one important difference between this and Faraday's experiments. He got only a momentary current when he switched a field on, and another (in the opposite direction) when he switched it off. The current was proportional to the e.m.f. (Ohm's law) and the e.m.f. was proportional to the rate of change of flux, so existed only during the growth and decay of flux. But our orbit is not a normal subject for Ohm's law, because there are no ohms. There is nothing for the electron to bump into and resist it. And although classical electromagnetism says it ought to lose energy by radiation because (as one can see when the orbit is edgewise) it is oscillating, classical electromagnetism is wrong in this particular respect, being overruled by quantum law. Once the electron is put into circulation it goes on until something is done to stop it. The ordinary orbital motion is evidence of that. In Faraday's lifetime there was no circuital equivalent of such a thing. But in 1914 Kammerlingh Onnes cooled a lead ring to the temperature of liquid helium and repeated some of Faraday's experiments. The resulting induced currents continued to flow without any perceptible falling off. So the superconductive ring makes an excellent model of our electron orbit.

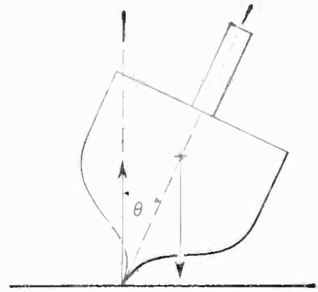


Fig. 2 When a top is spinning at an angle (θ) to the vertical, the forces tending to overturn it—indicated by arrows—actually make its axis describe an inverted cone.

Another way of regarding the matter is as an electric charge moving at right angles to a magnetic field. In such circumstances it is pushed by a force at right angles to the field and to its own motion. That means radially, so here is a third force acting along that line. Is it outward or inward? The usual way of telling is by using Fleming's left-hand rule. If you can't remember it and haven't a suitable book handy, you can do either (or both) of two things. If you are experimentally minded you can pass a current through a wire crossing a magnetic field and see which side it moves towards. Or if you are an armchair philosopher you will consider which is in accordance with Lenz's law. To save time and paper I'll tell you it is outwards, and then if it doesn't agree with Lenz's law you'll know I was wrong.

Our elementary book on electricity and magnetism tells us that the actual amount of force is *Bev*. Or, since v is the symbol we used for the electron's velocity with no field, and we cannot be sure that it is going to be the same with the field (especially as we are going to assume that the size of the orbit remains constant) let us call it v_f. Remembering that e is negative, then, we have

$$\frac{mv_f^2}{r} - Bev_f = \frac{e}{4\pi\epsilon_0 r^2}$$

This is a quadratic in v_f, so

$$v_f = \frac{eB \pm \sqrt{e^2B^2 + me^2/\pi\epsilon_0 r^3}}{2m/r}$$

If you look up the values of m and e (I have already told you ϵ_0), and take my word for it (or look it up) that r is of the order of 10^{-10} metre, you will find that even for such a large value of B as 1 m.k.s. unit (=10,000 gauss) the first term under the root sign is negligible compared with the second. So

$$v_f \simeq \frac{eBr}{2m} \pm \sqrt{\frac{e^2}{4\pi\epsilon_0 mr}}$$

$$\simeq \frac{eBr}{2m} \pm v$$

The $\pm$ in front of the original speed, v, means that the normal orbital movement of the electron could be either way round. We have been taking the direction shown in Fig. 1(b) as the positive direction of the *current*. The negative direction can be obtained simply by turning the orbit upside down. The interesting thing is that the sign of the *difference* between v and v_f is the same either way; e being negative, this component of velocity conferred by the field is negative when v is positive, so in Fig. 1(b) it is a slowing-down, which reduces the initial field in line with B (or adds a component against B, if you prefer to look at it that way). With the orbit upside down, so that v is negative, it makes it more negative, or speeds it up, again opposing the causing field, in accordance with Lenz, which clearly applies not only to whole circuits but also to atoms in those circuits—or, it seems, to atoms anywhere, even in insulators, provided that the orbits link with the flux of the applied field.

Of course if a flat circuit is turned so that its plane is parallel with the field there will be no flux linkage, no induced current, and no need to call in Lenz. So it might well seem. But again things are not quite so simple. Lenz's law is not to be escaped that way.

Let us go back to our childhood days and play with a spinning top (if such things are available nowadays; they certainly ought to be, in pursuance of the effort to turn out more physicists and electronic engineers). Almost inevitably, when we set the thing going, the axis will make a perceptible angle—call it θ—with the vertical through its point. The result is that the axis slowly traces out an inverted cone, in the same direction as it is spinning. This relatively slow movement is called precession. The earth does one complete cycle of it every 27,000 years.

If the top had not been spinning it would just have fallen over. This upsetting effect is due to the pair of equal forces marked by arrows in Fig. 2: the downward one, which is gravity acting on the mass of the top through its centre of gravity, and the upward one which is the pressure of the floor or table acting at its point. Between them they tend to make the top rotate clockwise from our point of view; that is to say, give it angular momentum about an axis along the direction we are looking. But the spinning top already has a lot of angular momentum about its own axis. Suppose it is turning clockwise from above; then its angular momentum is reckoned as downwards. Gravity tends to add angular momentum at right angles to that. Angular momentum being a vector quantity, the sum is obtained by "completing the rectangle". The resultant is represented by a line with its upper end leaning slightly towards us. That is how the axis of the top starts to incline. Directly it does so, the axis of the gravitational torque is moved round with it. And so the top is given its familiar precessional motion.

With a flywheel mounted on gimbals—a gyroscope—we can study this action when θ is 90°. Pushing one end of the wheel's axle downwards has the effect (when the wheel is turning) of making the axle move round bodily in its horizontal plane, to the surprise of the pusher, who expects it to move in the direction pushed—not at right angles to that. If the wheel was spinning clockwise as seen from the right (Fig. 3) a downward push at the right-hand end of the axle would bring that end swinging round towards us.

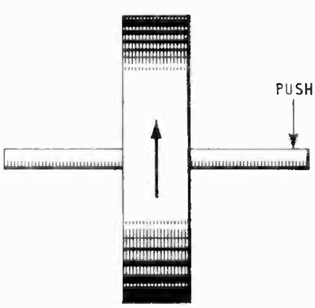


Fig. 3. This universally-mounted flywheel, or gyroscope, is similar to the top in Fig. 2, but with $\theta = 90°$. The downward push makes its axis swing around horizontally.

