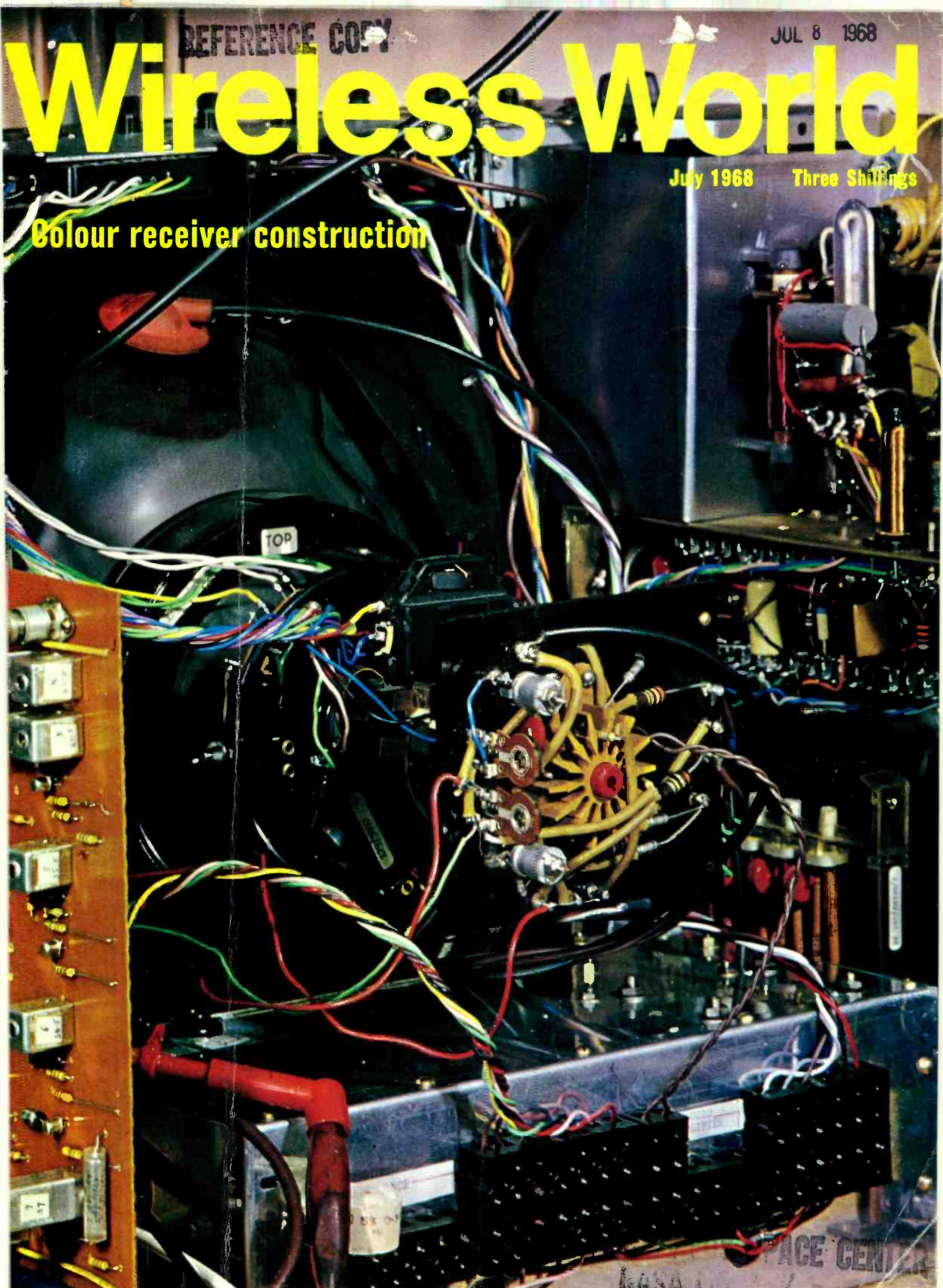
Wireless World

July 1968 Three Shillings

Colour receiver construction



Wireless World

Vol. 76 No. 1393

The Space Race

A good deal of heat, both in political and technical circles, has been generated recently in arguments about this country's future in space, and more especially space communications. The recently announced withdrawal of our support for E.L.D.O., the European Launching Development Organization, on economic grounds is seen by many as a false economy, it being argued, with a good deal of justification, that to withdraw, even for a period, from participation in so fast developing a field is to fall so far behind that this country would be out of the space race completely. As a journal we are concerned with satellites only in so far as they are sites for radio stations—whether it be a telemetry link, part of an international communications chain or a broadcasting station.

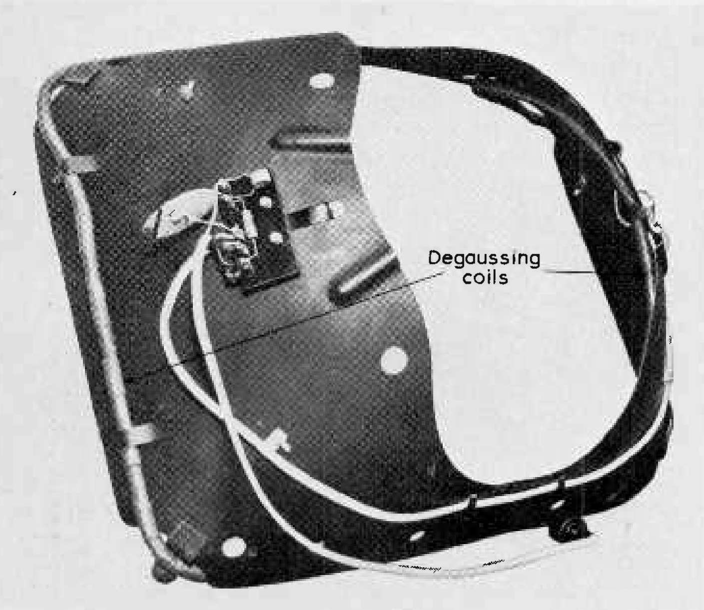
Opening a space communications symposium at the Northern Polytechnic, London, early in June Dr. J. A. Saxton (director of the Radio & Space Research Station of the Science Research Council) said "This country has always, up to now, been in the forefront of development in communications and has been a major world communications centre; none of us would like to see too great a retreat from this position". We would retort let's not retreat at all but make every effort to advance, for, as Dr. Saxton himself, went on to say "we in this country can contribute a great deal to space communications even though we may not yet have launched our own communications satellite".

Although it is to be deplored that, for one reason or another, we have not gone ahead with the various projects which could, at least, have given us a place in the space race, we can still make use of the know-how and expertise gained by Post Office engineers at the Goonhilly (Cornwall) earth station. It is encouraging to learn, therefore, that a new advisory and consultative agency, called Crown Communications, has been set up by the Crown Agents in collaboration with the British Post Office to make available to overseas telecommunications organizations this accumulated knowledge. It is stressed in the announcement of the formation of the Agency that it is "independent of all manufacturing organizations". While this may be admirable and will put it above suspicion of sordid commercialism, it is to be hoped that the Post Office engineers' know-how will be made available to British manufacturers of equipment so that they can compete in the world markets. In the official announcement from the Post Office on the formation of Crown Communications it was said to have got "off the ground", our hope is that it will keep its feet firmly on the ground and foster a strong Government-industry participation in satellite communications projects.

An interesting example of Government-industry collaboration in this field was the joint sponsorship by the Post Office, Ministry of Technology and the telecommunications industry of the seminar on earth stations held in London at the end of May. This was attended by some 250 delegates, representing telecommunications administrations in over 50 countries. In addition to hearing papers on the technical and administrative aspects of earth stations delegates had an opportunity of visiting scientific and industrial establishments engaged in the field of satellite communications. This, was in fact, a national shop window. Although some criticism of the dressing of the window has been expressed, it is to be hoped that with the setting up of Crown Communications we will, as a nation, be able to meet the challenge in what could be a very significant world market.

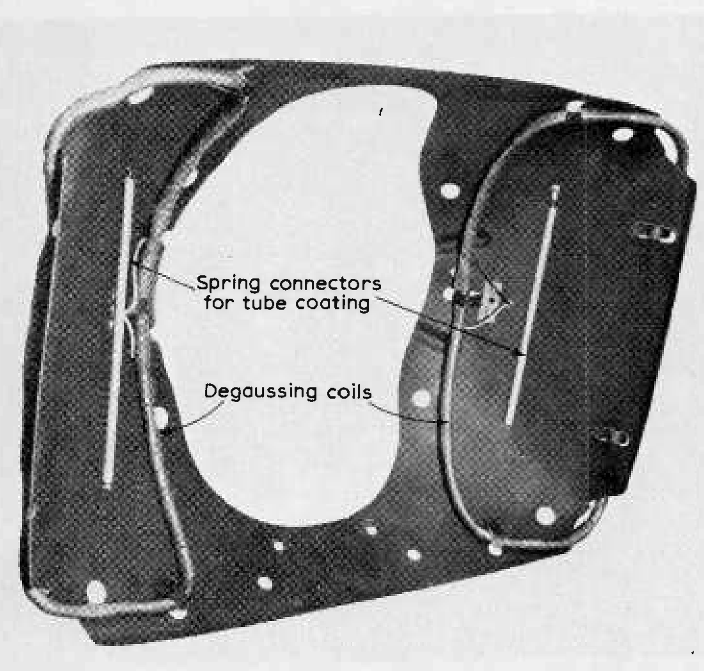
Wireless World Colour Television Receiver

2. Tube and timebases



Outside of tube screen fitted with degaussing coils and their feed components

Inside of tube screen showing degaussing coils and the spring connectors for the outer coating of the cathode-ray tube



The field timebase forms the main subject of this second article of the series. Before dealing with this, however, it is desirable to consider the tube and its immediate fitments. The tube used in the development model is the Thorn-AEI V3506A which has a rectangular face with a diagonal of 19-inches and a deflection angle of 90°. The V3508A is generally similar but has a diagonal of 25 inches. The equivalent tubes in the Mullard range are the A49-11X and A63-11X respectively.

The tube has the B14G base and the usual sunken contact for the final anode connection. It has the usual graphite external coating. It is fitted with four fixing lugs by which it can be bolted to a front support. This front support is, for a 19in. tube conveniently a piece of $\frac{3}{4}$in. chipboard not smaller than $21\frac{1}{2}$in. × $16\frac{1}{2}$in. with a shaped hole cut in it for the tube face. It is held by suitable side brackets to a similar board measuring $21\frac{1}{2}$in. × 17in. which forms the base.

The bulb requires an external magnetic screen. This is designated as 19in. Colour TV Shield, Mild Steel 0.020in. for the 19in. tube and is made by Magnetic and Electrical Alloys Ltd. The screen is provided with holes for fittings and with punched tabs for holding the degaussing coils. Spring contacts must be fitted inside it for the connection to the graphite coating of the tube. These are easily arranged with two lengths of spiral spring, like the spring curtain-support material. The ends can be hooked into holes in the screen and be under slight tension so that when the screen is placed on the tube they make contact with the coating and the tension is increased. The screen itself can be held in place by four lengths of similar spring external to the screen and attached to holes in the screen on the one hand and to lugs under the tube-mounting bolts on the other.

Before the screen is fitted to the tube it must have the degaussing coils fitted to it. These are two identical coils which are wound, taped and then bent to shape.

For the 19in. tube each of the two coils comprises 200 turns of No.28 s.w.g. enamelled wire wound on a circular former of $10\frac{5}{8}$ inches diameter to a roughly circular section. When the coil is taped it becomes of roughly circular section. Good quality tape should be used since the coil must withstand mains voltage between itself and the screen to which it is fitted. For a 25in. tube 200 turns of No. 26 wire are used and the former diameter is $14\frac{3}{4}$ inches. Each coil has a d.c. resistance of about 28 Ω (19in.) and 25 Ω (25in.).

Two coils are needed and are connected in series-aiding. Each coil is first bent to a roughly rectangular shape and then fitted one on each side of the tube screen. The front limb of each coil is outside the screen, but the rest of each coil lies between the screen and the tube. The coils are held in place by the lugs on the screen. The coils are a tight fit between the screen and the tube and, in fact, limit the forward position of the screen. The proper position is with the front of the screen not more than 1 cm from the metal band around the face of the tube. On the

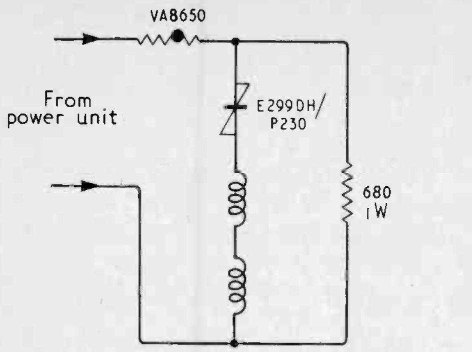


Fig. 1. Circuit of the degaussing coil with automatic current control components

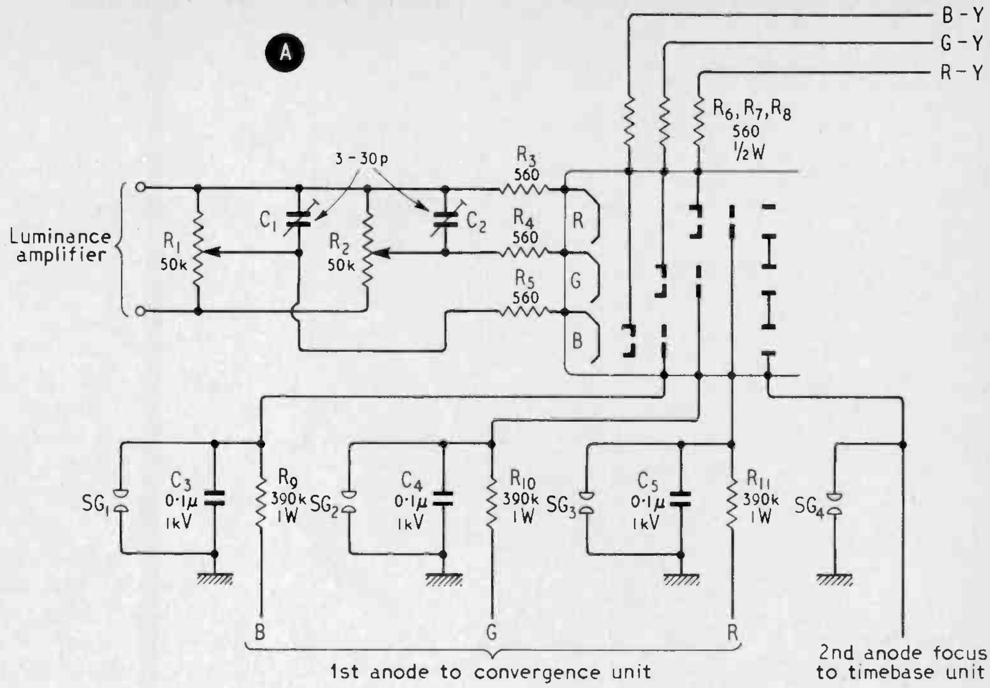
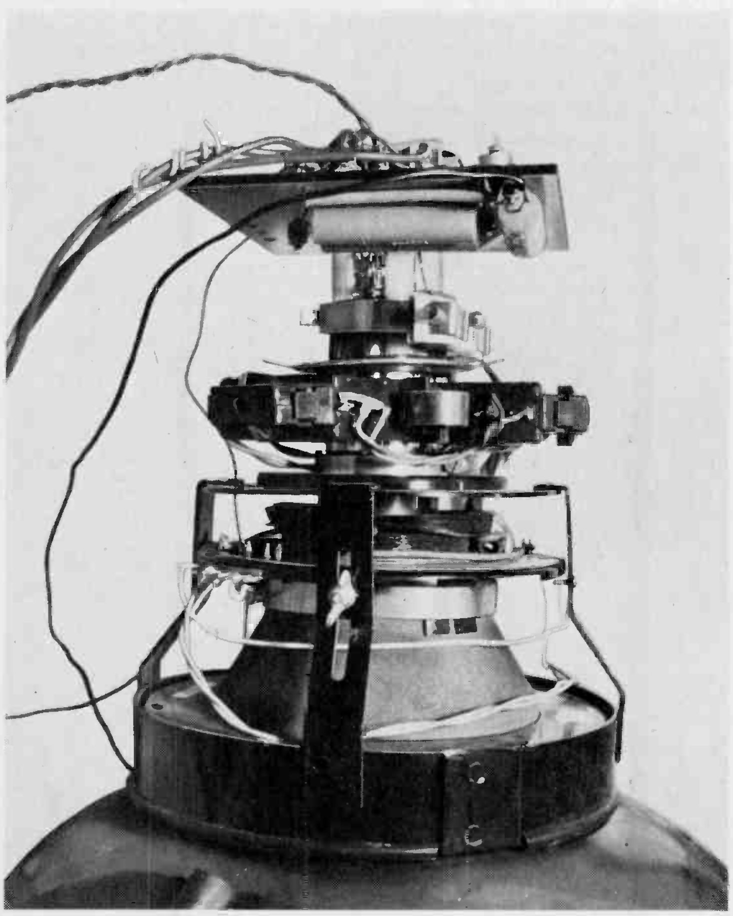


Fig. 2. Circuit diagram of the parts which are fitted to a board held by the tube socket. The 'earth' points must all be joined by a heavy flexible lead to the tube screen so that there is a direct low-impedance path to the graphite coating of the tube

other hand, the screen must not be allowed to touch the band since it is connected to the mains and the band is touchable from the front of the set.

The degaussing circuit is shown in Fig. 1 and in addition to the pair of coils it requires one 680Ω, 1-watt, resistor, one positive temperature coefficient thermistor (Mullard type VA8650) and one voltage-dependent resistor, Mullard type E299DH/P230. These are all mounted on a small tag-board fixed on the left-hand side (viewed from the back) of the tube screen and connected to the power pack by a short length of flex.

From right to left this photograph shows the deflector-coil assembly, the convergence coil assembly with the purity magnets on the left, the blue lateral assembly and the base component board



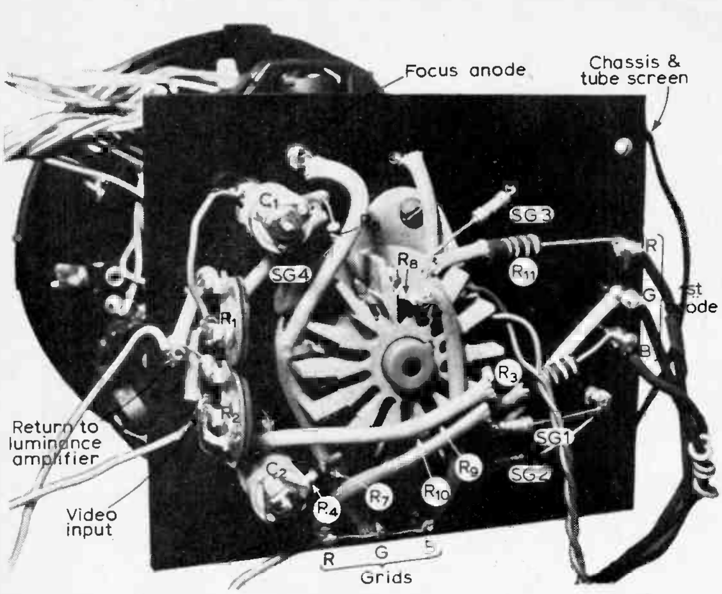
For proper degaussing some 500 ampere-turns are needed, but only for a fraction of a second. The current must then decay gradually to less than about 0.3 ampere-turn. The combination of the thermistor and the voltage-dependent resistor provides this. With the total of 400 turns, therefore, the initial current is 1.25A, but the final current is only 6mA.

The arrangement provides degaussing automatically every time the receiver is switched on so that, normally, no other degaussing is necessary. The degaussing circuits can be omitted, if desired, but then the use of an external degaussing coil will certainly be necessary on setting up the receiver and may also be needed from time to time during normal operation. It is especially likely to be needed if the position of the receiver is changed.

The deflector-coil assembly is a Plessey component designated Colour Television 90° Scan Yoke, Part No.413/1/02000/001 and the convergence and purity assembly is Part No. 413/1/01000/003. The blue lateral assembly is a Mullard part type, AT1025/00. The deflector coils go on the tube neck first, followed by the convergence coils, with the purity magnets away from the deflector coils, and, lastly, the blue lateral assembly. There is an earth tag on the deflector-coil assembly which is conveniently connected to the tube screen.

Fig. 2 shows the circuit of the parts which are mounted on a board carried by the tube socket. The board measures $4\frac{7}{8}$in. × $4\frac{1}{4}$in. and the photographs show the arrangement of the parts. The spark gaps for the first anodes are components which look very much like capacitors and are made by Erie Resistor Ltd. The one for the second anode is type SG3 while those for the first anodes bear the number 398. The 50-kΩ potentiometers R_1 and R_2 for the green and blue cathode inputs are miniature printed-circuit board types. The capacitors C_1 and C_2 associated with them are the well-known Philips trimmers. The earth return from all the spark gaps must be taken as directly as possible to the graphite coating of the tube. In practice, this means to the tube screen. The purpose of these spark gaps is to limit the effects of internal tube flash-overs.

We now come to the main subject of this article, which is the field timebase. The circuit diagram is shown in Fig. 3. It is convenient to start numbering component references afresh on



The panel carried by the tube base and holding the components and wiring of Fig. 2. Capacitors C_3, C_4 and C_5 are mounted on the reverse side.

every circuit. In order to avoid confusion when it is necessary to refer to parts in several units together, each circuit diagram will bear a letter and this letter will be appended to the component reference number when there is any likelihood of confusion. Thus the tube circuit of Fig. 2 carries the letter A; the frame timebase circuit of Fig. 3 is B. A resistor in Fig. 3 will be referred to as R_9, if there is no doubt at all as to which circuit is meant; otherwise, it will be called R_9, B.

The circuit of Fig. 3 is fairly conventional. It is a two-valve multivibrator type circuit, the anode of V_2 being coupled back to the grid of V_1 through C_1 and R_1 V_1 is one half of a double triode, the other half being unused. The sawtooth voltage is developed across C_4, the charging resistance being R_4 plus R_5. Charging takes place from the boost line of about 740 volts. There are 1-kV pulses at line frequency on this line and so it is smoothed by R_6 and C_2. A voltage-dependent resistor is connected across the latter to provide some degree of voltage stabilization.

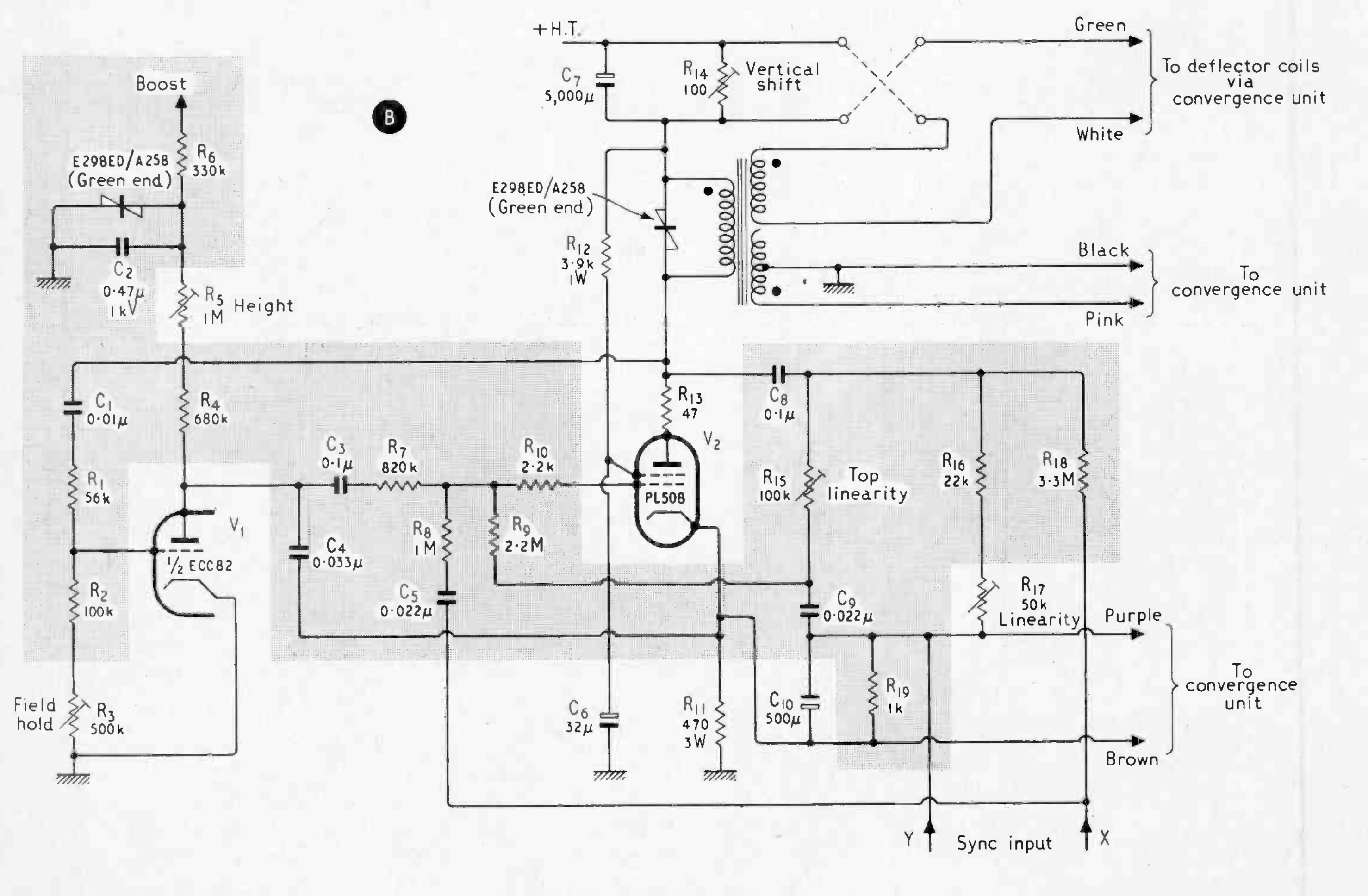
The network of resistors and capacitors associated with V_2 is more or less conventional and its purpose is to provide linearity of scan.

The main linearity control is R_{17} but R_{15} controls linearity at the extreme top of the picture. Picture height is controlled by R_5 and the field hold by R_3. The remaining control is R_{14} by means of which the picture can be moved as a whole vertically. Arrangements must be made for the easy reversal of the transformer and deflector-coil leads to it, for it is not possible to tell in advance which way round they must be connected. With this form of centring control the picture can be moved only one way from the position of zero coil current; that is, from the position when R_{14} is zero. If it needs to be moved the other way, the leads must be reversed.

The ouput leads marked on the diagram are shown as coloured. Some reference is necessary to tie them to their ending points on other diagrams and colour-coding is as good as any, especially as it is easy to carry through into the actual equipment.

The components C_{10} and R_{19} are strictly part of the convergence circuit but are conveniently located in the timebase unit. The field convergence circuits are fed in part from the cathode of V_2 and in part from a winding on the transformer.

Fig. 3. Circuit diagram of the field timebase. All components within the tinted area are mounted on a single tag board as shown in fig. 4.



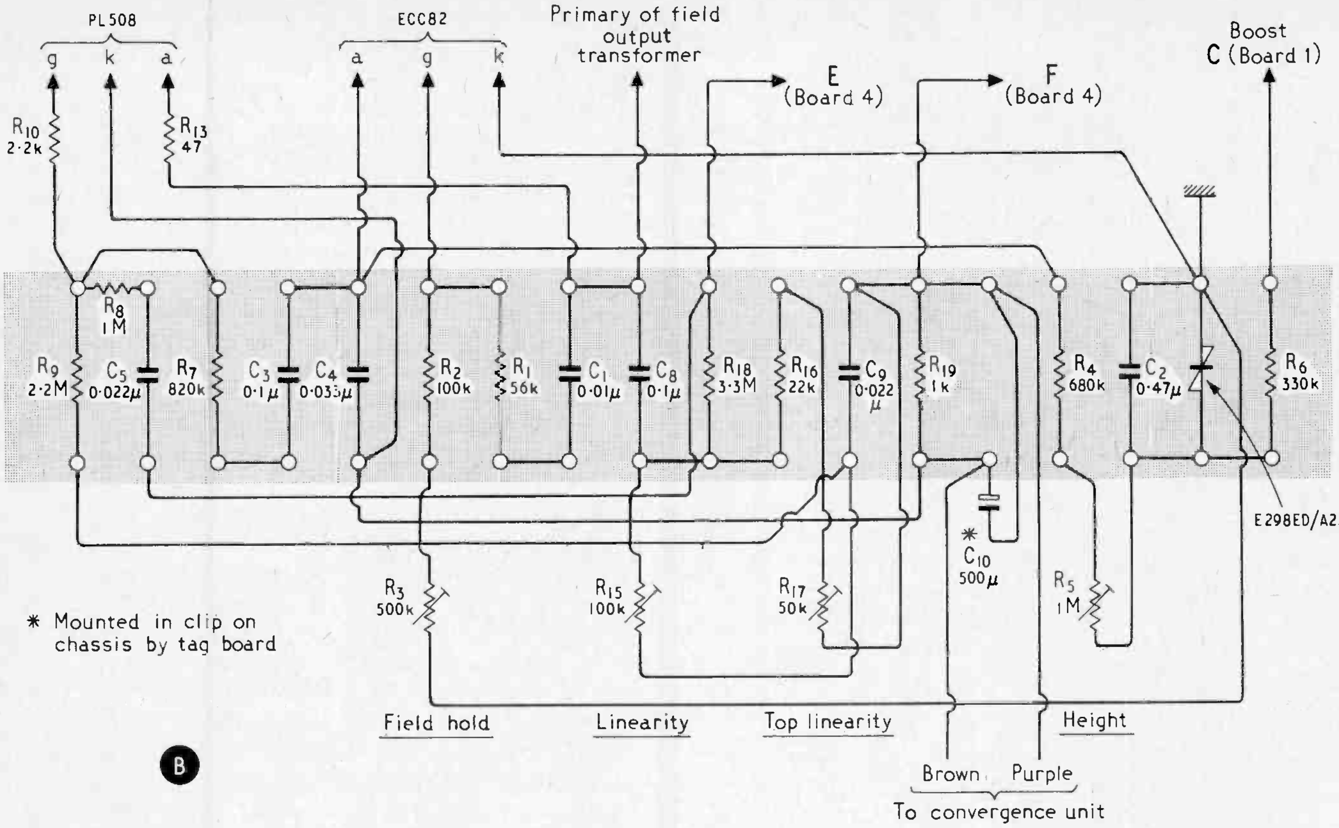


Fig. 4. This diagram shows the arrangement of the components on an 18-way tagboard, and the external connections to it.

This transformer also supplies a blanking pulse to the luminance output stage to cut it off during field flyback.

The timebase chassis contains both timebases and consists of a metal sheet with the ends bent at right angles to form an open-ended tray. This stands upright and has a shelf across it to carry the valves. It is hinged to the base and can be opened out to a horizontal position while it is working so that there is ready access to all parts. It will be described in more detail in the next article.

Nearly all the parts for the frame timebase are carried on a tag board with 18 pairs of tags, and Fig. 4 shows the arrangement adopted. There are actually three other tag-boards, two for the line timebase and one for the sync separator and as there are some connections between them it is convenient to number the boards. The one shown in Fig. 4 is Board 3 and the sync separator is on Board 4.

The capacitor C_{10} is shown in Fig.4 as mounted on the board itself. In view of its size it is actually more convenient to fix it by a clip to the chassis alongside the board.

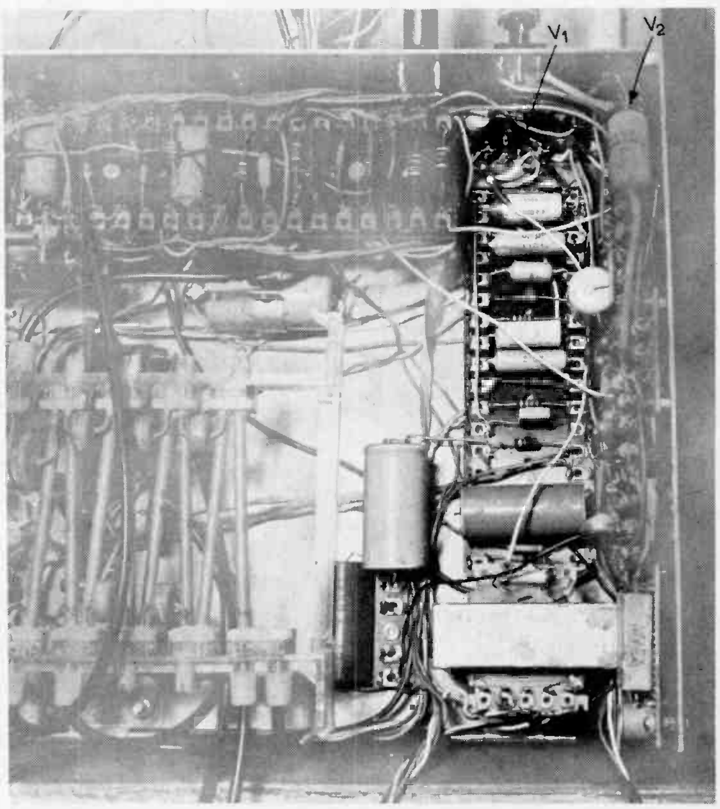
The field output transformer has a core with a $\frac{7}{8}$in. stack of 0.02in. E and I waste-free laminations, pattern MEA147, grade Silcor 25, Lamcor 4, Lasil 25, etc., 0.4% silicon reannealed. There is a 0.004in. air gap in each limb. The primary has 2730 turns, No.37 s.w.g. Lewmex F enamelled wire wound in 21 layers of 130 turns per layer. The layers are interleaved with one turn of 0.002in. paper and there are 4 turns between windings.

The convergence winding has 64 turns No.37 wire, centre-tapped. The secondary has 300 turns of No.30 s.w.g., in 4 layers of 75 turns per layer. The winding resistances are 230 Ω primary, 6. Ω convergence, and 9.5Ω secondary. The transformer used in this receiver was supplied by Hinchley Engineering Co. Ltd.

Potentiometers are mounted on the side of the chassis nearest the front of the set, so that they can readily be operated while watching the screen. Any which need to be user controls can be extended through the front panel.

This means that the leads to the potentiometers are all rather long and they are run as twisted pairs or triples flat against the face of the chassis. It is convenient to use distinctive colour for these leads since it greatly reduces the chances of errors in wiring.

The timebase unit is shown here with most of the field components prominent



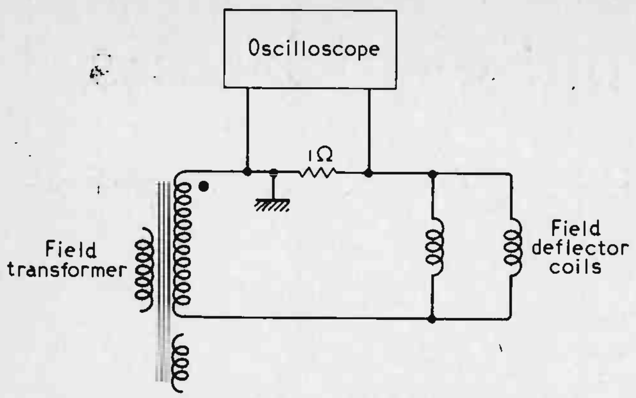
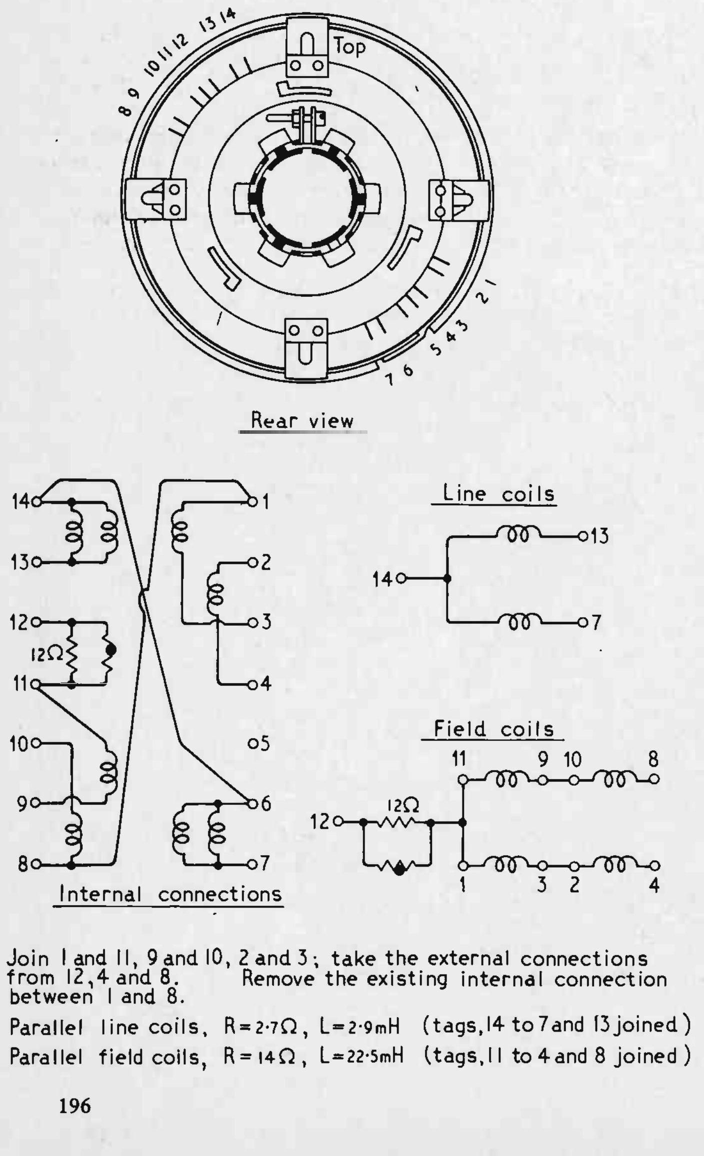


Fig. 5. The timebase can be checked independently of the rest of the equipment by altering the connections to the output transformer as shown here

It will be evident from Fig. 4 that the 2.2-kΩ resistor R_{10} and the 47-Ω resistor R_{13} are mounted right at the valveholder, one lead being soldered directly to the tag and the other extended to reach the tagboard. The 470-Ω, 3-W, cathode resistor R_{11} is mounted directly between the valveholder and the chassis. However, R_{12} and C_6 are mounted on a short tagboard near the shelf.