Mechanically, an electron in a circular orbit is, as we have seen, a tiny gyroscope. If the electron were revolving clockwise as seen from the right, it would also be a positive current clockwise from the left, which (the corkscrew rule tells us) would set up a magnetic field from left to right (Fig. 4), with the polarity shown. Placed in an upward magnetic field, this tiny magnet would tend to turn anti-clockwise—see Fig. 1 again. So, because the electron is a negative charge, the orbit will precess in the opposite direction to the gyroscope. Its angular momentum prevents it from turning into line with the main field, as a compass needle would.

If, without affecting its gyroscopic action, the electron were imagined to be fixed in its orbit at the point nearest to us, marked by an arrow-head in Fig. 4, the precession would carry it around relatively slowly in a horizontal orbit, clockwise as seen from below, and therefore causing a downward field, *opposing the main field*. So Lenz's law is not escaped, even when the orbit is turned so that no flux linkage takes place!

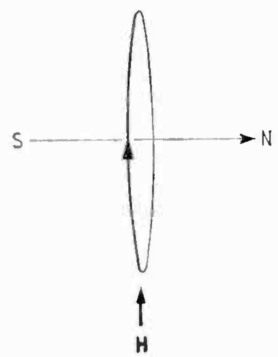


Fig. 4 Electronic equivalent of Fig. 3.

It is quite easy (but would take up some space to cover the necessary basic theory) to show that the rate of precession, with the electron rotating in its orbit, is equal to the amount by which our horizontal orbit in Fig. 1(b) had its speed changed by the field. So—again, with the electron fixed at the "equator" of the precessing orbit—the reverse field would be just the same as if the orbit were horizontal. However, as the electron is not so fixed but at any given moment can be at any horizontal distance from the nucleus from r down to zero, its average magnetomotive force is obviously less. When we consider the vast number of electrons in any piece of matter, we find that the workings of quantum laws make some of their axes point at right angles to the field, as in Fig. 4, and some of them at certain angles more or less than this—but none at 0° as in Fig. 1(b) or at 180° On the average the reverse magnetomotive force is one-third less than as calculated for Fig. 1(b).

According to Bohr, all electrons had angular momentum, and therefore magnetism, due to their orbital movements. But according to wave mechanics, now in vogue, an important series of electronic states is distinguished by the fact that there is no net movement *around* the nucleus, so no angular momentum or magnetism. Surely Lenz's law can have nothing on them in these states of alibi? In them, the directions of motion are quite random.

But the electrons *are* moving. And so far as their components of motion at right angles to an applied field are concerned, the field introduces a force (*Bev* again) that makes the electrons swerve to the left. The faster they do, the harder they swerve. So even if at any given instant their directions of motion are completely random, as in Fig. 5(a), a magnetic field immediately has them running round in small anticlockwise circles (b). This sets up another field, the direction of which is—yes! you are right first time!—in opposition to the field that caused it.

Even if the electrons were able (which they are not) to " lie low " by not moving at all, this would still fail to protect them from Lenz's law. If they are in a magnetic field there must have been a time when that field was growing. A stationary charge in a varying magnetic field experiences a force that sets it in motion. The explanation of the perpetual currents that Onnes set up in his superconductive ring (or, come to that, the transient currents set up by Faraday) depends in no way on the existence of prior motion on the part of the electrons constituting them. We may think, too, of the eddy currents set up in any conductor whenever a magnet is moved near it.

And so there is no hiding place for any kind of matter—even imaginary kinds—from Lenz's law. This gyroscopic action in the presence of a magnetic field applies to all electrons in all atoms of all elements, in all chemical compounds as solid, liquid or gas, and in any state of energy as defined by the quantum laws. All matter becomes anti-magnetized by magnetic fields.

This statement may seem quite contrary to experience. What about iron? And chromium, cobalt, and manganese? And the various magnetic alloys made of aluminium, nickel, etc.? They are all more or less strongly *magnetized*. Other substances show no obvious response, unless they are very delicately suspended, when careful tests show that some are very weakly anti-magnetized and others are very weakly magnetized. Everything, can, in fact, be divided into these three classes, called ferromagnetic, diamagnetic and paramagnetic.

The fact is that *all* matter is basically diamagnetic, owing to the all-embracing arm of Lenz's law as described. But in many of them this diamagnetism is concealed by the simultaneous operation of paramagnetism or ferromagnetism, into the complications of which we shall not enter; not just now, anyway.

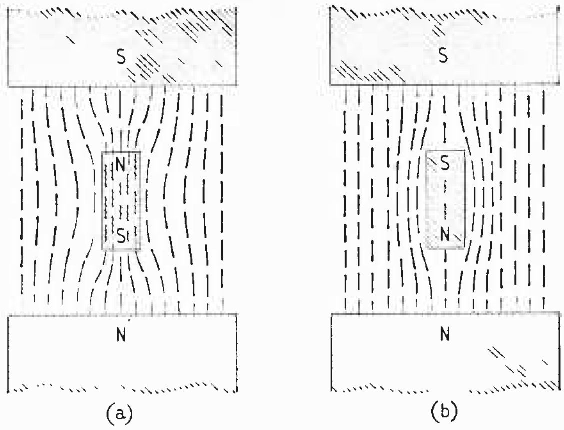


Fig. 6 Showing how rods of iron (a) and bismuth (b) tend to lie in a uniform magnetic field. Note that (b) contradicts the usual rule about like poles.

Paramagnetism was so named because bars of paramagnetic material tend to take up the same position as ferromagnetic material, parallel to the magnetic field in which they are placed and with the induced poles towards the inducing poles of opposite kind. This is where we came in—Fig. 1(a). The other effect was called diamagnetism in the erroneous belief that it made such material lie across the field. I much regret to say that on the assurance of more than one present-day textbook, I gave further currency to this error in the July/August issue of 1959, although the late Prof. G. W. O. Howe had exerted the weight of his authority to the contrary.* He showed that a bar of the diamagnetic metal bismuth, suspended in a uniform magnetic field, would tend to lie parallel to the field as in Fig. 1(a) except that the poles would be reversed. The bismuth's induced N pole would be attracted towards the main magnet's N pole, and the S pole to the S, directly contradicting the usual rule. The fact that two like poles face one another at each end is a result of Lenz's law. The conspiciously contrary effect when iron is used instead of busmuth is not evidence that Lenz's law is avoided; it is there all the time but is masked by a much stronger reverse effect.

The old elementary-course idea of regarding lines of force as the division between elastic bands filling the space, though crude, holds good here. In Fig. 6(a) showing a bar of iron, its much greater permeability than that of air encourages a much higher flux density within it. Any attempt to turn the bar around lengthens the flux lines through it, and so resists such attempt. Fig. 6(b) shows a bar of bismuth, with its permeability less than that of air or even of vacuum, so that the internal flux density is below normal. Turning this bar lengthens the lines outside it, with the same kind of result, though far weaker.

P.S. At least one reader spotted a slip near the top of column 2 in my last (January issue, p. 35): " susceptances" should of course have been " admittances."

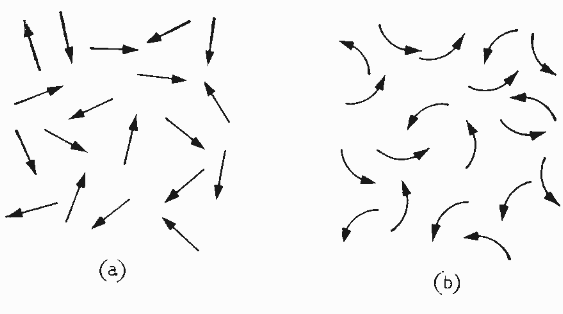


Fig. 5 In a magnetic field at right angles to the paper, random movement in the plane of the paper (a) is converted into circular movement all in one rotation (b).

**Wireless Engineer*, March 1949, pp. 75-77

TRANSISTOR CAR IGNITION SYSTEM

AN EXPERIMENTAL UNIT USING AN EXISTING IGNITION COIL

By J. H. WILLIS, Assoc.I.E.E.

NOW that high power transistors are readily available at reasonable prices it is possible for less than £2 to transistorize the ignition systems of many cars and gain the advantage of greatly increased contact-breaker life and an improvement in high-speed performance, using the existing ignition coil.

Circuit Description

The circuit tested and still in use by the writer in a high-performance, six-cylinder car, having the usual 12 volt positive-earthed supply, is shown in Fig. 1. It can be seen that two transistors are used, Tr1 is not critical but should be a power type rated for 30 volts. Tr2 is a Mullard OC28 high-power type rated for 80 volts maximum.

The operation of the circuit is simply as follows. With the contact breaker made Tr1 is cut off and the base of Tr2 is effectively joined directly to the 12 volt negative line via the 100 ohm resistor. Thus Tr2 operating as a switch is "on". When the contact breaker is open Tr1 conducts to bring the base of Tr2 almost to its emitter potential and Tr2 is switched "off".

It will be seen that a 0.1 μF capacitor is connected between emitter and collector of Tr2. This is necessary to keep down the transient voltage which occurs at the moment of switch-off across Tr2, and which could cause the failure of a transistor not designed for this duty. This capacity is about half the value of the condenser normally used across the contact breaker in the direct system; thus an appreciable improvement in high-speed performance is obtained.

The contact breaker now only has to break 10mA flowing through a resistor as against 4A approximately through the coil in the normal direct system, and so contact-breaker point erosion is practically eliminated.

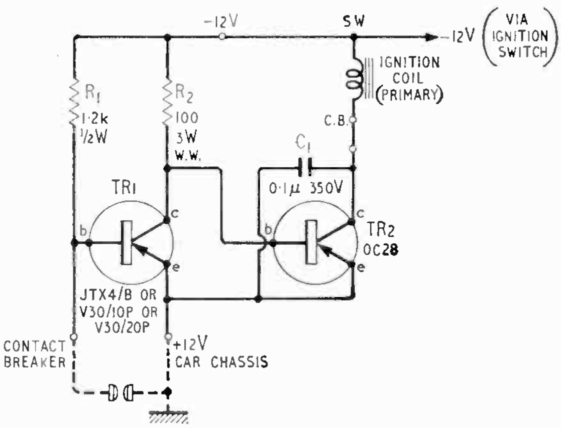


Fig. 1. Circuit diagram of transistor ignition system.

Construction

The method of construction used by the writer is shown in Fig. 2. This was to bolt the OC28 directly to a piece of 16 s.w.g. aluminium approximately 2 × 6in after bending into a U shape 2 × 2 × 2in. One side was screwed to a hardwood block 4 × 4 × ¾in to provide an insulated mounting. The OC28 is fixed to the side opposite the base block, and Tr1 is mounted in insulated (mica) washers in the centre of the aluminium heat sink. A three-way, screw terminal block fixed to the base was used for the contact-breaker 12 V−, and 12 V+ (chassis) connections. A 2B.A. screw terminal fixed directly to the edge of the heat sink near the OC28 transistor was provided for the coil connection.

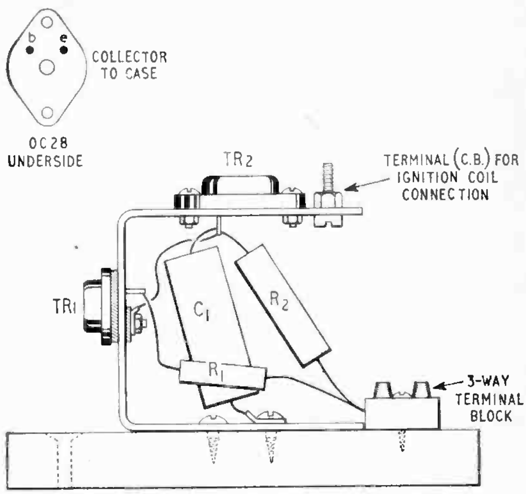


Fig. 2. Suggested component layout as seen in elevation.

Installation

The unit should be fixed by means of one or two bolts through the insulated base in as cool a place as possible on the side of the engine compartment well away from the exhaust manifold. The condenser is removed together with its connecting strip from the contact-breaker assembly, the connection from the contact breaker to the coil is removed and the coil (c.b. terminal) connected to the transistor

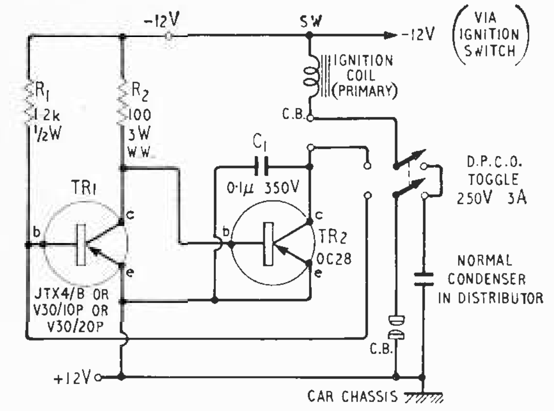


Fig. 3. Diagram showing method of switching from "normal" to transistor ignition.

unit heat sink. The contact breaker, 12 V− (from the SW terminal of the coil) and 12 V+ (chassis) are connected to the appropriate terminals on the transistor unit. In case of transistor failure the ignition can be easily restored to the normal direct system (the original condenser should be kept on the car!)

It is also possible to arrange a double-pole change-over toggle switch to switch from normal to transistor-ignition and *vice versa* as shown in Fig. 3.