There are six output leads from the field timebase which all go to the convergence unit and which are all conveniently twisted together to form a 6-wire cable. Two wires are for the field deflector coil and four are for the convergence circuits. In Fig. 3, they are shown as colour coded, green and white for deflection and black, pink, purple and brown for convergence.

Fig. 6. Connections of the Plessey deflector-coil assembly are given here



In colour television it is necessary to adjust the relative currents flowing in each deflector coil of a pair; this necessitates three wires to the field deflector coils and a balancing potentiometer. Similarly in the line circuit three wires are needed to the line coils and a balancing inductor. To correct for pincushion distortion the line and frame coils have to be coupled together through a transductor with an adjusting inductor.

These controls could all be placed in the timebase unit and the deflector coils could then be connected directly to the timebase. The controls, however, form part of the convergence adjustments and so are more conveniently grouped with the other convergence controls. This is why the deflector coils are connected to the timebase via the convergence unit.

The h.t. line is nominally 285V and an initial test of the field timebase can be carried out independently of the rest of the equipment if provision can be made for supplying the valve heaters and if a power supply of some 2[illegible]V, 100mA is available. For the purpose of the test, the output transformer secondary should be disconnected from + h.t. and connected as shown in Fig. 5. Since there will be no boost supply available R_5B should be disconnected from its supply components R_6B, C_2B, etc. and joined directly to the + h.t. line.

The parallel-connected field-deflector coils must be connected to the transformer secondary to give correct loading and if a 1-Ω resistor is connected in series an oscilloscope can be connected across it to measure the current waveform. The peak-to-peak sawtooth current output is about 0.9A, so up to 0.9V is developed across the 1-Ω resistor.

The test should be made with the timebase operating at as near 50Hz as possible, but unless it is synchronized to the mains, all controls are likely to affect the frequency. The proper operation of all controls can be judged, however. The scan waveform should be somewhat S-shaped and reasonably symmetrical.

It is necessary to disconnect the secondary circuit from the h.t. supply, because if it is left connected it will be found that mains-borne disturbances cause the trace on the oscilloscope to shoot up and down in a random manner.

Fig. 6 shows a sketch of the deflector-coil assembly viewed from the rear with the terminal numbering. This numbering is not marked on the actual component, at least in the models so far received. The internal connections are also shown and it is necessary to remove the existing connections between tags 1 and 8. This is necessary because of the particular symmetry control used, as will be apparent later.

Appendix

The following is a list of the main components which are special to colour television and which may thus be less readily obtainable.

Manufacturer The Plessey Co. Ltd. (Wound Components Division, Titchfield, Fareham, Hants.)

Component	Part No.
Colour Television Scan Yoke	413/1/02000/001
Convergence and Purity Assembly	413/1/01000/003
Line Scan Transformer (colour)	420/1/02500/001
Feed Choke	405/1/05008
Centring Choke	405/1/05005
Width Control	405/1/05006
Linearity Control	405/1/05009
Voltage Multiplier	420/1/01500/001
Manufacturer Mullard Ltd.	
Raster Correction Coil	AT4040/50
Blue Lateral Coil Assembly	AT1025/00
Blue Lateral Control	AT4040/58
Blue Parabola	AT4040/75
R/G Tilt	AT4040/76
R/G Symmetry	AT4040/77 or Plessey 405/1/05007
Transductor	AT4041/05

High Input-impedance Amplifier Circuits

Using bipolar transistors, integrated circuits and f.e.ts in a.c. amplifiers presenting low loading on the signal source.

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

In the ordinary course, engineers do not find many requirements for low-frequency, high input-impedance amplifiers. This is fortunate, because the "ordinary" bipolar transistor, with which they have done most of their circuitry for a decade now, is basically a low-impedance device. The "old-fashioned" thermionic valve had one big advantage; with comparatively simple circuit arrangements you could easily achieve input impedances of over 100MΩ. With bipolar transistors, quite specialized circuits had to be devised to get above even 100kΩ. But things are changing again; we are moving into an age where the f.e.t. and the monolithic integrated circuit are displacing bipolar transistors—just as transistors did valves.

High input impedance with bipolar transistors

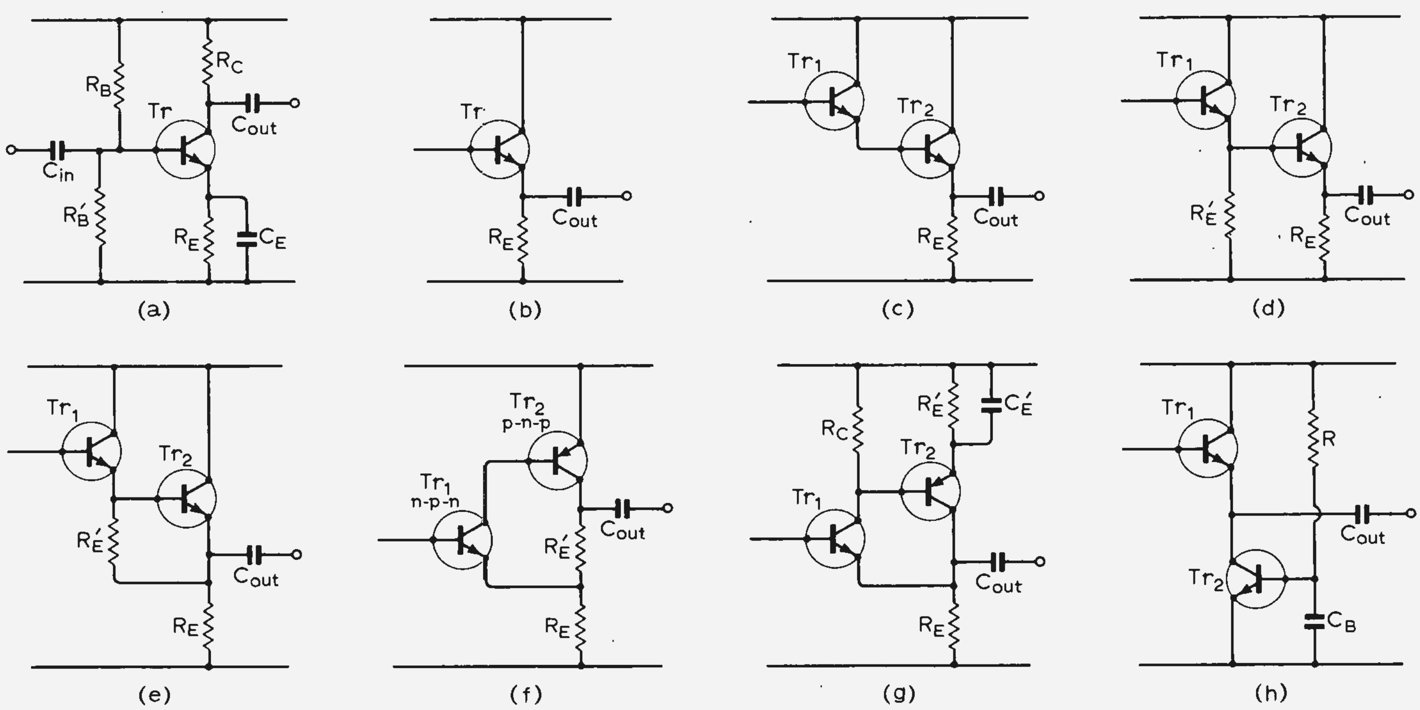
Consider the conventional common-emitter amplifier stage shown in Fig. 1(a). At frequencies where the input and output coupling and the emitter decoupling capacitors present negligible impedance, three factors control the low-frequency impedance seen looking into the amplifier input terminal. These are the shunt impedances presented by the emitter circuit, by the base-bias resistors and by the collector circuit, all in parallel across the input (both positive and negative supply rails being a.c. grounded).

*Newmarket Transistors Ltd.

Emitter circuit shunt impedance: So far as it is governed by the emitter circuit, the low frequency input impedance of the transistor itself is given approximately by $R_{in}=r_{bb'}+25h_{fe}/I_E$, where $r_{bb'}$ is the device "base spreading resistance" (for transistors used in low-level circuits usually 30 to 300Ω), h_{fe} is the common-emitter current gain (nowadays usually 50 to 250), and I_E is the emitter current in mA. For a typical low-level stage with I_E set about 1mA, we find R_{in} typically 1 to 2kΩ. The formula for R_{in} shows that you can increase the device input impedance by reducing the emitter current, provided current gain does not fall at the same time. With germanium transistors, h_{fe} tended to fall almost linearly with current below 1mA, so that little use could be made of reducing the emitter current to put up input impedance. Modern silicon transistors generally hold up their current gain to much lower current levels than germanium. With devices of the common BC107, 8, 9 family, for example, a current gain of 100 at 100μA makes possible a transistor a.f. input resistance of 25-50kΩ.

High input impedance with input transformer or series resistor: Before we go on to examine other high-impedance circuit arrangements, we should not forget that you can use a transformer with a high step-down turns ratio. Such a transformer has the advantage of isolation, but, to get high impedance at low frequencies, its size and cost can become prohibitive. The upper frequency limit may also be limited by stray capacitances. Careful screening is called for, and it is sometimes difficult to provide simultaneously minimum noise and high impedance.

Fig. 1. Arrangements for reducing shunting of emitter circuits on transistor input impedance. (a) Basic common-emitter amplifier operated at low bias current. (b) Common-collector (emitter-follower) single transistor. (c) Compound two-transistor Darlington-pair common-collector. (d) Modified Darlington-pair common-collector. (e) Bootstrapped Darlington-pair. (f) and (g) Complementary n-p-n/p-n-p compound emitter-follower circuits. (h) Transistor-loaded emitter-follower.



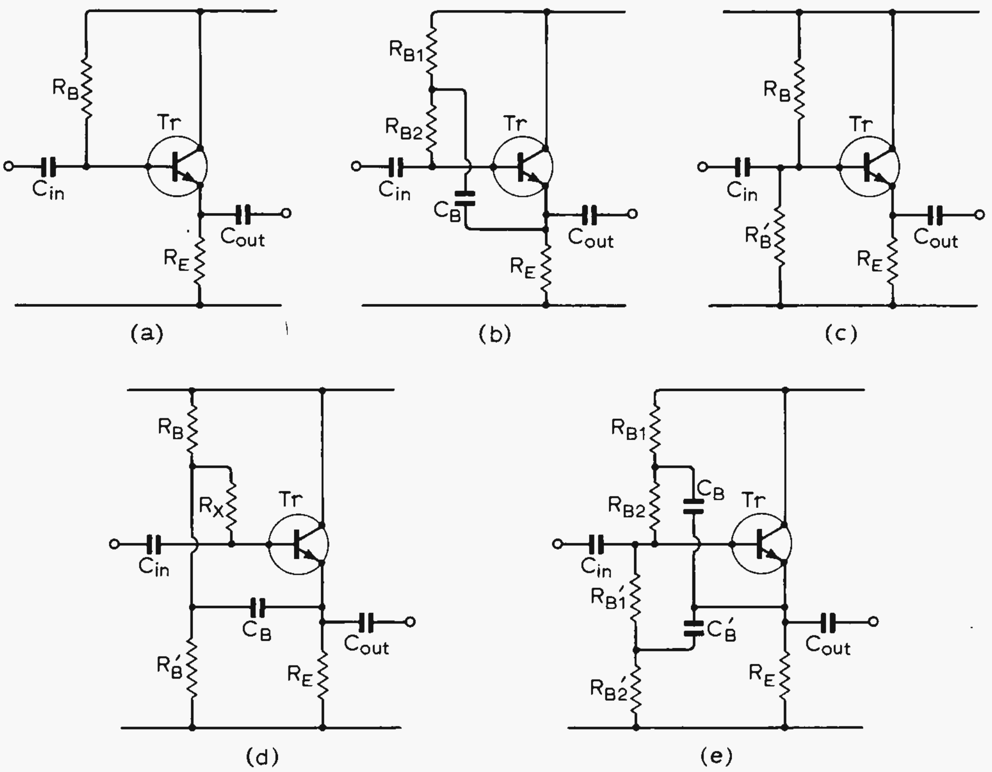


Fig. 2. Reducing the shunting of base bias resistors on input impedance. (a) Basic single-resistor transistor bias circuit. (b) Bootstrapping single bias resistor by capacitance feedback to its centre. (c) Basic two-resistor base bias circuit. (d) Single-capacitor method of bootstrapping two-resistor bias network. (e) Two-capacitor method of bootstrapping two-resistor bias network.

One other simple approach is to accept the intrinsic low input resistance of the transistor and achieve the required high input resistance by using a series resistor to the input. The main objection to this is the high noise level likely to arise from the large value series resistor.

Reducing shunting effect of emitter circuits on input impedance: Going back to the common-emitter stage of Fig. 1(a), if we remove the emitter bias resistor decoupling capacitance, C_E, the transistor input impedance becomes $R_{in}=r_{bb}+h_{fe}(25/I_E+R_E)$. This shows that we can increase the input impedance by using an undecoupled emitter resistor. It would seem that you could increase R_{in} indefinitely by increasing R_E, but, when R_E rises above about one-tenth of the collector load resistance, R_C, the voltage gain of the common-emitter stage approaches R_C/R_E. The gain thus falls to unity when $R_E=R_C$. This is why designers looking for high transistor input impedance tend to use the alternative near-unity-gain common-collector arrangement of Fig. 1 (b). By using silicon transistors with high gain at low current, it is possible to increase R_E to a value giving input impedances of the order of several thousand ohms with this simple arrangement.

Unless you go to a very high rail voltage, even when you resort to low bias currents, you are limited in how high you can raise the value of R_E. You can get round this with the Darlington compound-emitter-follower arrangement of Fig. 1(c). Here, then; $R_{in}=h_{fe1}h_{fe2}R_E$ approx., and you can see that a.c.-wise by adding the extra transistor you have effectively multiplied R_E by h_{fe2} without raising its d.c. value, and thus without having to go to a higher rail voltage. The emitter current of Tr_1, being the base current of Tr_2, is usually low: typically of the order of 1-5μA only. Tr_1 should be a transistor with high gain at low current, such as the 2N930 with h_{fe} greater than 100 at 10μA. Some designers raise the standing current in Tr_1 with a separate emitter bias resistor, $R_{E'}$, in Fig. 1(d). This shunts the input impedance of Tr_2, but its shunt effect on the overall input impedance may be more than offset by the increase in h_{fe1} due to the higher Tr_1 bias current. Usually $R_{E'}$ is made 5 to 20 times R_E.

To reduce the loading of R_E on the input, you can use the bootstrap feedback arrangement of Fig. 1(e), where the bottom of $R_{E'}$ is connected to the top of R_E. By the emitter-follower action of Tr_2, the lower end of $R_{E'}$ moves with its top, and its resistance value is effectively multiplied by the current gain of Tr_2 (provided, as is usually the case, R_E is small compared with $R_{E'}$). With silicon transistors, the V_{BE} (d.c.) of Tr_2 is approximately 0.6V, so that $R_{E'}$ is fixed by the selected bias current, I_{E1}, of Tr_1 as $R_{E'}=0.6/I_{E'}$ (ignoring the negligible base current into Tr_2).

Combinations of n-p-n and p-n-p transistors permit other arrangements for bootstrapping up the effective value of the emitter resistor in an emitter follower. For example, in both Fig. 1(f) and 1(g), it can be shown that R_{in} has a high value give approximately by $R_{in}=h_{fe1}h_{fe2}R_E$.

Another elegant circuit for providing a high-resistance emitter load in an emitter-follower without high rail voltages is shown in Fig. 1(h). Here the output resistance of Tr_2 (of the order of megohms) functions as an emitter load to Tr_1 and makes possible an overall input resistance over 10MΩ.

Reducing shunting effect of base bias resistors on input impedance: So far, we have ignored the effect on input impedance of any base bias resistor networks shunted across the transistor input. Fig. 2(a), showing an elementary single-resistor bias circuit, illustrates the problem. You will see that R_B is directly across the input (both supply rails being a.c. earthed). Obviously the total R_{in} cannot exceed R_B.

The conventional technique to raise the effective a.c. resistance of R_B without raising its d.c. value is to bootstrap it as shown in Fig. 2(b). R_B is replaced by two resistances R_{B1} and R_{B2} of the same total resistance. Provided R_{B1} and R_{B2} are large compared with R_E, the transistor emitter-follower action makes the top end of R_{B2} move up and down with its bottom end. Thus its a.c. impedance is raised effectively by the current gain of the transistor.

The more thermally-stable conventional two-resistor bias network of Fig. 2(c) can also be bootstrapped for high impedance. Fig. 2(d) shows an arrangement using a single bootstrap capacitor, C_B, in which the resistance R_X in series with the base can be low value for thermal stability, but have high effective impedance so as not to shunt the input a.c. signal. Fig. 2(e) shows a two-capacitor arrangement where both top and bottom bias resistors are capacitor-bootstrapped by splitting each as explained for Fig. 2(b) above.

In general, the bootstrap capacitance values must be large enough to present negligible impedance at the lowest frequency, f_o, to be handled. A useful guide is to make C_B greater than $10/(f_oR_B)$, where R_B is the bias resistor being bootstrapped.

Reducing shunting effect of transistor collector output resistance: From the conventional low-frequency T-equivalent circuit of the transistor in the common-collector configuration with emitter resistor, R_E, shown in Fig. 3(a), you can see that the internal collector resistance, r_c, shunts the signal path. At low current levels with modern transistors, r_c usually lies between 1 and 5MΩ, so that it is difficult to reach higher input impedances than r_c unless it too is bootstrapped. Fig. 3(b) shows the basic arrangement for this, where a resistance, R_C, is inserted between the collector and h.t. (to isolate r_c from earth a.c.-wise) and a capacitor, C_F, to the collector (and thus the outer end of r_c) feeds back in phase signals from the top end of the emitter resistance. This raises the effective a.c. impedance of r_c and reduces its shunting effect on the input signal. If possible, the collector bias resistance, R_C, value should be at least ten times R_E, but, if only a limited d.c. supply voltage is available, this may not be possible, unless we are using a multiple emitter-follower, as explained previously in Figs. 1(c)-(e), where R_E is relatively small.

Fig. 3(c) illustrates a circuit using a separate transistor, Tr_2, to bootstrap the Tr_1 collector output resistance without excessive loading of its emitter output. The a.c. voltage at the top of R_E is transferred via C_F and the base-emitter of Tr_2 to the collector of Tr_1.

It is also possible to bootstrap the base bias resistor and the collector output resistance at the same time with a single capacitor as in the simple circuit arrangement of Fig. 3(d).

One aspect of bootstrapping with capacitors is that high input impedance circuits tend to be operated at low transistor bias currents, and the leakage currents in ordinary aluminium electrolytic capacitors can upset bias conditions drastically. For this reason, you will often find low-leakage tantalum capacitors specified, where the total capacitance required is beyond the range of solid dielectric types.

Practical high-impedance transistor amplifiers: Fig. 4(a) shows a simple single-transistor, emitter-follower, high input impedance amplifier operating at a low collector current of about 100μA, and with bootstrapping of base-bias resistors and collector output resistance. These techniques produce an input impedance down to below 50Hz not less than 0.5MΩ.

For input impedances greater than about 1MΩ, usually two stages are necessary with bipolar transistors. Fig. 4(b) is a typical circuit with an input resistance of 1.5MΩ and an output resistance of only 30Ω. It employs an n-p-n/p-n-p direct-coupled pair with bootstrapping of base bias resistors and emitter resistor.

Two stages can give an input impedance of the order of 10MΩ, as, for example, the cascaded emitter follower circuit of Fig. 4(c) by General Electric Co, U.S.A. This employs bootstrapping of all three shunt elements. C_1 and C_2 values depend on the lowest frequency, f_o, to be passed by the amplifier and can be selected at the nearest preferred values to $C_1 = 1/(150 f_o)$ and $C_2 = 1/(50 f_{o\mu})$.

Adding a third stage, as for example in Fig. 4(d), makes input impedances in the 100MΩ range possible. With the capacitor values shown, the measured input impedance was about 300MΩ for $f = 0.5$ to 2kHz.

About the limit you can ordinarily push bipolar transistor circuits up to is 1,000MΩ input resistance, although circuits up to 8×10^{11} Ω have been constructed. For example, G. W. Horn in "Feedback reduces bio probe's input capacitance" in *Electronics*, March 18, 1968, pp. 97-98, describes a circuit to give 20,000MΩ input resistance shunted by only 0.02pF. A less ambitious example with only 1,000MΩ input resistance is given in Fig. 4(e) to illustrate the various bootstrapping techniques used. The approximate value of the input resistance is $h_{fe1} h_{fe2} h_{fe3} h_{fe4} R$, where R is the parallel combination of the 1.5kΩ emitter resistance of Tr_3 and the amplifier load resistance. Values of $R_{in} = 1{,}000$MΩ at 10Hz and above were obtained dropping to 50MΩ at 1.5 Hz.

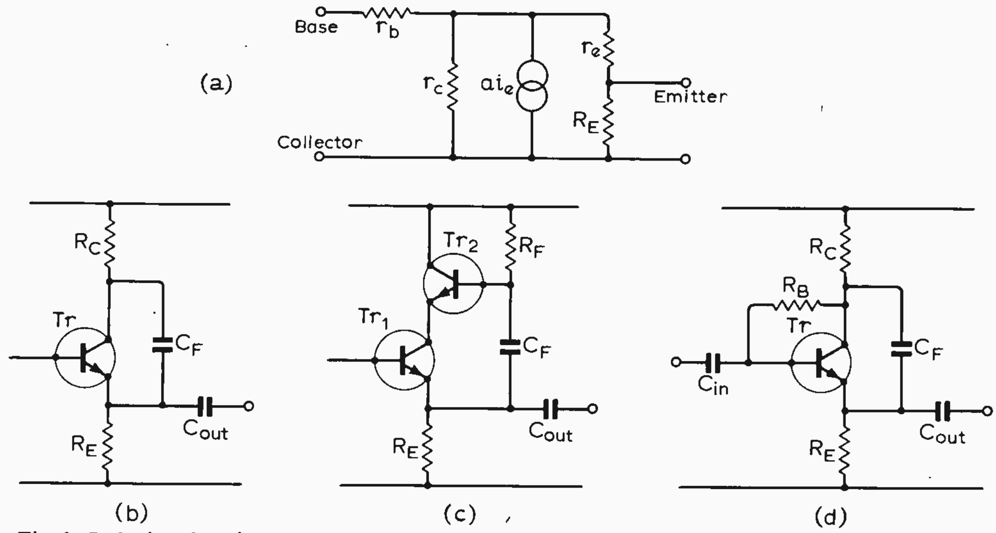
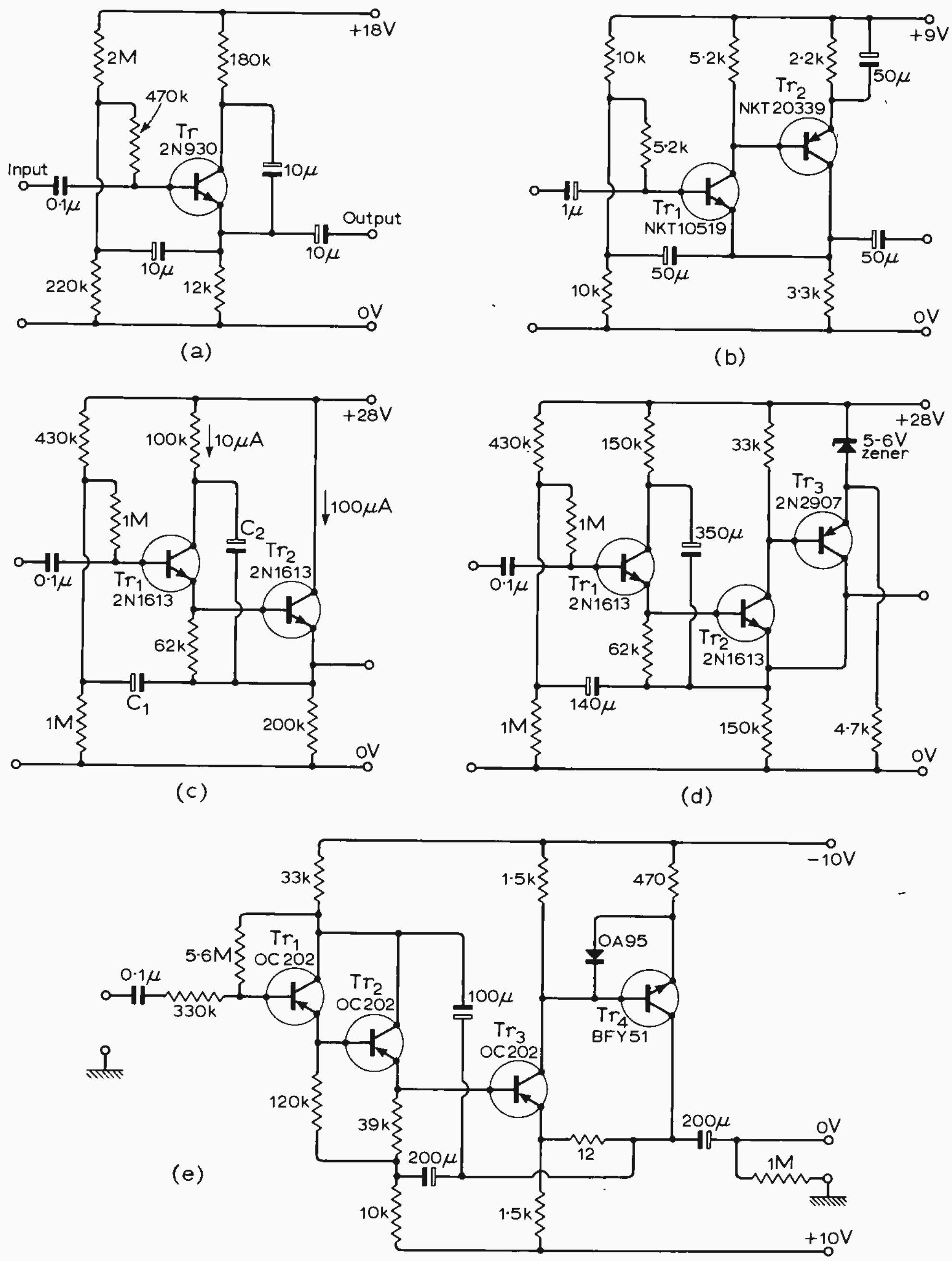


Fig. 3. Reducing shunting of transistor collector output resistance on input impedance. (a) T-equivalent circuit of common collector transistor with external emitter resistor, R_E. (b) Bootstrapping r_c via capacitor from emitter. (c) Bootstrapping r_c via buffer transistor. (d) Simultaneous bootstrapping of r_c and R_B.

Fig. 4. High-input-impedance amplifiers. (a) Single-transistor amplifier with R_{in} greater than 0.5MΩ down to 50 Hz. (b) Two-stage amplifier with 1.5MΩ input and 30Ω output resistances. (c) Two-stage 10MΩ circuit with bootstrapping of all three shunt circuits. (d) Three-stage 300MΩ circuit with bandwidth 0.5 Hz-2,000 Hz. (e) Four-stage 1,000MΩ circuit down to 10 Hz.



F.E.T. high input-impedance amplifiers

The bipolar transistor has a low inherent input resistance (1 - 50kΩ) and we have seen that amplifier input impedances above 1MΩ can be obtained only with quite complex transistor circuits. The f.e.t. on the other hand has a high inhereent input resistance (from 10^9 Ω upwards with modern devices). Consequently, only simple f.e.t. amplifier circuits are needed to get input impedances at a.f. from 10 to 1,000MΩ, while more complex circuits can

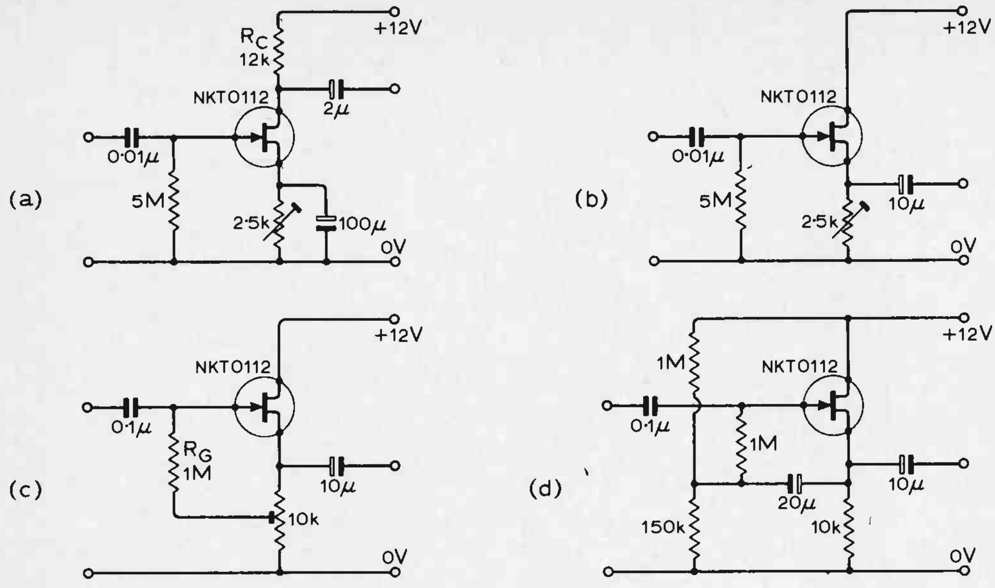
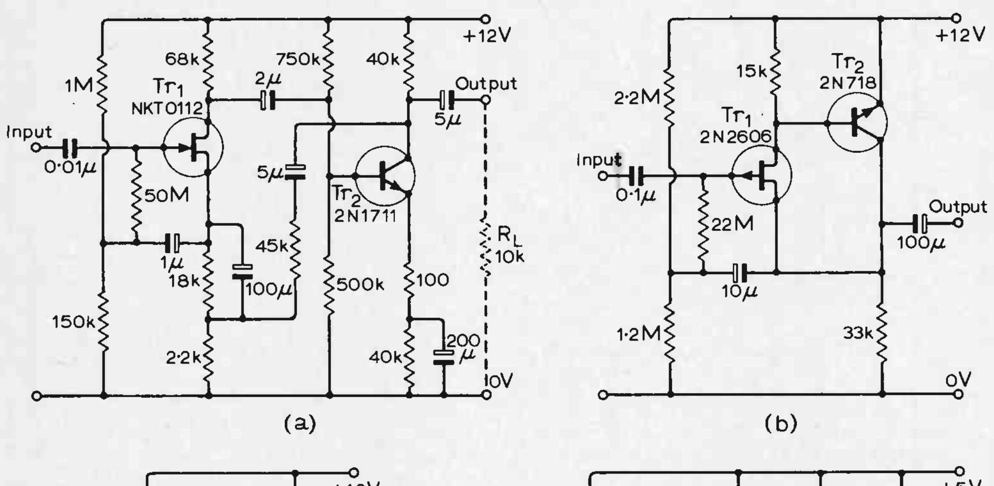


Fig. 5. Single-stage f.e.t. high-input-impedance amplifiers. (a) Common-source amplifier with input impedance of 5M Ω shunted by 30pF. (b) Common-drain amplifier with input impedance of 5M Ω shunted by 2pF. (c) Common-drain temperature-stable amplifier with 15M Ω, 5pF input impedance. (d) Capacitor-bootstrapped amplifier with input impedance of 5M Ω, 3pF.



easily give up to 1,000,000MΩ. The bootstrapping techniques described earlier for bipolar transistors apply equally to f.e.ts, whether p- or n-channel, junction- or insulated-gate, depletion- or enhancement-mode types. The n-channel, depletion, junction f.e.t. is the commonest in use at the time of writing, and most circuitry will be illustrated in terms of this.

Single stage f.e.t. high input impedance circuits: If you want an input impedance of only a few megohms, you can use an n-channel depletion f.e.t. in the common source arrangement for which a typical circuit is given in Fig. 5(a). The NKT0112 here has a typical $V_P = 1.0$V, $I_{DSS} = 1$mA, and $g_{mo} = 1.5$mA/V, and is set up at a bias current of 0.5mA, giving a voltage gain of about 15 times with an a.f. input impedance of 5MΩ shunted by about 30pF.

In the common-drain or source-follower circuit of Fig. 5(b), while the input resistance is still only 5MΩ, the shunt capacitance has been reduces to about 2pF at the expense of voltage gain, $A_v = g_mR_S/(1+g_mR_S)$ which has been reduced to 0.7 times. The 5M Ω input-resistance-controlling gate bias resistor can be increased to 10 or even 15MΩ, but gate leakage currents then make the circuit sensitive to temperature.

The source-follower circuit of Fig. 5(c) with the gate-bias resistor bootstrapped gives high input impedance with better high-temperature stability, because the gate resistor network has a relatively low d.c. resistance. With R_G at 1MΩ as shown in the diagram, Z_{in} is 15MΩ shunted by $C_{in} = 5$pF. Increasing R_G to 10MΩ raises R_{in} to 150MΩ without affecting C_{in}, but the circuit becomes temperature sensitive.

An alternative arrangement sometimes used is shown in Fig. 5(d), where the 20μF capacitor bootstraps the 1MΩ gate bias resistor to give an overall input impedance of approximately 5MΩ shunted by 3pF.

Multistage f.e.t. high input-impedance amplifiers: For better temperature stability and lower input shunt capacitance, the input f.e.t. can be cascaded with bipolar transistor stages, using also bootstrap feedback techniques.

An input resistance of 150MΩ shunted by 5pF is obtained with the circuit of Fig 6(a) which utilizes a common-source f.e.t., Tr_1 RC-coupled to a common-emitter transistor Tr_2, with overall feedback from transistor Tr_2 collector to f.e.t. source to provide the necessary bootstrapping to reduce the shunting effect of the 50MΩ gate bias resistance across the input. With a voltage gain of 26dB the amplifier has a bandwidth down to 10Hz for any signal source resistance. The top end

Fig. 6. Multi-stage f.e.t. high-input-impedance amplifiers. (a) 150MΩ, 5pF input impedance with RC-coupled f.e.t. and bipolar transistor. (b) 1,200MΩ, 3.5pF input impedance with d.c.-coupled f.e.t. and transistor. (c) Low input capacitance (0.4pF), high impedance (5MΩ) d.c.-coupled f.e.t. and transistor. (d) 1,000MΩ, 0.1pF input impedance four-stage m.o.s.f.e.t biological amplifier. (e) 1,000,000MΩ input impedance m.o.s.f.e.t. amplifier.

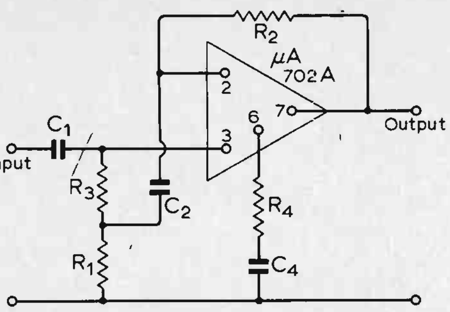


Fig. 7. Connecting up an integrated circuit monolithic operational amplifier to give high input resistance (2-6MΩ).

of the bandpass ranges from 500Hz for a 10MΩ source up to 50kHz for a 10kΩ source.