Testing the Unit

The simple d.c. voltage measurements shown below should be made to check the unit before attempting to start the engine. For the peak voltage measure-

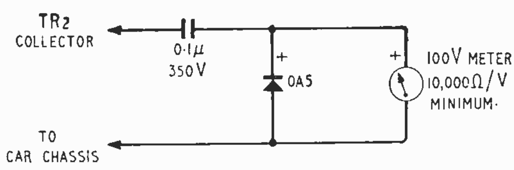


Fig. 4. Method of measuring peak voltage across Tr2.

ments a meter having a resistance of at least 10,000 ohms per volt must be used, the diode used should be rated for 100 volts or more.

Static voltage measurements

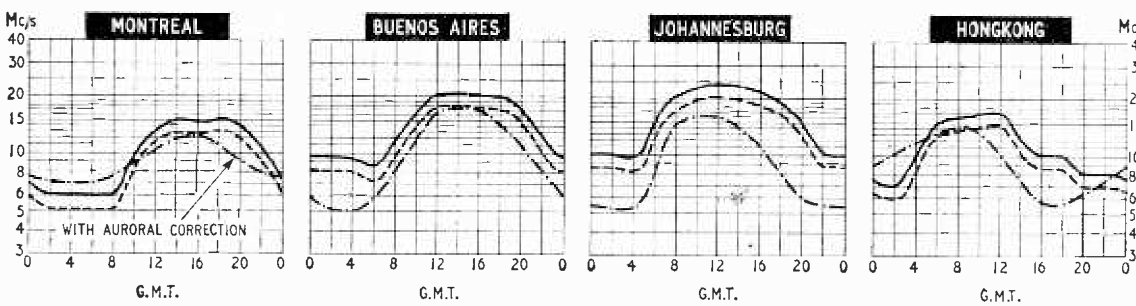
C.B. closed: Tr2 collector to chassis, 1.5 volts
C.B. closed: Tr1 collector to chassis, 0.75 volts
C.B. open: Tr2 collector to chassis, 12 volts
C.B. open: Tr1 collector to chassis, 0.1 volts

The peak voltage across Tr2 should be checked at various engine speeds, and should not exceed 75 volts for the OC28. A simple way of doing this is shown in Fig. 4. The peak voltage measurement obtained with the Lucas "Sports" ignition coil used by the writer was 72 volts maximum, and this type of coil is recommended for use with the circuit described.

Conclusion

This article has attempted to show how anyone with some knowledge of electronics who is also a car owner can successfully use reasonably priced transistors to improve the existing coil ignition system. Contact-breaker point erosion is eliminated, and an improvement in spark intensity at high engine revolutions is obtainable so that engine performance is noticeably improved.

H. F. PREDICTIONS—MARCH



MEDIAN STANDARD MUF
OPTIMUM TRAFFIC FREQUENCY
LOWEST USABLE HF

The seasonal change in the shape of the prediction curves is becoming apparent this month and it should result in a longer availability of the higher daytime frequencies.

The curves show the median standard MUF, optimum traffic frequency and the lowest usable high frequency (LUF) for reception in this country. Unlike the MUF, the LUF is closely dependent upon such factors as transmitter power, aerials, local noise level and the type of modulation; it should generally be regarded with more diffidence than the MUF. The LUF curves shown are those drawn by Cable and Wireless, Ltd., for commercial telegraphy and they serve to give some idea of the period of the day for which communication can be expected.

Direct-coupled Transistor Amplifier

HIGH GAIN-STABILITY AND INPUT IMPEDANCE

By M. BRONZITE, B.Sc.

A REQUIREMENT existed in a meteorological data-recording system for a d.c. amplifier to feed an integrating d.c. motor. The amplifier described below was designed for this function, but as will be shown, is of general application, with high input impedance, low output impedance, high linearity, bipolar operation and relatively low drift. All this has been achieved with a relatively simple circuit which uses only transistors and a diode.

The amplifier was designed in three sections: high impedance pre-amplifier, main amplifier, and output stage. These three sections can best be dealt with individually, as they are reasonably independent of each other.

Pre-amplifier:—Most amplifiers develop voltage gain in the first stage, in order to reduce the effects of succeeding stages on the overall noise level of the amplifier. However, this implies that a collector is used for gain, thus limiting the input impedance, due to Miller effect. High input impedance can best be obtained by " starving " a transistor[1], or by bootstrapping[2]. The latter is to be preferred since a " starved " transistor operates in a very non-linear mode.

In order to provide thermal compensation for V_{be} changes, a second complementary emitter follower is used (see Fig. 1). Perfect matching is unlikely to be achieved, but thermal effects will be minimized. The source of bootstrapped voltage levels for the pre-amplifier is discussed in the section on the output stage.

Main Amplifier:—This consists of two complementary long-tailed pairs (l.-t.p.) with two feedback loops; one to increase common-mode rejection[3] and the second to stabilize gain [4]. The loop for improved common-mode rejection operates as follows (see Fig. 1). A change in the voltage across the emitter resistor of the second l.-t.p., R_{18}, causes a change in voltage on the base of T5 (the constant-current generator of the first l.-t.p.). This causes a change in current through T5, i.e. through transistors T3 and T4, and thus causes a voltage variation across R_7 and R_8. This voltage variation appears on the bases of T6 and T7 and is of such polarity as to oppose the original change in the voltage across R_{18}. This reduction in change of voltage at the emitter of each l.-t.p. is such as to raise the parallel resistance to the equivalent current generator by the amount of feedback. Common-mode rejection is also increased by the same ratio.

The second feedback path consists of R_{17}, and R_{10} and R_{13} in parallel (equal to R_p). Since the input transistors T1 and T2 have different V_{be} there will be a standing voltage of approximately 0.2 volts on the emitter of T2 for the zero-input/zero-output condition. T3 " sees " a source voltage of −0.2