The Siliconix circuit of Fig. 6(b) shows a p-channel f.e.t. d.c.-coupled to a bipolar transistor to give $Z_{in}=1{,}200M\Omega$ shunted by 3.5pF, with an overall voltage gain of 0.98, and an output resistance of 600Ω. Here both the gate bias resistor and the source resistor are bootstrapped.

An input impedance of 5MΩ shunted only by 0.4pF is provided by the d.c.-coupled f.e.t./bipolar pair in the Ferranti circuit of Fig. 6(c). It features overall bootstrapping of both the gate bias resistor and the gate-drain capacitance to achieve the low input shunt capacitance.

The four-stage circuit of Fig. 6(d) given by R. E. Webb in "Field Effect Transistor for Biological Amplifier" in *Electronic Engineering*, December, 1965, pp. 803-805, produces an input impedance greater than 1,000MΩ with a shunt capacitance less than 0.1pF. Using an n-channel depletion mosfet with a gate leakage current of less than 10^{-11} A, it features unity voltage gain with an output resistance of only 25Ω. The amplifier and input connections have to be doubly screened. The internal screen is connected to the amplifier output and the external screen to ground, thus reducing the stray capacitance to ground by the same amount as the input resistance is increased by the large overall feedback from the top of the 5.6kΩ last emitter load resistance.

As the final f.e.t. example, the relatively simple Mullard circuit of Fig. 6(e) gives an input resistance of 1,000,000MΩ with a voltage gain of about 0.98 and an output resistance of only 50Ω. The f.e.t. 3.3kΩ source resistor is bootstrapped by the BCY72 transistor, as is also the $10^{11}\Omega$ gate bias resistor via the 2μF capacitor.

High input impedance with i.c. operational amplifier

Engineers are now beginning to use integrated circuit monolithic operational amplifiers as complete circuit elements instead of building up circuits with discrete bipolar transistors or f.e.ts. High input impedance can be obtained with these by the simple expedient of putting the required input resistance in series with the amplifier input, which is a virtual earth point. However, bootstrapping techniques can also be used as shown in Fig. 7. Here a standard Fairchild μA702A operational amplifier is set up for positive feedback from the output to the non-inverting input pin (3). The approximate expression for the overall low frequency input impedance is $R_{in}=A_{vo}R_A/A_f$, where A_{vo} is the open loop voltage gain, A_f is the gain with feedback and R_A is the input impedance into pin (3). By general operational amplifier theory, A_f can be shown to be approximately $(R_1+R_2)/R_1$. For the μA702A, typically $A_{vo}=2{,}000$, and $R_A=10k\Omega$. Two sets of circuit component values are given below to produce input resistances of 2 and 6MΩ.

C_1	C_2	C_4	R_1	R_2
1μF	1μF	910pF	10kΩ	91kΩ
1μF	4.7μF	1000pF	51kΩ	100kΩ

R_3	R_4	A_v	R_{in}
82kΩ	220kΩ	10	2MΩ
51kΩ		3	6MΩ

The phase-shift network, R_4, C_4, provides frequency stability. For best thermal stability, $R_1 + R_3$ should be made equal to R_2.

When f.e.t.-input operational amplifiers become commonly available, they will have an input terminal resistance, R_A, of the order of 10MΩ. Looking back at the formula for bootstrapped input resistance given for the bipolar μA702A, it will be seen that very high overall input resistances can be expected in the future with f.e.t. operational amplifiers.

Announcements

The series of Philips **colour television courses** for service engineers, started in July 1967 by Combined Electronic Services Ltd, have ceased for the time being. Over 1,000 people attended. Plans are now under way for a new series scheduled for the Autumn. The courses will be of 4 days' duration and take place at the colour television school at C.E.S. Ltd, Waddon, Croydon, Surrey.

A one-day symposium on "The Numerical Solution of Laplace's Equation" will be held at the John Dalton College of Technology, Chester Street, Manchester 1, on 8th July. Fee £4 15s.

At the recent annual general meeting of the **Radio & Electronic Component Manufacturers' Federation**, the following result of the postal ballot for the election of the Council was announced:— Belling & Lee (N. D. Bryce), A. F. Bulgin & Co. (R. A. Bulgin), Colvern (R. F. Collinson), A. H. Hunt (S. H. Brewell), McMurdo Instrument Co. (F. W. Irons), Mullard (Dr. F. E. Jones, elected chairman), Multicore Solders (R. Arbib), Painton & Co. (C. M. Benham), and Standard Telephones & Cables (E. E. Bivand).

The **Institution of Electrical and Electronics Technician Engineers** has decided to accept the City and Guilds of London Institute's Electrical Technicians' Certificate with two endorsement certificates as satisfying the technical education requirements for election to the class of Graduate.

The Munich Fair and Exhibition Co. have announced that the fourth **Electronica**—the international trade exhibition of electronic components and related measuring and production equipment—will be held from 22nd to 28th October, 1970. The third Electronica exhibition takes place this year from 7th to 13th November.

An agreement has been reached, subject to contract, between **Rediffusion Ltd** and the **Rank Organisation Ltd**, for the purchase by Rediffusion of the whole of Rank's wired sound and television networks and the television set rental business associated with these relay undertakings.

Industrial Instruments Ltd, the Bromley, Kent, manufacturers of Transipack inverters, have been appointed U.K. agents for Varo-Atlas, the American company whose interests lie in the military static inverter field.

The Venner Group have recently announced an agreement with **Control Logic Inc.**, of Massachusetts, which gives Venner manufacturing and sales rights for a family of integrated circuit logic cards and accessories. This agreement applies exclusively in the U.K., the Commonwealth and all E.F.T.A. countries.

S. Davall & Son Ltd, of 4 Wadsworth Road, Greenford, Middlesex, have appointed **agents in France and North America** for the precision relays and associated components made by their manufacturing division, Perivale Controls Co. Ltd. The agents are Crouzet S.A., of Paris, for Common Market countries and Eastern Electric Company, of Montreal, for Canada and the United States.

Standard Telephones & Cables Ltd, have been awarded a contract by Hawker Siddeley Aviation, worth approximately £250,000, to supply **aerial systems** for the Hawker Harrier V/STOL aircraft destined for service with the R.A.F.

A £430,000 contract has been placed with the M.E.L. Equipment Company Ltd, by the Ministry of Technology on behalf of the Ministry of Defence (Army Department), for the supply of **military radio equipment.** The equipment comprises single sideband h.f. transmitters L.556 and radio telegraph adaptors L.607.

Racal Communications Ltd, of Western Road, Bracknell, Berks., have received contracts to the value of £1M for new **submarine h.f. communication equipment** for use by the Royal Navy.

An order worth approximately £400,000 has been awarded to Standard Telephones and Cables Ltd, by the Italian Ministry of Defence, for **instrument landing systems** to be installed at the airports of Rome, Turin, Milan, Genoa, Venice and Naples.

Cossor Electronics Ltd, of Harlow, Essex, have received an order, worth approximately £250,000, for the supply and installation, at Stornoway, Isle of Lewis, and Burrington, Devon, of two dual-channel and two single-channel SSR 700 interrogator systems.

Henry's Radio Ltd, have opened an additional electronics centre at 309 Edgware Road, London W.2.

A licensing agreement has been completed between the Decca Navigator Company, London, and International Standard Electric Corporation, a subsidiary of International Telephone and Telegraph of U.S.A., to co-operate in the field of marine and commercial aviation electronics.

Thorn Electrical Industries (London) and International Rectifier Corporation (California) have signed a 12-year agreement to continue as **joint ventures** the six jointly owned semiconductor companies in Europe. International Rectifiers will exercise management control (receiving a management fee) and will provide technical assistance and licences relating to semiconductor products.

Texas Instruments and Sony announced that the Japanese Government has approved the establishment of **Texas Instruments Japan Ltd.** Fifty per cent of the capital is to be furnished by each of the companies, and semiconductor devices including integrated circuits and certain electrical control devices are to be manufactured.

Amphenol and Plessey recently signed an agreement whereby the new Astro 348 connector range developed by the Amphenol Corporation of Illinois is to be manufactured by the Plessey Company Ltd.

GEC-AEI Telecommunications Ltd. of Coventry, have won orders worth £250,000 for completely solid state 2 GHz and 7 GHz radio links and multiplex equipment in Hong Kong and Bahrain. The contracts have been placed by Cable and Wireless Ltd.

Marconi Company, of Chelmsford, have won a contract valued at £700,000 to supply a completely new television system to the state of Bahia in Brazil.

News of the Month

Industrial Training Criticized

The Annual Report of the Electrical and Electronic Manufacturers' Joint Education Board criticizes both the composition and operation of the Engineering Industry Training Board. E.E.M.J.E.B. considers that the present composition of the Training Board reflects too great a bias in favour of the mechanical and aeronautical sections of the engineering industry. "It is essential that in view of the large contribution to the national economy made by the electrical and electronics sections of industry, especially in the exports field, and the highly complex nature of their training needs, they should have direct representation on the Training Board, E.E.M.J.E.B. has taken the matter up with the E.I.T.B. and intends to pursue the question of the appointment of suitably qualified members who are closely in touch with the day-to-day training problems of the industries it represents.

"E.E.M.J.E.B. reaffirms that the continuing basic disagreement between industry and the Training Board is that industry's training methods conform to a rigid pattern laid down in manuals published by the board which are unrealistic, taking into account regional variations and individual company needs. E.E.M.J.E.B. maintains that, within reasonable limits, companies should lay down their own programme of training which should be approved as adequate, or otherwise, by the Training Board's inspectors."

E.E.M.J.E.B. has asked manufacturing companies to support a trial scheme which is intended to give industrial experience to technical college teachers of physics and chemistry. Under the trial scheme about 15 teachers annually will have the benefit of short courses during the summer or autumn terms at manufacturers' works, preferably those with development and research laboratories. E.E.M.J.E.B. feels it is important that teachers should gain first-hand knowledge of industrial methods and have the opportunity of keeping abreast of new techniques.

Commenting on the pattern of development of the Institution of Electrical and Electronic Technician Engineers E.E.M.J.E.B. states:

"It is apparent that the Institution is still firmly entrenched in its objective of providing only for a limited group of 'higher technicians'. The institution is therefore still leaving a very large number of much needed technicians without the benefits of membership of a learned society—technicians who are equally vital to the progress of the electrical and electronic industry".

Thames Television Plan for Colour

Announcing plans for their colour television centre now being built as part of the new Euston complex, Howard Thomas, managing director of Thames Television, the London weekday independent television company, revealed that July 6th 1969 was the date on which all I.T.A. transmissions would be radiated on u.h.f., 625 lines. Full colour programmes would commence in November or December of the same year.

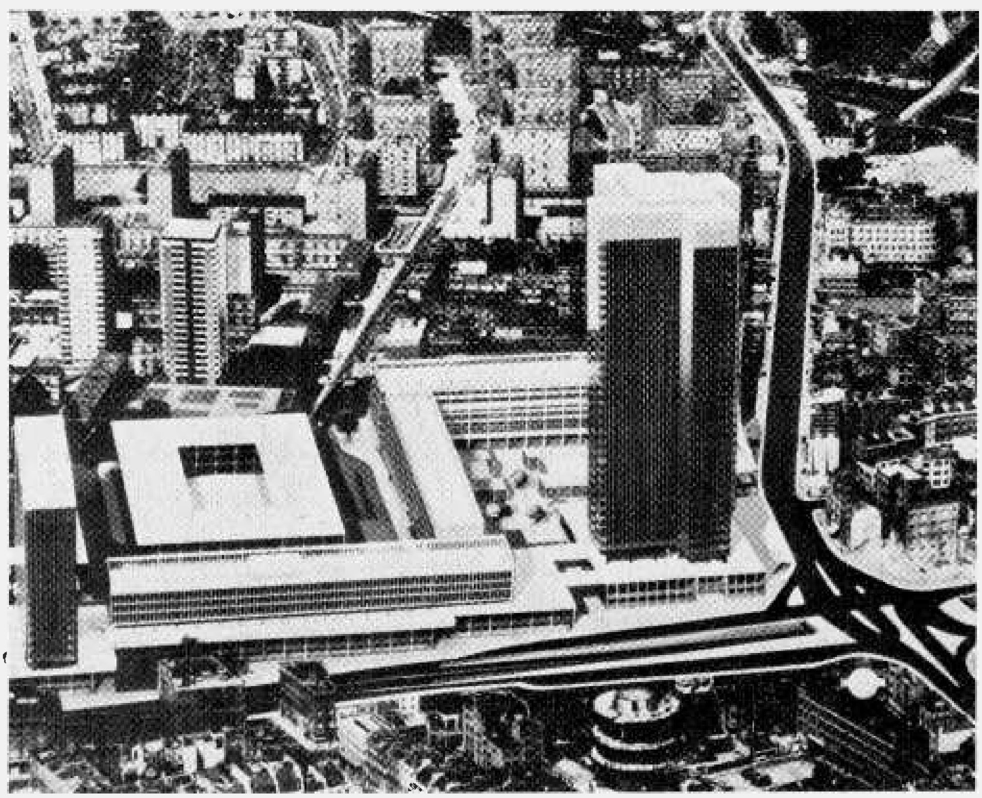
The new centre in the heart of London will specialize in current affairs, features, documentaries, live events and schools' and children's programmes. Occupying 90,000 sq ft, it will be fully equipped for colour and will include two studios and a "master control". The main production centre for large-scale entertainment programmes will remain at the company's Teddington studios, and programmes will be routed to the transmitter or to the I.T.A. network as required. Thames Television has ordered Marconi four-tube cameras and Rank Cintel telecine equipment for their new centre. Thames Television is due to start transmission on July 30th this year but the move from Television House, Kingsway, to the Euston Centre will not take place until July 1969. According to the company's chairman, Sir Philip Warter, the capital cost of the new centre, including technical equipment, will be about £3.75M.

Re-equipping Goonhilly No. 1 Aerial

A contract worth approximately £400,000 has been awarded by the Post Office to GEC-AEI (Electronics) Ltd. of Stanmore, Middlesex, for re-equipping the original aerial at Goonhilly to enable it to carry commercial telephony traffic and television programmes between the United Kingdom and countries in the East via the Intelsat satellite over the Indian Ocean.

The re-equipping has been planned to take place when it is freed from its present operational role with "Early Bird" on the Atlantic Ocean route. This will be when the new aerial (No. 2) and its associated equipment, now under construction, comes into operation. The re-equipping of aerial No. 1 is due to be completed in the first half of 1969. It will cater for a total of 264 two-way telephone channels between Goonhilly and 12 different destinations. In the outgoing direction, the channels will be assembled into two basebands which will modulate two s.h.f.

A photograph of a model of the completed Euston Centre superimposed on an aerial photograph of the partially developed area. Thames Television will occupy part of this complex.



radio carriers, each with a capacity of 132 channels. These carriers will be received by many distant stations, each selecting only that part of the baseband that contains its own traffic. Similarly, the equipment at Goonhilly will enable up to 12 carriers, with capacities of 132, 60 or 24 telephone channels to be received. Additional transmitting and receiving equipment for television will cater for 625-line video and sound channels as well as cue and order wire channels.

To reduce the amount of apparatus that otherwise would be needed in the limited space on the aerial itself, the connection for the receiving direction between the aerial and the central control building, a quarter of a mile distant, will be by means of a semi-flexible waveguide operating at 4GHz. This is the longest piece of semi-flexible waveguide ever installed, and it is being supplied by Kabelmetal of Hanover, West Germany. It will avoid the need for the down-converters on the aerial structure at present in use. These hetrodyne the received signal to 70MHz for transmission to the control building via coaxial cable. The contract will also include tests to determine the feasibility of using a similar waveguide, operating at 6GHz in the transmitting direction. If tests on a trial length are successful this waveguide will be incorporated in the system.

The apparatus to be provided in the central building will include modulators and threshold-extension demodulators, frequency converters, and a comprehensive control, supervisory and test system integrated with that now being installed for aerial No. 2. The drive amplifiers and 8kW output stages of the working and reserve transmitters will be installed in the main apparatus cabin on the aerial. The wideband, high-power travelling-wave tubes in the transmitting system will enable all the telephony channels to be handled simultaneously by one transmitter. Modifications will also be made to the aerial control system to simplify the autotracking arrangements.

Space Consortium Formed

Thirteen satellite ground stations, seven with 40ft diameter dishes and six with 20ft dishes, are to be built at a cost of £12M to provide a flexible and secure communications network throughout the N.A.T.O. area. It is expected that each station will operate from a static site within a member country; however, one of the design requirements is that each station should be fully transportable and capable of being resited at short notice.

A large international consortium has been formed, called EUROCAN, which consists of six major organizations with considerable experience in the space field, that will bid for the N.A.T.O. contract. The partners are: Marconi (U.K.), Siemens (West Germany), Telefunken (West Germany), Philips (Holland), R. C. A. Victor (Canada) and S.T.S. (Italy). Contracts will be split up to provide each of the N.A.T.O. member countries with a share of the work, including civil engineering and site construction, in such a way that the balance of payments problem is minimized. The share that would be carried by British industry amounts to just over £2M.

Satellite Programme needs International Co-operation

A new concept in international understanding will have to be achieved before all the benefits of current and future space programmes can be fully exploited. This was the subject of an address given by the assistant general manager of the Space Vehicles division of TRW Incorporated, Dr. Russell, at the annual convention of the Aviation /Space Writers Association held at Cocoa Beach, Florida.

In the near future several nations will have their own domestic communications satellites and agreement will have to be reached on exactly where these satellites will be positioned in space. For instancee, satellites serving Canada, the United States and Mexico would require almost an identical position in space.