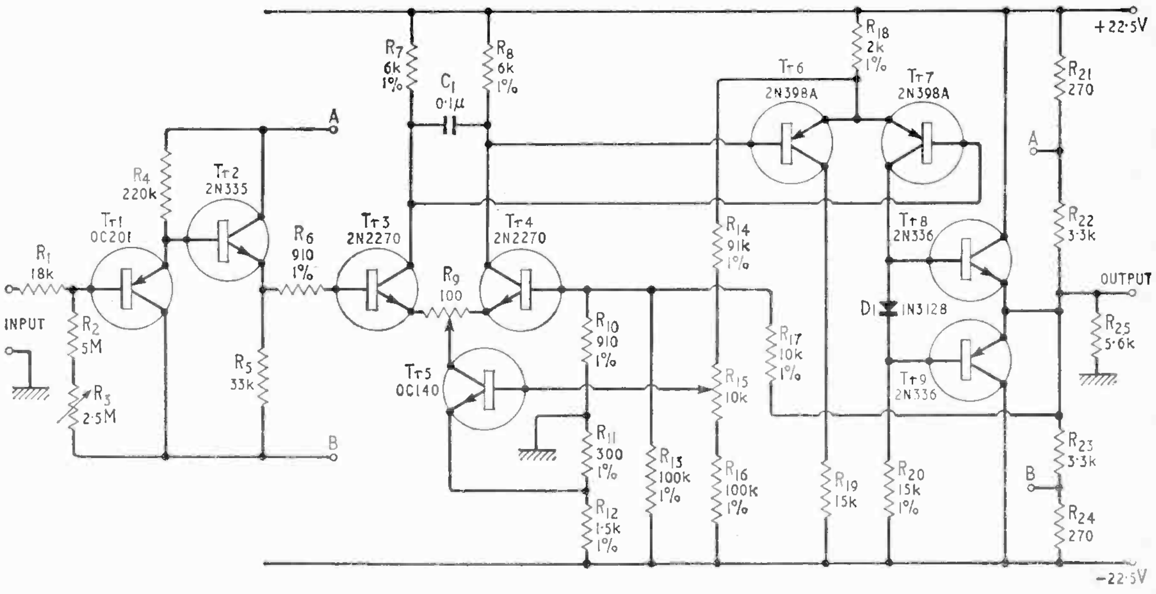


Fig. 1. Circuit diagram of complete amplifier.

volts with a source impedance of approximately 1kΩ. The combination of R_{10} and R_{13} simulates a similar arrangement on the base of T4. In a similar manner R_{11} and R_{12} are used to provide a low-impedance voltage source for the emitter of T5.

The overall gain of the amplifier is determined by the ratio of R_p to (R_p + R_{17}). This method of feedback has the advantage of increasing the input impedance, as seen from the emitter of T2, by the amount of feedback. Thus, in the circuit shown, with over 60 dB of feedback, the input impedance is approximately 1 MΩ. A 300-ohm variation, say, in the source impedance, i.e. at the emitter of T2, will then have no effect on amplifier operation. But such a 300-ohm change in this impedance will be equivalent to a change of approximately 200kΩ of signal source impedance. From this example, it can be seen that the problem of placing a resistor, equal to the source impedance, on to the base of the second transistor of the input l.-t.p. has been effectively eliminated.

The capacitor C_1 is used to prevent high frequency oscillation.

Output Stage:—Several disadvantages exist when only one output transistor is used for bipolar operation. Thus, without transistor T9, transistor T8 will cut off with negative signals (see Fig. 2(a)).

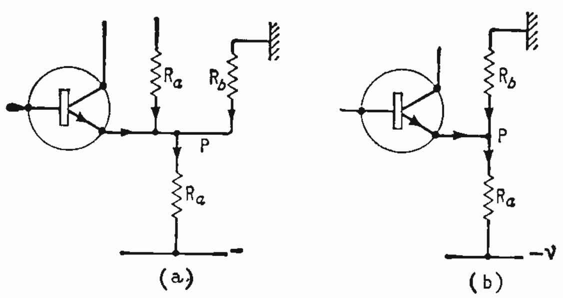


Fig. 2 (a). Transistor will cut off with small positive signal at P· (b). If $V_P \approx \frac{V}{2}$ then $R_a \leqslant R_b$ for transistor to conduct.

This difficulty can be overcome by removing R_{21} and R_{22}, although an alternative source of bootstrap voltage will now have to be found. With maximum negative excursion (approximately half available power supply voltage), the current in R_{23} must be higher than that in R_{25} in order that transistor T8 may still conduct (Fig. 2(b)). Thus the load impedance must always be higher than the sum of R_{23} and R_{24}—in this case 3.6kΩ, or the available output swing must be reduced. Both alternatives are undesirable. For the above reasons a class-B complementary output stage is used. Cross-over distortion is reduced by means of D1, which also provides bias compensation to prevent thermal runaway.

The resistors R_{21} —R_{24} provide two bootstrapped voltage sources for the pre-amplifier. The ratio of R_{21} to (R_{21} + R_{22}) is about 10% higher than the gain, to allow for resistor tolerances, etc. The current through these resistors is about ten times the current required by the pre-amplifier, although a higher ratio would be preferable, since the constant current drain from the circuit introduces non-linearity.

In spite of this disadvantage, it is felt that this method is to be preferred to the use of Zener diodes. A Zener diode, for example, could be placed at the emitter of T2. However, such a diode is a low-impedance device, and its use at a point of the circuit operating with low standing current is undesirable. Further, Zener diodes are expensive and suffer from temperature variations.

The nett effect of the non-linear operation is that the input impedance is varied by about 10%, which is of little consequence.

Adjustments

Care should be taken when first testing the circuit, to short-circuit diode D1.

The V_{be} of T1 and T2 will be known approximately from manufacturers data. Any difference greater than 100 mV must be compensated by R_{13}, which will go to the positive or negative supply depending on the polarity of the voltage at the emitter of T2.

To zero the amplifier the input is short-circuited, the trimmer R_{15} is set to half way, and the potentiometer R_9 adjusted for minimum value of output voltage. Then the trimmer is adjusted to provide zero output. If necessary R_9 and R_{15} are adjusted consecutively to obtain zero. Then R_3 is adjusted, with input open circuit, to provide open-circuit balance.

The collector current of the output transistors with no input signal should be about 0.5mA. This is adjusted by padding the diode D1 with an appropriate series or parallel resistor. If necessary more than one diode, germanium or silicon, should be used, depending on the output transistors used.

Results

The amplifier was designed for a gain of 12, and when so adjusted showed a variation of gain of less than 0.1% for an input range of 0 ± 1 volt, and impedance variations of 0-30kΩ. Gain without feedback is about 90dB, input impedance greater than 30MΩ, and output impedance less 0.2Ω (the amplifier was tested at low levels with maximum load current of 20mA). With the present output configuration, load impedances as low as 1kΩ may be used. Drift referred to input is 300μV/°C (tested over a 0–35°C range). In order to minimize thermal transients the input pair of transistors, and both l.-t.p.s were mounted on heat sinks. When adjusted for a 40dB gain by changing feedback and bootstrap resistors, gain variation was $\pm\frac{1}{4}$% with amplitude and polarity, with frequency response 1dB down at 10 kc/s. It should be noted that the transistors that were used were not necessarily the best ones for the given function. The choice was primarily based on availability.

Improvements

The input with its high drift is the most unsatisfactory part of the amplifier. This drift is largely due to the different rates of change of V_{be} with temperature for the two input transistors. This, in turn, is mainly caused by the different collector currents. By redesigning the circuit so that the collector currents are approximately equal, and then adjusting the emitter resistor of T2, the thermal

(*Continued on page 155*)

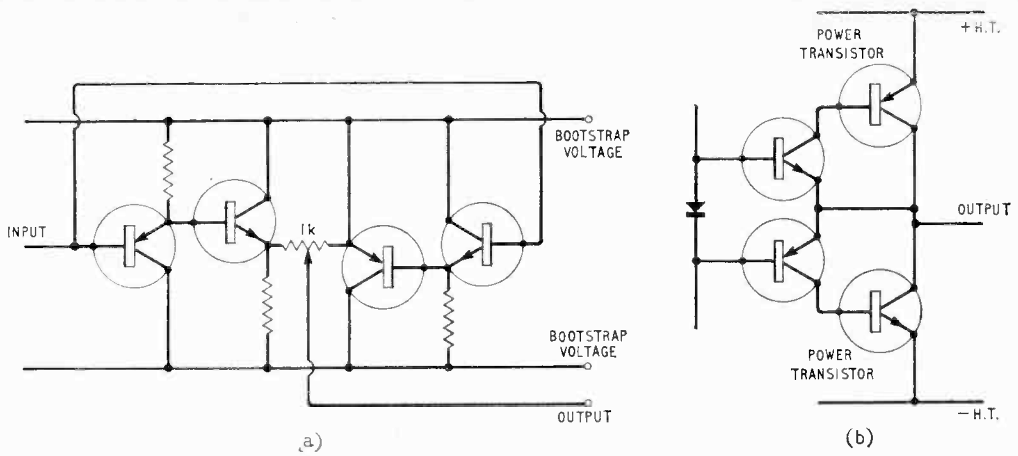


Fig. 3 (a). Input bridge circuit to reduce effect of thermal variations. (b) Output stage to increase available power output.

variation may be minimized. This method, however, either reduces the input impedance or increases the output impedance.

Further, a p-n-p transistor will only "track" with an n-p-n transistor over a small temperature range. A circuit which eliminates this problem, at the cost of added complexity, is shown in Fig. 3 (a). With perfect transistors there is no signal or standing direct voltage across the output potentiometer. However, in practice there will be 100-200 mV across the potentiometer, which is unimportant. Thermal balance is achieved by adjusting the output potentiometer until thermal cycling causes minimum changes in output. Results in the 20μV/°C region should be attainable. By using high gain planar transistors the current taken by the pre-amplifier may be reduced. Further, close attention to the resistor chain can provide better bootstrapping and a 200MΩ input impedance should be attainable.

Owing to the large amount of feedback in the main amplifier, oscillation will be hard to eliminate by the use of active elements alone. However, using high frequency transistors (f_α greater than 100 Mc/s), the frequency of oscillation will be high, which will ease its removal by means of a passive network. Further, the operating frequency of the amplifier will be extended. With high-gain transistors the operating current may be reduced, permitting large load resistors, and thus increasing the open-loop gain. An overall gain of 60dB might require a third l.-t.p. stage. Under these conditions, the problems of drift and power-supply stabilization become more important.

The output stage can be easily adapted to provide more power as in Fig. 3 (b). This Darlington configuration is to be preferred as it provides local feedback to reduce the effect of I_{co} changes in either transistor. Higher-voltage outputs can be achieved by the use of transistors with high voltage ratings in the last l.-t.p. and output stage.

Conclusion

It has been shown that a relatively simple transistor amplifier may provide adequate performance with inputs in the 0 to $\pm$1-volt range. The design may be easily modified for individual requirements.

The above work was sponsored by the Reactor Safeguards Committee of the Israel Atomic Energy Commission, and carried out in the Meteorological Department of the Hebrew University. The author would like to thank Mr. F. J. Goldwater for the helpful suggestions made during the course of the work.

REFERENCES

1. B. M. Bramson, "Starved Transistors Raise D.C. Input Resistance". *Electronics.* P.54. Jan. 30, 1959.

2. "Very High Input Impedance Amplifiers". Application note No. 6. Texas Instruments Ltd. (England).

3. Dr. D. J. Griffin, "Some Design Techniques for Low drift D.C. Amplifiers using Silicon Transistors." Semiconductor Application Report Vol. I, No. 5. Texas Instruments Ltd. (England).

4. Dean W. Slaughter. "Feedback Stabilised Transistor Amplifier." *Electronics.* P. 174, May 1955.

THIS MONTH'S CONFERENCES AND EXHIBITIONS

LONDON
Mar. 18-25 — Earls Court
Electrical Engineers Exhibition
(Assoc. of Supervising Electrical Engrs., Museum Street, W.C.1.)

CAMBRIDGE
Mar. 16-19 — Cavendish Laboratory
Cold Cathode Tubes and their Applications
(Brit. I.R.E., 9 Bedford Square, London, W.C.1)

EDINBURGH
Mar. 31-Apr. 3 — Heriot-Watt College
Joint Computer Conference
(Computer Conference Secretariat, I.E.E., Savoy Place, London, W.C.2)

HARROW
Mar. 4-5 — King's Head Hotel
Public Address Equipment
(A.P.A.E., 394 Northolt Road, South Harrow, Middx.)

OVERSEAS
Mar. 1-10 — Leipzig
Leipzig Spring Fair
(Leipziger Messeamt, Postfach 329, Leipzig, C.1)
Mar. 12-17 — Paris
Festival of Sound
(Syndicat des Industries Electroniques de Reproduction et d'Enregistrement, 16 rue de Presles, Paris 15)

MARCH MEETINGS

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

LONDON

2nd. I.E.E.—Discussion on "Merits and demerits of equivalent circuits" at 5.30 at Savoy Place, W.C.2.

4th. Brit.I.R.E.—"Recent trends in transistor audio amplifier design" by P. Tharma at 6.0 at the London School of Hygiene, Keppel Street, W.C.1.

4th. British Kinematograph Society.—"Film telerecording" by A. B. Palmer at 7.30 at the Central Office of Information, Hercules Road, S.E.1.

5th. Television Society.—Discussion on "Factors affecting the choice of a colour TV system for the U.K." at 7.0 at the I.T.A., 70 Brompton Road, S.W.3.

6th. I.E.E. & Brit.I.R.E.—Discussion on "Encapsulation of electronic circuits and materials compatible with human-body implantation" at 2.30 at Savoy Place, W.C.2.

6th. I.E.E.—"Fuel cells" by Dr. A. B. Hart at 5.30 at Savoy Place, W.C.2.

10th. I.E.E.—"Principles governing the design of systems for continuous numerical control of machine tools" by D. J. Mynall at 5.30 at Savoy Place, W.C.2.