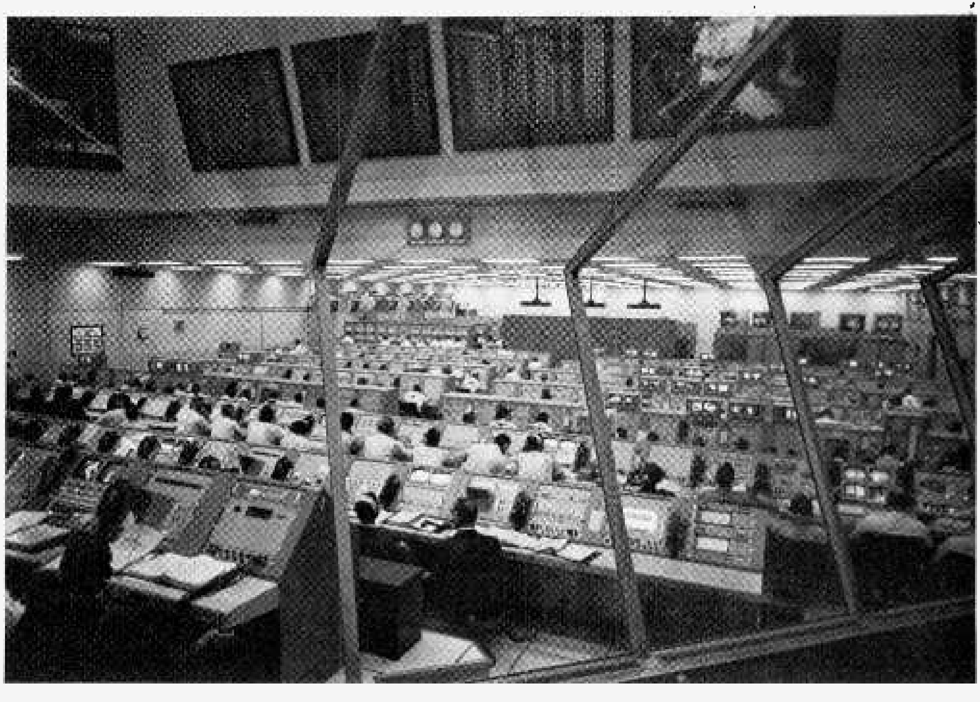
Dr. Russell went on to outline some of the future benefits of the space programme. "Earth Resources" satellites will take colour photographs of the earth surface and mix the colours in an unnatural way so that conditions on earth, not normally evident, will become apparent. In this way it will be possible to determine mountain snow coverage during winter, information of great value to those concerned with flood control and the preservation of reservoirs. Large scale geological patterns will provide clues as to the location of mineral and oil deposits. It will also be possible to detect large shoals of fish through temperature patterns or the thin film of oil that they leave on the surface of the sea. Forest fires and tidal waves can be spotted in an early stage. New navigation satellites at present under development will be able to fix position to within an accuracy of 30 yards and do a good deal to relieve the present aircraft collision problem.

In the future vast amounts of data will be bombarding earth from space borne vehicles and it is going to be a huge problem to process this information and present it quickly to those who must need it; the farmer, fisherman, city administrators, governmental establishments and the like. A network such as this must be world wide in order to be efficient, and such an organization could not be met without complete understanding and trust between nations.

Sun used as Signal Source

In order to study the effect of the earth's atmosphere on the transmission of radio waves the sun is being used as the signal source in an experiment being carried out by Bell Laboratories of America. The study is being conducted at two frequencies useful to satellite communications—16 and 30GHz. Energy from a 5 × 9ft metal reflector, which continually tracks the sun, is directed into a horn reflector aerial. Since the sun radiates only a small amount of power in the millimetre wavebands direct measurement is impractical and radiometric methods are used. The received signal is transmitted by a circular waveguide to a microwave radiometer for measuring the intensity of the radiant energy. A twin-stylus chart recorder keeps a record of the signal strength at the two frequencies of interest. The total radiation received from the direction of the sun is a combination of solar and atmospheric radiation. In order that only the solar radiation be taken into account the aerial is directed away from the sun at one second intervals. During this time it is receiving atmospheric radiation only so that the percentage of the composite signal that is generated by the sun can easily be computed. Received signal strength variations are compared with atmo-

One of three firing rooms at the launch control building at Kennedy Space Centre, it is equipped with a total of 450 consoles containing the central control and display systems needed for check-out. Sixty television cameras positioned around the Apollo-Saturn V Rocket, three and a half miles away, transmit visual information back to the centre on ten r.f. channels.



spheric conditions and the effect of the weather on the transmission path can be determined.

Communications and the Queen Elizabeth 2

Cunard are claiming three firsts in the ship-to-shore communications field when the *Queen Elizabeth 2* makes her maiden voyage in January next year. These will be the use of notch aerials—designed by the British Aircraft Corporation for aircraft, the use of the Post Office Lincompex system and the employment of self-tuning transmitters.

The notch aerials are inconspicuous and can transform any part of the ship's structure into an efficient radiator. The problems of siting aerials to prevent mutual interference and screening associated with wire aerials are largely eliminated and the notch has the advantage of an omni-directional characteristic. In all, five of these aerials are employed on the *QE2*, four of them being mounted on the funnel.

The Post Office designed Lincompex system is being manufactured by G.E.C. In this 300Hz of the audio pass-band is used to accommodate a control signal. At the transmitting end the signal to be sent is compressed and the 300Hz wide control signal is impressed with details of the compression applied. At the receiving end the control signal dictates the amount of expansion that has to be applied at any given point of the signal to reconstitute it to its original form. The net result is that full use can be made of the available transmitting power with a consequent reduction in the signal-to-noise ratio.

The eight transmitters will be supplied by the International Marine Radio Company (an S.T.C. company), four of these are v.h.f. types. In the 1.5 to 25MHz band three transmitters with self tuning facilities will operate in conjunction with the notch aerials at p.e.ps of 1kW. Covering a greater frequency range at higher power, 1.5kW p.e.p., another transmitter covers the ranges 405-525kHz, 1.6 to 3.8MHz and the h.f. bands 4, 6, 8, 12, 16, 22 and 25MHz. Four v.h.f. transmitters are fitted for short-range working with power outputs of 10W.

One Line, Two Subscribers

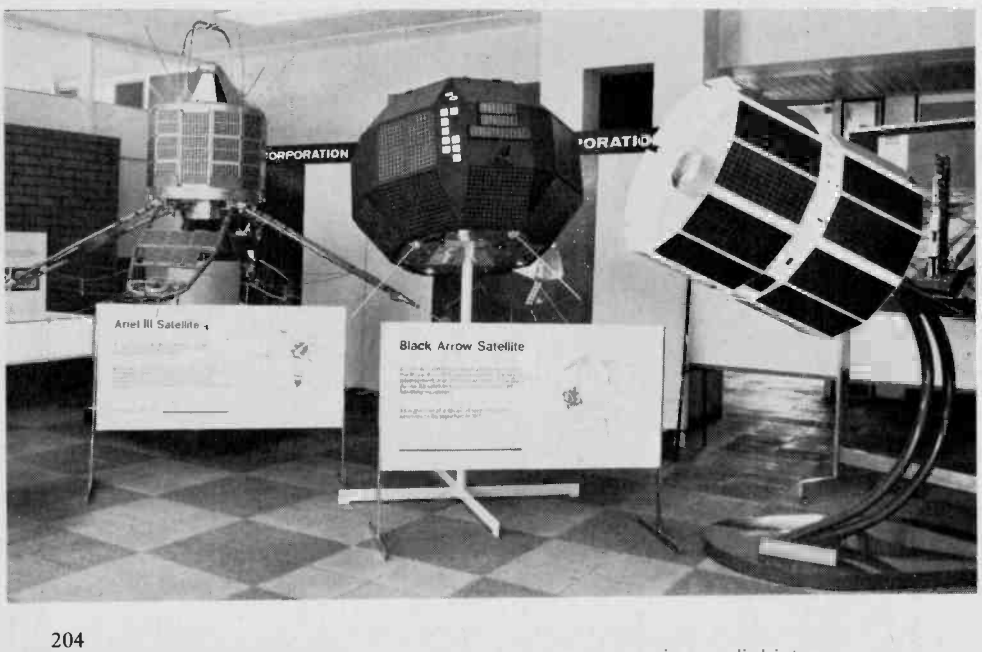
Two subscribers can now share a single pair telephone cable and still have uninterrupted access to the exchange with complete privacy. This has been made possible by a subscriber carrier system, called SUB-IA, designed by Standard Telephones and Cables Ltd. The only subscriber equipment required is contained in two plastic boxes $3+1\frac{1}{2}+1\frac{1}{4}$ inches and $7+5\frac{1}{2}+2\frac{1}{4}$ inches which are easily installed and removed.

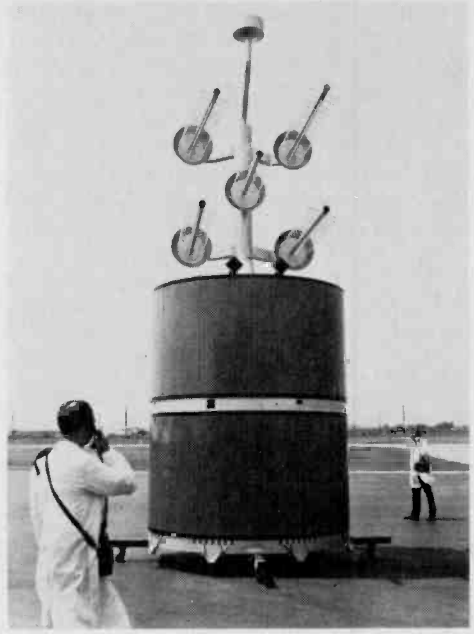
In operation a carrier, for the additional subscriber, is superimposed on the voice frequency circuit of the existing subscriber. Separate carriers are used for the two directions of transmission, 28kHz from the subscriber to the exchange and 64kHz in the reverse direction. A low-pass filter is connected in series with the existing telephone isolating it from the carrier circuit, and in turn, the carrier circuit is isolated from the voice-frequency circuit by a carrier band-pass filter. The subscribers equipment includes modulation and de-modulation equipment.

At the exchange a similar set-up is employed to separate the two circuits and connect them into individual switching equipment. Dialling pulses are transmitted to the exchange by interrupting the carrier and, in the opposite direction, the ringing voltages are converted to carrier pulses.

No external power supply is needed at the subscribers' premises since the carrier equipment unit incorporates a nickel-cadmium re-chargeable battery which is recharged from the exchange control battery.

A model of the British Aircraft Corporation's Black Arrow satellite (centre) was on view with Ariel III (left) and ESRO II at the space communications symposium held at the Northern Polytechnic, London at the beginning of June. A contract for the design, development and manufacture of four Black Arrow X-3 satellites together with handling equipment, for launching in 1971 has been placed with B.A.C. by the Ministry of Technology.





A mock-up of the world's largest communications satellite. It is being built for the U.S. Department of Defence by Hughes Aircraft Company. The experimental satellite will have a capacity comparable to 10,000 two-way telephone channels. It is scheduled for launch by a Titan 3C booster later this year. It will enable even small army units in the field to communicate with each other.

International Patent Co-operation

An inter-governmental organization, located in Geneva with more than 80 member states, the Bureaux Internationaux Reunis pour la Protection de la Propriété Intellectuelle (BIRPI), have stated that they are currently engaged in finding a way to simplify patenting inventions in a number of countries. International patents will not be issued by BIRPI under the scheme, this would be the responsibility of the national patents offices involved, however, it is hoped that the idea, if pursued, will avoid duplication of effort in member countries and prevent wasting the time of both the patents office and the inventor concerned. A patent would go through three stages under the scheme. Any applicant would be allowed to file an international application with BIRPI, normally through his own patents office, and the effect of any such application would be extended to the countries designated by the applicant. The fact that a single application will suffice means the a standard form can be produced, the only difference between countries being the language in which it is printed. In stage two a search report would be produced by a national patents office or the International Patent Institute that would comment on the current state in the field to which the invention applies and highlight any factors that may question the originality of the invention. In the final stage, following a successful search report, the applicant would ask for what is tentatively being called a certificate of examination. The certificate would be issued under the authority of BIRPI but would actually be produced by a patents office and would contain the criteria of patent-ability. It is intended to set up machinery to ensure the uniformity of these criteria in the various countries involved.

Computer Aids Lone Yachtsman

The 57-ft ketch Sir Thomas Lipton being handled by Geoffrey Williams, competing in the transatlantic yacht race, is being guided by information received from a shore-based English Electric KDF9 computer. The KDF9 already holds the performance details of the ketch and also holds programmes simulating sections of the Atlantic under average weather conditions. The yachtsman will radio his current position and the computer will provide course details based on the existing weather conditions, the weather forecast, the performance of the craft and current position. The new course will be transmitted to Williams after being vetted by the Meteorological Office.

Determining the Volt, Amp and Ohm

A new "non-magnetic", or magnetically clean, laboratory has been built by the American National Bureau of Standards. A uniform magnetic environment is essential for absolute determinations of the ampere and volt in terms of basic mechanical units. In these measurements, the absolute ampere is first determined and then used with the absolute ohm to determine the absolute volt by application of Ohm's law.

Two types of ampere determination will be performed in the non-magnetic building. In one room, a horizontal solenoid is mounted with a smaller, vertical solenoid supported on a fused silica balance frame inside it. When a current is sent through the dynamometer formed by the two series solenoids, the experimenter adds weights to balance the torque produced. Knowing the distance between the knife edges of the balance, the balancing mass, and the local acceleration of gravity, the experimenter can assign the value of the current in amperes. To determine the volt the same current is sent through a known resistance; the voltage drop developed can be used to assign the value of the standard cells which maintain the reference unit of e.m.f.

The second current balance consists of a stationary coil and a movable coil suspended coaxially within it from one arm of a balance. Here, also, the current through the series-connected coils can be calculated from the coil dimensions and geometry and from the force which the current creates on the movable coil. This force is known from the action of gravity on the masses required for the balance. The value of a steady current through the coils is most accurately determined by attaining a balance, reversing the relative polarities of the coils, and determining the change in mass necessary to obtain a balance again.

Another experiment, one making use of the precession frequency of protons in a magnetic field, is performed occasionally to detect any change in the electrical units maintained by the Bureau. A current established in terms of the N.B.S. volt and ohm is sent through a solenoid of stable dimensions to produce a magnetic field in which the proton precession frequency is measured. It is critically important in this experiment that magnetic gradients in the observed volume be as small as possible and that the earth's magnetic field be compensated so that only the field of the current in the solenoid acts on the protons. If the precession frequency is found to be the same each time the experiment is repeated, then the units defining the solenoid current are known to be unchanged. This is because the measured frequency is dependent only on the magnetic field and on a fixed atomic constant . . . the proton gyromagnetic ratio. A change of less than 1 p.p.m. in the N.B.S. ampere can be detected in this way.

"The Change to International System (SI) Units for Energy" is the title of a conference organized by the Ministry of Technology to be held on October 31st and November 1st at Church House, Westminster. The need for a national conference on SI energy units has arisen from the decision of the Government and industry to change to the metric system, and the general desire to align new standards and practices in the U.K. with international agreements and recommendations.

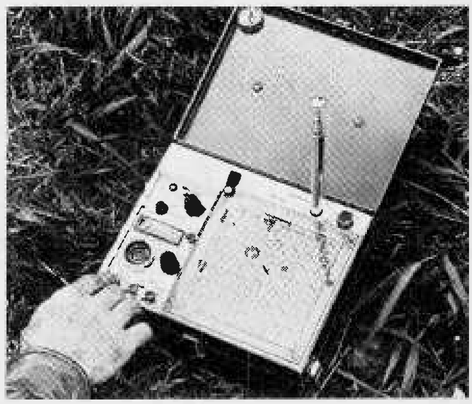
Two Mariner space craft will be launched between mid-February and mid-April 1969 on a Mars "fly-by" mission. The space craft should pass within 2,000 miles of the planet by the middle of August. Because of this extremely close approach there is some possibility that one of the space craft may in fact collide with the planet. All the experiments carried by the space craft are designed to send back information on the atmosphere and surface of Mars including television pictures.

A Decca Navigator system covering the entire length of the Norwegian coastline was officially opened on May 14th by King Olaf of Norway. The Norwegian system consists of five chains of transmitters plus one joint Norwegian/Swedish chain. The transmitters are the first to be designed for unmanned operation.

N.A.S.A's Nimbus B weather satellite will carry a tape recorder capable of recording digital and analogue signals simultaneously and replaying them thirty times faster than they were recorded. The recorder handles information from a TV camera, three infra-red sensors and the space-craft timing clock and combines them into one signal for transmission to earth. The instrument can record for up to 156 minutes and replay the same amount of information in less than five minutes.

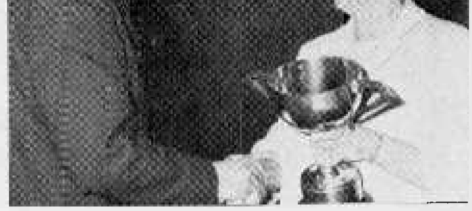
Attenuation figures, telexed from S.T.C. engineers engaged in the installation of a **12MHz 2700-circuit telephone cable** in Europe, were manipulated by a computer at Cockfosters to obtain the necessary optimized component values required to equalize the system properly. The link, which stretches the 37 miles from Salzburg to Bischofshofen in Austria, has a measured

Portable colour camera. This experimental three-tube colour television camera, comparable in size and weight with a 16mm film camera, has been built by Philips Research Laboratories, Eindhoven, as a test bed for the latest miniature Plumbicon pick-up tubes. Technical details were given last month (p.152).



This compact display unit is associated with a highly mobile radar system that can detect high-speed aircraft at tree top level. Called the Forward Area Alerting Radar (F.A.A.R.) the system is an early warning radar for use in forward battle areas as part of the US Army's air defence system Chaparral Vulcan. (Vulcan is a 20 mm gun and Chaparral is a guided missile.) A radar unit housed in a truck transmits aircraft position information to the portable displays at the gun-missile emplacement.

Peter A. Sharp, of Crayford, Kent, receiving the Rowland Memorial Cup at the prize-giving to apprentices of the Electrical Inspection Directorate of the Ministry of Technology. He is the first recipient of the cup to be awarded annually for the best electronics work of the year. His project was the Wireless World Oscilloscope.



noise performance of less than 1pW/km, that is 2pW/km better than the C.C.I.T.T. standard. The cable is the first to operate at 12MHz in Europe. Installation was completed in six weeks.

Many **aids for assisting teachers of electronic circuitry** have been produced, each with its own particular merits. The latest of these comes from a firm called Lock Instrumentation, of Prudential Buildings, 79 Union Street, Oldham, Lancs., and is called the Locktronics system. Although the aid is fundamentally based on the traditional bread-board method of circuit construction and presentation it offers one very important advantage. That is, *current measurements* can be made without making any circuit disconnections. Individual components and conductor lengths are housed in plastic carriers clearly printed with the appropriate symbol. Circuits are assembled by plugging the plastic carriers into a matrix of fairly widely spaced pillars, connection being made via self-cleaning phosphor-bronze leaf-springs. A probe consisting of a sandwich, conductor-insulator-conductor, can be slid in between the leaf-springs connecting a meter, coupled to the probe, in series with the circuit, hence allowing current values to be measured. Four kits are currently available, these being, (1) simple electrical investigations (2) the transistor (3) radio circuits and (4) digital circuits.