10th. Brit.I.R.E.—Symposium on "Some new possibilities in parametric devices" at 6.0 at the London School of Hygiene, Keppel Street, W.C.1.

11th. I.E.E.—"The planning of communications satellite systems" by F. J. D. Taylor and J. K. S. Jowett at 5.30 at Savoy Place, W.C.2.

11th. Brit.I.R.E. — "Stereophonic broadcasting and receivers" by Dr. G. J. Phillips and J. G. Spencer at 6.0 at the London School of Hygiene, Keppel Street, W.C.1.

12th. Radar & Electronics Assoc.—"Observation of radio galaxies" by Dr. J. S. Hey at 7.0 at the Royal Society of Arts, John Adam Street, W.C.2.

13th. R.S.G.B.—"Radio astronomy" by F. Hyde at 6.30 at I.E.E., Savoy Place, W.C.2.

18th. I.E.E.—Discussion on "The measurement of the amplitude and peak power of pulse r.f. systems" at 5.30 at Savoy Place, W.C.2.

18th. I.E.E. Graduates—"The London Post Office Tower" by L. R. Creasy at 6.30 at the Institution of Civil Engineers, Great George Street, S.W.1.

18th. British Kinematograph Society.—Discussion on "Film requirements for colour television" at 7.30 at the Central Office of Information, Hercules Road, S.E.1.

19th. I.E.E. and Inst. P. & Phys. Soc.—"Gaseous lasers" by Dr. H. A. H. Boot at 5.30 at Savoy Place, W.C.2.

19th. Institution of Electronics.—"Variable resistance pressure transducers" by J. Dean at 7.0 at the London School of Hygiene, Keppel St., W.C.1.

20th. Institute of Navigation.—Discussion on "Man or machine" at 3.0 at the Royal Geographical Society, 1 Kensington Gore, S.W.7.

20th. Television Society. — "The propagation of colour television signals at u.h.f." by K. Bernath at 7.0 at the I.T.A., 70 Brompton Road, S.W.3.

20th. B.S.R.A.—"Stereophonic microphone techniques" by R. L. West and P. M. Clifford at 7.15 at the Royal Society of Arts, John Adam St., W.C.2.

23rd. I.E.E.—"Practical aspects of microwave radio-relay systems" by B. Wilson, H. D. Hyamson and W. Grossett at 5.30 at Savoy Place, W.C.2.

24th. I.E.E.—Tenth Graham Clark Lecture on "The science of near space" by Sir Edward Appleton at 5.30 at the Institution of Civil Engineers, Great George Street, S.W.1.

24th. Society of Instrument Technology.—"A data handling system for a radar installation" by J. E. A. Harrison and R. J. Chase at 7.0 at Manson House, 26 Portland Place, W.1.

ABERDEEN

11th. I.E.E. — "V.H.F. television broadcasting— planning the transmitting equipment" by H. Page at 7.30 at Robert Gordon's Technical College.

BIRMINGHAM

10th. I.E.E.—"Lasers" by K. D. Harris at 6.15 at the College of Advanced Technology.

13th. Society of Instrument Technology.—"Instrumentation and control in satellite communication" by C. F. Davidson at 7.0 at the College of Advanced Technology, Gosta Green.

23rd. I.E.E.—"Telemetering and tele-control" by R. E. Young at 6.0 at the James Watt Memorial Institute.

BRIGHTON

4th. Brit.I.R.E.—"Solid state control systems" by G. B. Kent at 6.30 at Brighton College of Technology.

BRISTOL

18th. Brit.I.R.E.—"The development of the Atlas computer system" by Dr. D. B. G. Edwards at 6.30 at the University, Engineering Lecture Rooms.

CARDIFF

4th. Brit.I.R.E.—"Latest developments in electronic weighing" by L. F. Cohen at 6.30 at the Welsh College of Advanced Technology.

COVENTRY

16th. Brit.I.R.E.—"Machine tool control" by C. J. Charnley at 7.15 at the Herbert Art Gallery.

CRAWLEY

25th. I.E.E.—"The present state of colour television" by S. N. Watson at 6.30 at the Institute of Further Education.

DUBLIN

19th. I.E.E.—"Microwave radio systems with special reference to links provided for the Irish TV service" by W. Dain and T. Forsythe at 6.0 in the Physical Laboratory, Trinity College.

DUNDEE

12th. I.E.E.—"V.H.F. television broadcasting—planning the transmitting equipment" by H. Page at 7.0 at the Electrical Engineering Department, Queen's College.

EDINBURGH

10th. I.E.E.—"Results of tests at Goonhilly using experimental communications satellites Telstar and Relay" by R. W. White at 7.0 at the Carlton Hotel, North Bridge.

11th. Brit.I.R.E.—"Counting techniques" by W. R. Diggle at 7.0 at the University, Department of Natural Philosophy, Drummond Street.

23rd. I.E.E.—"From graduate to professional engineer" by J. E. C. McCandlish at 7.0 at the Heriot-Watt College.

EVESHAM

9th. I.E.E.—"Colour television systems" by T. Worswick at 6.30 at the B.B.C. Training Department, Wood Norton.

FARNBOROUGH

24th. I.E.E.—"The present state of colour television" by S. N. Watson at 6.15 at the Technical College.

GLASGOW

9th. I.E.E.—"Results of tests at Goonhilly using experimental communi-

cations satellites Telstar and Relay" by R. W. White at 6.0 at the Royal College of Science and Technology.
12th. Brit.I.R.E.—"Counting techniques" by W. R. Diggle at 7.0 at the Institution of Engineers and Shipbuilders, 39, Elmbank Crescent.

LEEDS
24th. I.E.E.—"The Atlas computer" by Dr. D. B. G. Edwards at 6.30 at the Department of Electrical Engineering, the University.

LEICESTER
10th. Television Society.—"Aerials for u.h.f." by R. S. Roberts and F. J. Tomlin at 7.15 at the New Vaughan College, St. Nicholas Street.

LIVERPOOL
2nd. I.E.E.—"An engineer in Moscow" by Prof. M. G. Say at 6.30 at the Royal Institution, Colquitt Street.
18th. Brit.I.R.E.—"Parametric amplifiers" by Dr. T. Buckley at 7.30 at the Walker Art Gallery.

MANCHESTER
5th. Brit.I.R.E.—"Recent advances in h.f. transmission equipment" by V. O. Stokes at 7.0 at Reynolds Hall. the College of Science and Technology.
11th. I.E.E.—"Navigational aids—Manchester airport" by R. E. Smith at 6.15 at Reynolds Hall, the College of Science and Technology.
23rd. I.E.E.—Discussion on "Academic routes to graduate membership" at 6.15 at Reynolds Hall, the College of Science and Technology.

NEWCASTLE-UPON-TYNE
2nd. I.E.E.—"Optoelectronics" by M. J. Coupland at 6.30 at the Rutherford College of Technology, Northumberland Road.
11th. Brit.I.R.E.—"The application of numerical control to machine tools" by J. M. Hutchison at 6.0 at the Institute of Mining and Mechanical Engineers, Westgate Road.

NEWPORT
20th. I.E.E.—"Masers" by Dr. R. Hoselitz at 6.30 at the Isle of Wight Technical College, Hunnyhill.

PORTSMOUTH
18th. I.E.E.—"A portable h.f. communication system" by F. P. Newell and A. Buchan at 6.30 at the College of Technology, Anglesea Road.

READING
9th. I.E.E.—"Lasers" by R. H. F. Christie at 7.30 at the Great Western Hotel.

SOUTHAMPTON
10th. I.E.E. & Brit.I.R.E.—"Microwave techniques" by Dr. G. D. Sims at 6.30 at the University.

SWANSEA
12th. I.E.E.—"Stereophonic listening—facts and fancies" by Prof. E. C. Cherry at 6.15 at College House, University College, Singleton Park.

WEYMOUTH
19th. I.E.E.—"Aircraft blind landing" by J. S. Shaler at 6.30 at South Dorset Technical College.

WOLVERHAMPTON
11th. Brit.I.R.E.—"Applications of industrial television" by P. Wontner at 7.15 at the College of Technology.

UNBIASED

By "FREE GRID"

Hyper-het

WHEN talking about the super-het in the January issue I said, in what must have been a moment of mental aberration, that it was given its name of supersonic heterodyne because the beat frequency which is passed through the i.f. amplifier was above audibility. This is so, but so is the frequency of the local oscillator and, it is, of course, the local oscillator which is the "other power" represented by the word heterodyne. I am rather surprised, however, that so few readers wrote pointing out my "clangtron."

Of course the name supersonic heterodyne is a bit of a linguistic hotchpotch like the word television. However, even if the super-het had been called a hyper-het, or in other words a hyper-acoustic heterodyne, I doubt if it would have prevented the slip of the pen which I made.

Some readers wrote in defence of the vague expression "ultrasonic waves" which I also attacked in the January issue. But I still don't like it any more than I do the expression ultra-violet rays. In neither case are we told whether the waves or rays are higher or lower in frequency than the datum of "sonic" or of "violet." Ultra vaguely tells us they are "beyond" in contrast to the definite "below" in the expression infra-red rays.

What is the matter with the word supra in place of ultra? It is a word favoured by the medical profession in preference to the more commonplace super in phrases like "supra-renal glands." Above all, I dislike the expression ultra-short.

Where Lethe Lurks

QUITE frankly, I don't know much about the regulations governing the ordinary electrical installations which we have in our houses for lighting, heating, operating our radio sets, and other purposes.

I was greatly surprised, therefore, to learn from the columns of one of our more respectable dailies that, according to the chairman of the Eastern Electricity Consultation Committee, it is the responsibility of the consumer to see that his electrical installation is properly earthed. The question had arisen because two women had been killed owing to their electrical installations having been earthed to plastic water pipes.

To me, it seems fantastic that this responsibility for earthing should be placed on to the shoulders of householders who are usually as ignorant of electrical matters as they are of the calculus. It reminds me of the early days of broadcasting when some people used to earth their crystal sets by sticking a skewer into the pot of the nearest aspidistra, a favourite indoor plant in 1922.

I fully agree with the learned chairman of this consultative committee that some action ought to be taken to remedy this state of affairs.

Nauseating Gnosticism

IT is not my intention to usurp the functions of high ecclesiastical authority by anathematizing the gnostics and their doctrines. In any case I feel sure the Editor would not allow it.

All the same, I do think the title of this note is singularly apt for condemning the use of the wretched expression "know-how" in place of the old and well-established word "knowledge." If some synonym for our word "knowledge" is needed, then surely the word "gnosticism" would be no more grotesque than the rather childish expression "know-how."

Maybe, of course, the advocates of the slang expression "know-how" wish to convey some subtle meaning which is not to be found in the word "knowledge." If so, let them write to the Editor or to me so that we may hear all about it, as it may open our eyes to something new in semantics.

"Know-how" is an expression usually applied to *technical* knowledge, but I have heard a clergyman, who ought to know better, speak of St. Paul's know-how in the matter of writing epistolary exegeses on doctrinal matters.

Pædohypnotron

I HAVE received through the Editor particulars of an electrical device which when attached to a pram rocks and therefore soothes the baby to sleep. This is stated to be the very first device of its kind so far as prams are concerned.

It is certainly the first I have heard of this type of device being used in connection with a pram, but I described an electrical cradle-rocking device in these columns many years ago. I was rebuked for so doing, as I was told that continuous rocking is bad for a baby's digestion. Apparently rocking tends to make butter out of the milk which babies imbibe, and this does not meet with the approval of pædiatricians. I wonder if the makers of this pram-rocking device have thought of that?

I am eagerly looking forward to seeing this device, as I am told that it is to be demonstrated at the Ideal Home Exhibition in March. I hope the exhibitors will have the goodness to provide a baby for practical demonstration.

Not Augustine Cantuar

WHEN recently I was browsing through the 1962 volume of the *Journal* of the I.E.E. I was surprised to read in a letter from Mr. I. C. Demetsopoullos, of the Department of Physics, Borough Polytechnic, that St. Augustine had interested himself in magnetism, and had written about some experiments which had been witnessed by another bishop.

For the moment I was misled into thinking that this was our own St. Augustine who landed on the Isle of Thanet with his 40 monks in A.D. 596 and became the first Archbishop of Canterbury. He was not of course the first man to bring Christianity to what we now call England, as one of his first acts, after converting the Kentish King Ethelbert, with the assistance of his Christian consort, Queen Bertha, was to hold services once more in the existing church of St. Martin.

It was not, in fact, until I read a footnote to the effect that the St. Augustine who had written about magnetism had done so in his book "The City of God," that I realized that it was, of course, the other St. Augustine who was Bishop of Hippo in the previous century. I recollect starting to read this massive work of many volumes in its original Latin (*De Civitate Dei*) but Kitchener called me away to what he regarded as the more important work of peeling potatoes.

It is interesting, however, to note that a bishop of those early centuries should have discussed magnetism. Maybe the time will come when some more Dead Sea scrolls will be found revealing some trenchant comments by St. Paul on the vagaries of magnetic effects which I feel sure he would have likened unto the ways of women, of whom he always seemed to disapprove, which is not really surprising in view of their reputation in the city of Corinth.