Bitter Pill for the Flying Doctors. Under an international agreement the Royal Flying Doctor Service in Australia must change all its present a.m. (d.s.b.) transceivers for s.s.b. equipment by 1975. In all, this will entail re-equipping 14 base stations at an estimated cost of as much as A$35,000 each, and replacing 5,600 portable and fixed homestead stations at an estimated cost of A$2.8M. In the twelve months to June 30th, 1967, R.F.D.S. aircraft flew 917,237 miles (2,488 flights) taking 2193 patients to hospital.

Handwriting is being transmitted, as it is written, over a v.h.f. radio link coupling repair teams working on ships with their control office. The equipment to do this has been installed in the offices of the Vosper Thornycroft Group at Southampton Dockyard and consists of the marriage of a Pye v.h.f. link and the Modern Telephones Electrowriter. The Electrowriter is an analogue device originally intended to be coupled to landlines. Movement of a pen is translated into two audio tones, corresponding to the pen's x and y co-ordinates, at the transmitting end. Movement of the pen is reproduced at the receiving end by frequency sensitive servos driving another pen. This is the first time that the Electrowriter has been used over a v.h.f. link.

An equipment capable of **controlling and interrogating a remote radar** installation over telephone lines has been ordered by the Royal Netherlands Air Force from Elliott Automation. In this particular installation a controller will contact the radar installation on a "control" telephone line and request that it sends its data, specifying the particular range scale required. The digitally encoded information is sent along a "data" telephone line to the control centre where it is decoded and presented on a conventional radar display.

An automatic test equipment which allows virtually unskilled operators to perform complex test schedules on complicated equipment and components has been introduced by Marconi. Called Mentor, the equipment consists of three main units: the controller, the instrumentation and digitizing assembly, and the test jig. The instrumentation and digitizing assembly consists of a bank of programmable test gear selected to provide all the facilities necessary for the type of test to be conducted and an analogue-to-digital converter that converts the outputs of the test gear to digital form. The input to the system is punched tape which operates, via the control unit, the test equipment and the equipment being tested and routes the results to a line printer or tape punch. Pass/Fail Outputs can be given and are determined by whether outputs fall within or outside programmable variable limits.

A modern **diffusion facility** has been opened in SGS-Fairchild's Falkirk, Scotland, factory. The company claim that the new plant is comparable with the best in the USA. The plant will be the first in this country to use two-inch diameter wafers, one inch being the norm, and work is at present being carried out on the problems associated with using three-inch wafers.

C.B.B. Wood (centre) head of the television section in the physics group of the B.B.C's Research Department, holding the Geoffrey Parr Award of the Royal Television Society received for his team's work in improving TV reproduction of colour films. With Mr. Wood are Aubrey Buxton (left) and Alan Whicker who each received the Society's silver medal.

Mullard meetings, which are designed primarily to keep members of the retail trade abreast of technical developments and are held at approximately 80 centres during each twelve months, are for the 1968/69 season again concerned with colour television. The particular subjects covered are degaussing, purity, convergence and grey scale tracking and the illustrated talk is followed by the film "It's the tube that makes the colour". Most meetings are organized in collaboration with R.T.R.A. local centres and the July meetings will be in Londonderry (3rd), Belfast (5th), Swansea (10th), and Cardiff (11th). Further details are obtainable from the organizer, Ian Nicholson, Films and Lectures Organization, Mullard House, Torrington Place, London, W.C.1.

The **Electronic Components Board** have announced the appointment of Sir Alan Dudley, K.B.E., C.M.G., as the director. One of his many functions will be to represent the components industry in negotiations with the various Government Departments with which the industry is involved. Sir Alan Dudley was until recently a deputy secretary in the Ministry of Overseas Development. The Electronic Components Board is the forum of the British electronic component industry of which the constituent associations are the British Radio Valve Manufacturers' Federation, the Electronic Valve and Semiconductor Manufacturers' Association, and the Radio and Electronic Component Manufacturers' Federation. Shall we at last see one organization acting on behalf of all sections of the components industry?

A second **Decca Radar chain** is to be built that will cover the Northern Kyushu area of Japan. This is in addition to the existing chain in Hokkaido that has been in operation for the past year. The new chain will be operational in the Autumn of this year. It has been reported that more than 200 receivers are in use in fishing boats using the Hokkaido chain.

An **exchange-of-ideas agreement** has been reached between the Royal Television Society in London and the German Television Society in Darmstadt. It is hoped that the agreement will lead to more active co-operation between the two societies at exhibitions and conventions in Europe.

In **Literature Received** last month errors occurred in the piece on Mullard Educational Films. Firstly, Educational Systems Ltd. distribute only Mullard Educational filmstrips, not Mullard films. The address is Educational Systems Ltd., ESL House, not ESC House. Applications for Mullard films should be addressed to the Mullard Film Library, 269 Kingston Road, Merton Park, S.W.19.

Stereophonic Image Sharpness

Results of experiments to discover how the width of the sound image is related to the image position; also how image position is related to interchannel level difference

*by H. D. Harwood**, B.Sc.

The main advantage of stereophonic over monophonic reproduction is the ability to hear sound images spread out in space as in real life, and the greater the number of different sources we can distinguish the better the system will satisfy us in this regard. This number is dependent on how sharp the images are and how evenly they are distributed across the acoustic space or stage, corresponding in television terms to focus of the beam and linearity of the scanning. In stereophony, using the usual coincident microphone sound pick-up, the spacing of the images is determined by the relative levels applied to the two loudspeakers; on the other hand the sharpness of the image depends on a number of factors, and in the end can only be determined by listening tests as the image is entirely a subjective phenomenon. If then we try to improve the stereophonic effect by changes in circuits, loudspeakers or acoustics of the listening room we must measure both the displacement and the sharpness of the image if we are to determine fully the results of the changes we have made. For example, it would be of little value to introduce a circuit which improved image sharpness over part of the stage width only to find that the linearity of image position had been distorted.

The possibility of improving the technical quality of broadcast programmes has been examined and the first requirement was to make a full and accurate assessment of the performance of the standard arrangement. To keep matters simple, images of a point source were used; ideally of course these should have no width at all, but in practice do have a finite size. An account is given here of experiments using male speech and designed to measure the relation between image position and interchannel level difference, to determine the variation of image width for differing image positions across the stage and to investigate the efficacy of a circuit, (described in one of the references) in reducing image width. The tests were with one exception carried out both in a listening room, thus simulating the average domestic acoustic environment, and in a free-field room, which has the advantage of providing not only one extreme acoustic condition but an environment that could be duplicated accurately elsewhere. The experiments on the image-width reducing circuit were carried out only in the free-field room.

* *B.B.C. Research Department*

There are several references [1, 3, 4, 5, 6, 7] in the literature to the relationship between image position and interchannel level difference but, as will be shown, the conclusions vary considerably; very little quantitative information has been published on image width, and none on the way in which it varies for differing positions across the stage or with the acoustics of the listening room.

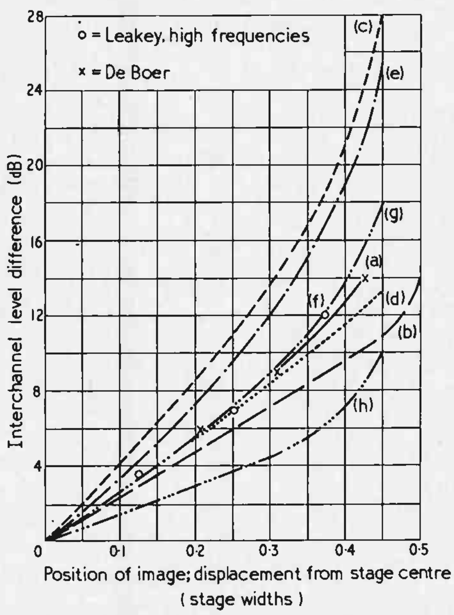
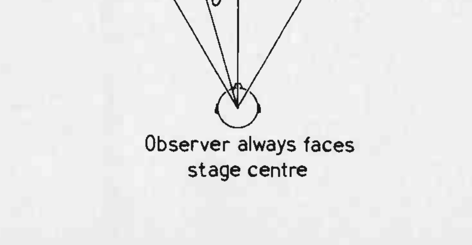


Fig. 1. Relation between image position and interchannel amplitude difference, by various authors: (a) De Boer; (b) Brittain and Leakey; (c) Clark, low frequencies; (d) Clark, high frequencies; (g) Wendt, $\frac{1}{3}$ octave band, fc 316Hz; (h) Wendt, $\frac{1}{3}$ octave band 3160Hz.

Fig. 2. Relative positions of loudspeakers and observers.



The first reference in the literature to a measurement of the relation between image position and interchannel level difference is an article by de Boer[1]. No details are given of the acoustics of the listening room, the number of observers, nor of the programme employed, other than that it was from a gramophone record. His results are reproduced in curve (a) of Fig. 1. To account for the relationship shown by the curve he considered that diffraction around the head, resulting in difference in sound level at the two ears, was the main factor in providing directional information and that the difference in the time of arrival of the sound at the two ears played only a minor part. The interaural level difference due to diffraction varies considerably with frequency[2] and he weighted it according to the corresponding variation in energy density for speech, to arrive at the relationship between level difference and angle of incidence. It is, however, difficult to see how a single relation connecting image position with interchannel level difference can hold for all types of programme material if the hearing mechanism has to make a similar weighting for differing types of sound.

The next publication was by Brittain and Leakey[3] who employed excerpts, a few seconds long, of recorded speech with a frequency range up to 5kHz; the measurements were made in the open air on a site free of reflecting obstacles. The number of observers is not stated; their results are given in Fig. 1 curve (b).

In an article describing the "Stereosonic" system Clark *et al*[4] develop a theoretical expression determining the image position for low frequency sounds as a function of the interchannel level difference. For the experimental layout shown in Fig. 2, in which the subject faces stage centre, the theoretical relation is given as $\sin a = \{(L-R)/(L+R)\}\sin\theta$ and from data obtained with 4 observers this is claimed to be accurate up to about two thirds of the stage width. They state that the results of experiments carried out with variety of programme materials are in agreement with this relation for frequencies up to 700Hz, but that above this frequency the experimental displacements are greater than the predicted value and it is necessary for the value of sin a obtained from the above expression to be increased in the ratio of 1.4 to 1; to correct this they employ what they call a shuffle circuit. The paper by de Boer[1] is quoted in support of this requirement, but this support is not at all clear from an examination of the article in question. The theoretical relationships for both low and high frequencies are plotted as curves (c) and (d) in Fig. 1; it should be noted that the shuffle circuit is claimed to reduce the image width, presumably by an amount corresponding approximately to the difference between these two curves. In a subsequent article[5] one of the authors gives data to show that the acoustic environment has only a small effect on image position for a given interchannel level difference.

Leakey[6a, 6c] describes the limitations, even at low frequencies, of the sine law given above and derives another relation tan $a = \{(L-R)/(L+R)\}$ tan θ which takes account of the variation of interaural time differences with small involuntary head movements; measurements he made in the open air with a number of observers varying from 4 to 12 and using a band of noise covering the frequency range 250 to 500Hz are in reasonable agreement with this law but he states that "to obtain a somewhat closer agreement with the practical results it is necessary to allow for the effect of signal attenuation around the head". Although he does not claim it, his formula implies that image position as a fraction of stage width is independent of the distance of the observer from the loudspeakers, and it can be seen from his results that this holds fairly well except at close range; on the other hand this cannot hold, except at small angles, for the formula given by Clark *et al* although they claim that it does. At high frequencies Leakey makes allowance for the shadowing effect of the head and assumes that it is the envelope function of the waveform reaching the ears which contains the directional information. The final expression is somewhat complex but agrees well with his own experimental results for a band of noise extending from 2 to 4kHz. Data calculated from these theoretical expressions for low and high frequency sounds are presented in Fig. 1 curves (e) and (f). To the extent that these curves differ from each other, Leakey also implies the need for some form of shuffle circuit although not to the degree indicated by Clark *et al.* In contrast to this, however, he also gives a curve[6b] showing the image displacement for "wide range speech", apparently 250Hz to 4000Hz bandwidth. This curve follows closely his curve for displacement of low frequency sounds only and does not show the deviation which might be expected if the high frequency components followed a different law.

Wendt[7] also carried out experiments in a room, whose characteristics were not stated, by a team of ten observers. He used various 1/3 octave bands of noise separated by half a decade, and found that for a given interchannel level difference the image displacement varied with the frequency of the test band; the results for the bands centred at 316 and 3160Hz respectively, i.e. similar to those of Leakey, are reproduced in Fig. 1 curves (g) and (h). From the slopes of these curves and the corresponding ones for other frequency bands, he obtained a weighting factor for middle and high frequencies somewhat resembling that obtained by Clark *et al.*

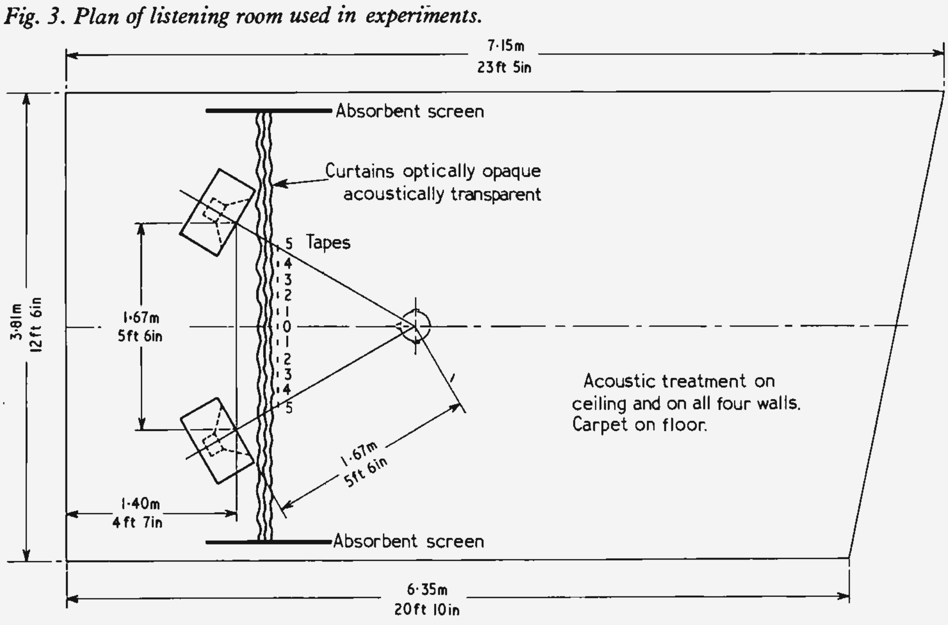
It will thus be seen that there is a considerable divergence not only in the results predicted by the theories mentioned but also in the experimental results.

The only data on image width appears to be that given by Clark *et al*[3] who state that image widths within about $\pm 2°$ were obtained for recorded music investigated in two separate bands: from the bass up to 700Hz and 600Hz upwards. This comment appears to cover differing image positions but the acoustic conditions are not stated.

Experimental Details

In the series of tests carried out by the author the observer faced stage centre in accordance with normal practice and with the requirements of the remarks given above.

Fig. 3. Plan of listening room used in experiments.



The arrangement of loudspeakers, scale divisions and position of subject is given in Fig. 3, which shows a plan of the listening room; the volume is approximately 85m³ and the average reverberation time is 0.3 second. The same arrangement was used in the free-field room, but in this case the reflection coefficient of the surfaces was less then 10% for frequencies down to about 80Hz. Twelve observers took part; they were all experienced in making subjective judgments.

To take account of any asymmetrical effects in the listening conditions, the loudspeaker system or the observer's reactions, tests were carried out with the image displaced both to the left and to the right of the central position. There is some evidence[8a] that the position of components at either of the extreme ends of the audio-frequency range is masked by that of components further within the band. To avoid this effect in the present series of measurements the test material employed was male speech, which is known to contain very little energy at either very low or very high frequencies; other advantages were the relatively constant level and continuous spectrum compared with other programmes. In the tests, recorded speech was played continously to the observer, until he had made his decision, at a maximum sound level reading of 74dB on an unweighted sound level meter; this level has been shown[8b] to be that preferred both by the team and by the general public. The observer was provided with a double attenuator with which he could change the relative levels of signal in the right- and left-hand channels, thus displacing the image position without changing the loudness.

The first set of experiments was designed to measure three things: the law connecting image position with interchannel level difference, the width of the image at various positions across the stage, and the minimum perceptible image shift. The observer was therefore asked to adjust the attenuator for the following conditions:

(a) Centre of image coinciding with each of the tapes 0 to 5 (Fig. 3)

(b) Left-hand edge of image coinciding with each of the tapes 0 to 5

(c) Right-hand edge of image coinciding with each of the tapes 0 to 5

(d) Minimum perceptible shifts of image from centre to left-hand side and to right-hand side

The order in which tests were made was random.

The second set of measurements was designed to check the claim made by Clark, Dutton and Vanderlyn[4,5] mentioned earlier that the sharpness of the image can be improved by electrical means. According to those authors the part of the spectrum above 700Hz requires a smaller interchannel level difference for a given image displacement than the portion below this frequency. They designed the circuit shown in Fig. 4(a) having the amplitude frequency characteristic shown in Fig. 5, to be inserted in the difference channel of a sum-and-difference network, as shown in Fig. 6. The circuits

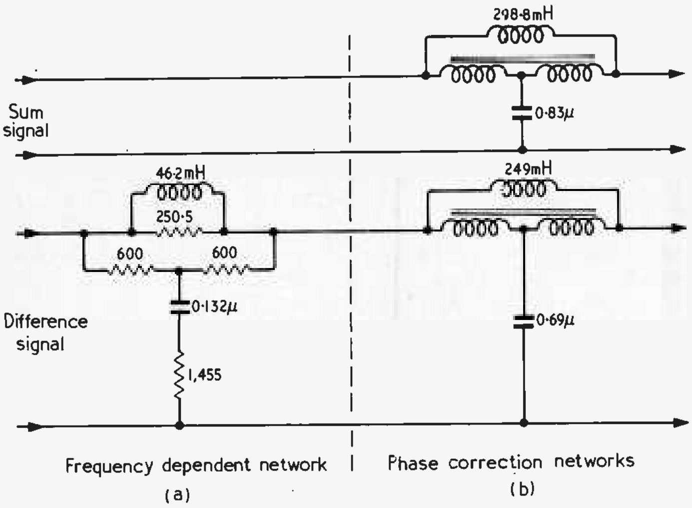


Fig. 4. Shuffle circuit intended for improving sharpness of image.

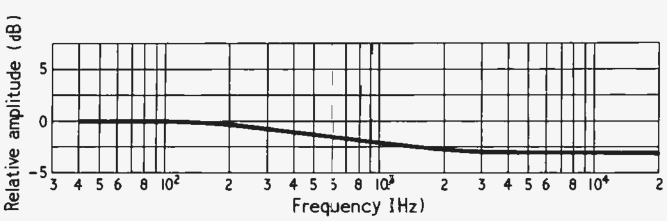


Fig. 5. Amplitude/frequency characteristic of shuffle circuit.

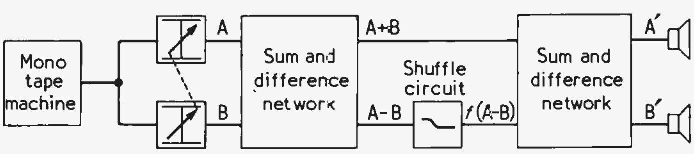


Fig. 6. Showing how shuffle circuit is inserted in sum-and-difference network of test apparatus.

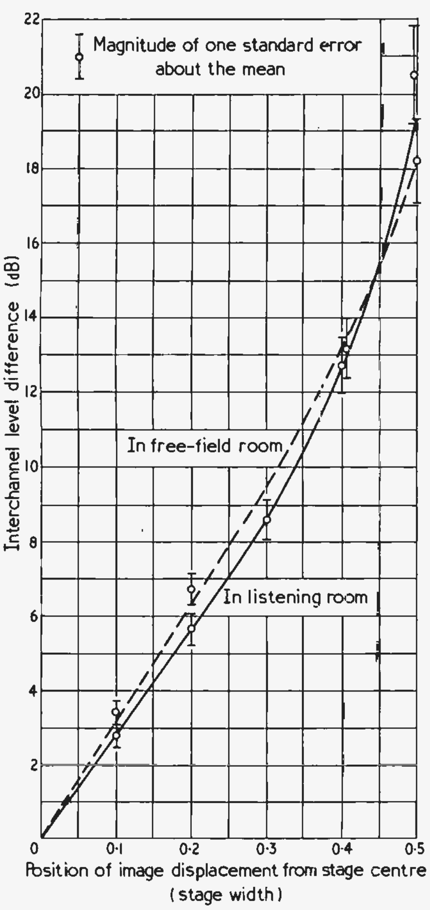
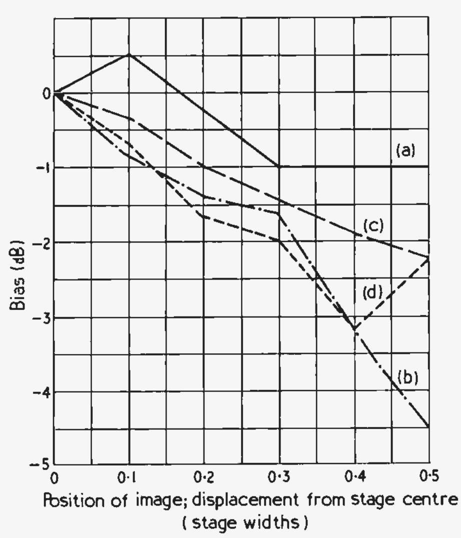


Fig. 7. Relation between image position and interchannel level difference, in free-field room and in listening room.

Fig. 8. Variation of bias with image position: (a) in free-field room, centre of image, average of team; (b) in free-field room, centre of image, average for individuals irrespective of sign; (c) in listening room, centre of image, average of team; (d) in listening room, centre of image, average for individuals irrespective of sign.



marked (b) in Fig. 4 are to compensate for the unwanted phase delay introduced by circuit (a); losses in the two circuits are equalized by means of attenuators not shown.

The efficacy of this device in reducing image width was tested in the free-field room by repeating observations (b) and (c) with the new device in circuit. For a central image there is no difference signal and therefore the added circuit has no effect; when the image is at one extreme of the stage the sound is radiated effectively by one loudspeaker only and the added circuit does not appreciably change the image width or position although it does change the sound quality. Observations were therefore confined to the case of an image at tape 3, where calculations indicated that the effect on image width should be quite noticeable.

The results of the first set of experiments are given in Fig. 7. The curves show the image position as a function of the inter-channel level difference for the tests in the listening room and free-field room respectively. The points plotted are the median values for the team and the standard error for each value is also shown. It will be seen that the results in the two rooms are very similar and that the relationship is substantially a linear one except near tape number 5. This position will be seen from Fig. 3 to represent the extreme edge of the stage and in order that the image should be displaced to this extent, substantially all the sound must come from one loudspeaker. A linear relation therefore cannot be expected; in fact, owing to the finite image width smaller displacements must also be affected. Another factor involved is that most observers are found to have a bias in their observations so that the number of decibels required to shift the image to a tape on the left is different from that required for the corresponding tape on the right. Fig. 8 shows this bias averaged for the team (curves (a) and (c)) and the average of the absolute values (irrespective of sign) for the individual observers as a function of the image position both in the listening room and in the free-field room. Some persons found it impossible to displace the image centre to tape 5 on one side of the stage although on the other side they could displace it even beyond this position. The values shown in Fig. 7 for tape 5 are thus affected by the fact that subjects on one side of the mean have not been able to give a reading for the test, this applied particularly in the listening room, and the size of the standard error is also increased. On the other hand, the extreme value shown is in very good agreement with our figure of 19 dB given elsewhere[8] for the interchannel difference required to give a minimum perceptible displacement of the image from tape No. 5.

Image Width. Figs. 9(a) and 9(b) show the relationship between width of image and image position for tests in the listening room and free-field room respectively. For tapes 0 to 4 these results were obtained from the team averages for the positions of the inner and outer edges of the image. For tape 5 it was not generally possible to displace the inner edge of the image to the tape, as this involved displacing the centre to a position

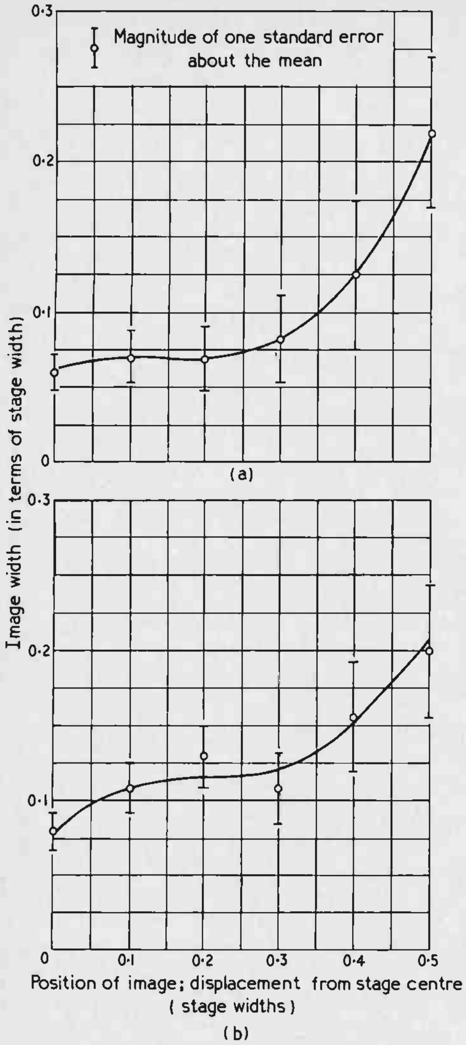
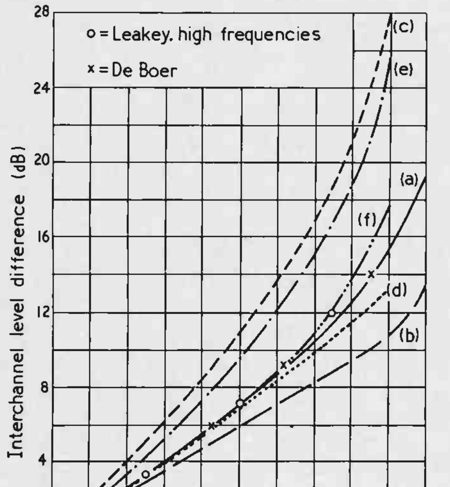


Fig. 9. Variation of image width with image position: (a) in listening room; (b) in free-field room.

Fig. 10. Relation between image position and interchannel amplitude difference: comparison of present results, shown by curve (a), with previous work. (b) Brittain and Leakey; (c) Clark, low frequencies; (d) Clark, hiagh frequencies; (e) Leakey, low frequencies; (f) Wendt, $\frac{1}{3}$ octave band f_c 316Hz.



beyond the corresponding loudspeaker axis; the image width could not therefore be obtained directly. However, an examination of the results for the other positions showed that the position assigned by the team to the centre of the image was in fact very closely halfway between the two edges and it was assumed that this would probably hold at tape 5 also; to obtain the point plotted for tape 5 the difference between centre and outer edge of the image was therefore doubled.

It will be seen that up to 0.4 of a stage width the image is always narrower in the listening room than in the free-field room with a fairly constant ratio of 1 to 1.4; moreover, the standard errors are similar in the two rooms for the same image positions so this difference cannot be accounted for by the test eing more difficult in one room than in the other.

At tape 5 the values of image width, having been estimated, are somewhat less certain, but the value is the same in both rooms and, as a matter of interest, amounts to about two-thirds of the loudspeaker width. For this image position the sound is radiated almost entirely from one loudspeaker and so it might be expected that as faults due to imperfect matching of the two loudspeakers are at a minimum the image would be sharpest. What is surprising therefore is that the image width at stage centre is only about one-third of that at tape 5; it is possible that if observers had always faced the image rather than the stage centre, this result would have been different for the off-centre positions.

The median value of the minimum perceptible shift for a central image in the listening room is 0.03 of a stage width, with a standard error of 0.007; the corresponding figures for the free-field room are 0.02 and 0.003 of a stage width. It will be seen therefore that the limit determined by the powers of discrimination of the ear has not been reached and it would seem that given suitable conditions the image width even for a central image could still be appreciably reduced.

The results were further analysed to see if there was any correlation between the width of image determined by a particular subject and the interchannel level difference necessary to displace the image position by a given amount. It is clear that for image positions near the stage centre such a connection must exist; for example, it is almost certain that a person who hears an image extending almost to tape 1 will require less interchannel level difference to displace the image to that tape than will someone for whom the image is narrower. The analysis showed this expected correlation for tape 2; for tapes 3 and 4, however, the correlation coefficients were too low to be significant. These low values are in part due to the smallness of the team, 12 persons, but it seems probable that even if a larger sample were taken the correlation would not be very marked.

Effect of Shuffle Circuit on Image Width. In the second set of experiments the median value for the image width at tape 3 in the free-field room when the shuffle circuit was used was 0.16 stage width, with a standard error of 0.025; the value obtained without this circuit and shown in Fig. 9(b) was 0.11 stage width, the standard error again being 0.025. It is seen that the effect of the circuit, far from reducing the image width, has been to cause an increase in width which is just significant. At this particular tape position L/R = 9dB and the 3dB step (Fig. 5) in the ratio of sum signal to difference signal $((L + R)/(L - R))$ introduced by thecircuit at high frequencies changes the ratio of the signals in the left and right channels by 3 dB also; from Fig. 7 it can be seen that an inter-channel difference of this amount will displace the image by 0.09 stage width. As, however, the image width has been increased by only 0.05 (from 0.11 to 0.16) stage width it appears that the frequency components causing the increased width could previously have been well inside the image area.

Comparison with Previous Work

The results given in the full-line curve o Fig. 7 for the measurements in the listening room of the relation between image positior and interchannel level difference have beer replotted as curve (a) in Fig. 10, together witl some of those from Fig. 1. it will be seen tha they agree extremely well with those of de Boer (shown by crosses) and with those obtained at high frequencies by Leakey (shown by circles). On the other hand, the values obtained by both Clark *et al* and Leakey a low frequencies are well removed from ou results.

The difference between their high fre- quency and low frequency curves implie that in the absence of a shuffle circuit th width of image should vary in a correspond ing manner and it is of interest to calculat this variation. The difference between th curves is plotted for both authors in Fig 11(a) and (c) and the correspondin displacements of the edge of the image ob tained with the aid of Fig. 10 is shown in Fig 11(b) and (d). If it is assumed that the imag area originally contained all frequencies uni formly distributed, then the width should b increased by an amount corresponding t these displacements. Fig. 12 shows the resul obtained when the width for a central imag which the shuffle circuit cannot affect, i superimposed on Figs. 11(b) and 11(d). I will be seen that the resulting curves do no bear a very close resemblance to that of th actual image width obtained and shown i Fig. 9(a) and in Fig. 12 and thus thro further doubt on the validity of a shuff circuit with these constants. The theories o Clark *et al* and Leakey both assume that th observer always faces stage centre, but it i not explicitly stated whether this conditio did apply in their supporting experiment They show that a change of head angle doe affect the image position to some extent bu no information is given as to the effect o image width.

It was shown earlier that the image widt was less in the listening room than in th free-field room for a spectrum containin little energy below 100Hz. This is in contras to the results of other tests [10] in which most c the energy was below 100Hz. In the latte

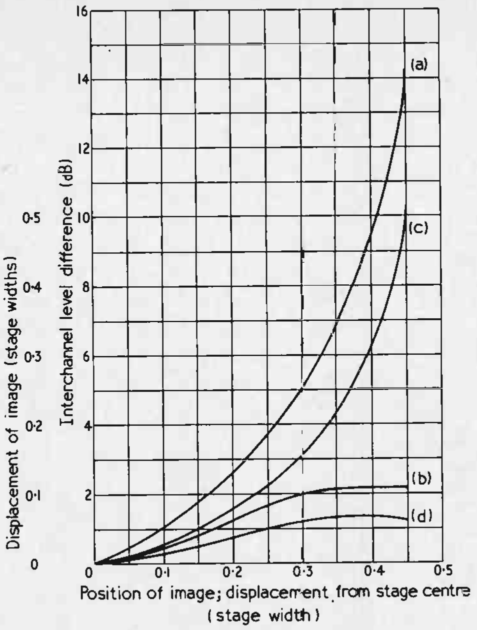
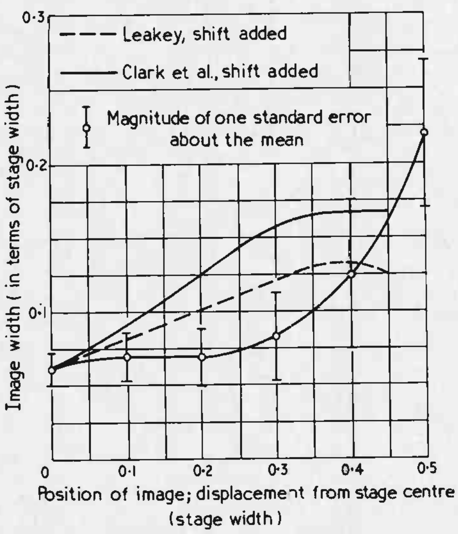


Fig. 11. Variation of image parameters with image position: (a) interchannel level difference produced by shuffle circuit (Clark); (b) shift of image which would be produced at low frequencies by (a); (c) interchannel level difference required by Leakey; (d) shift of image which would be produced at low frequencies by (c).

Fig. 12. Measured and calculated variation of image width with image position.



case the programme consisted of plucked double bass, drum and organ and the image at stage centre was wider in the listening room, although least so for the organ which in turn had more sound energy above 100Hz than did the other two programmes. It appears therefore as though at the bass end of the spectrum the effect of the acoustics of the listening conditions on the image width at stage centre varies somewhat with frequency.

Future Work

It has been shown that there is some agreement in the literature on the need for a form of shuffle circuit but the transition frequency and amount of the step appear to be based on rather scanty data. It should therefore be profitable to repeat Leakey's work with octave bands of noise over a wider frequency range in order to determine the optimum frequency characteristic and height of the step, and then to check whether in fact this relationship does appear to hold for a wide-band signal. It should be noted, in this connection, that neither of the theories proposed by Leakey and Clark and given earlier in this article takes account of the precedence effect whereby one sound reduces the apparent level of other sounds immediately following it. Leakey also admits that signals covering only a narrow frequency band give results differing from those having a wider band, and it is not clear whether signals extending over an octave will give the same results as programme.

In these tests it has always been assumed that the observer should be in a central position facing straight ahead. An examination of the data on the variation of diffraction around the head[2] and of the interaural time difference[1] with the angle of the incident sound wave indicates that the directional data supplied to the ears does not vary appreciably for angles of incidence up to $\pm 40°$ in the horizontal plane. The natural reaction, however, when attention is focused on a particular sound is to face the direction from which it appears to come, and the possibility should be examined that if such a movement is prevented this may have an effect on the image width, and thus afford some explanation of the results given in Fig. 9. Such an effect would in some ways be similar to the corresponding optical case in which visual acuity is higher for an image in the centre of the retina than for one at the periphery. For the tests described, image width is already smaller in the listening room than in the free-field room and this fact suggests that no improvement over the range covering speech frequencies would be obtained by increasing the ratio of direct to indirect sound. The use of directional loud-speakers might help, however, to reduce image width for listeners in off-centre listening positions, and possibly at the lowest frequencies for those in a central position. In this connection the effect of the width of the loudspeaker cabinet on image widths should also be examined.

Conclusions

The relation between stereophonic image displacement and the interchannel level difference has been obtained both in a typical listening room and in a large free-field room for observers facing stage centre. The results in the two rooms are very similar and show a substantially linear relationship over most of the stage width; the bias for the team and the average bias for individuals in these experiments have also been determined for the differing image positions chosen.

The image width shows an unexpected variation with position across the stage and is much smaller at the stage centre than at the edges. The variations between individuals were similar in the listening and free-field rooms, but the absolute widths were greater in the latter; measurements of the minimum perceptible shift at the centre position show that even for this position where the image is narrowest a reduction in width would still be observable.

The circuit claimed by Clark *et al* to reduce image width has been tested subjectively for one image position which it was thought would show such an effect most clearly. The measurement gave the unexpected result that the effect of the circuit has been to increase the image width by an amount which is statistically just significant.

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

References

1. "Stereophonic Sound Reproduction" by K. De Boer. *Philips Tech. Rev.*, 1940, *5*, 4, p. 107.
2. "On minimal audible sound fields" by L. J. Sivian, and S. White. *J. Acoust. Soc. A.*, 1933, *4*, 4, pp. 288-321.
3. "Two channel stereophonic sound systems" by F. H. Brittain and D. M. Leakey. *Wireless World*, 1956, *62*, 5, pp. 206-210.
4. "The stereosonic recording and reproducing system" by H. A. M. Clark, G. F. Dutton and P. B. Vanderlyn. *Proc. Instn. Elect. Engrs.*, 1957, 104B, *17*, pp. 417-432.
5. "The assessment of two channel stereophonic reproduction" by G. F. Dutton. *J. Audio Engng. Soc.*, 1962, *10*, 2, pp. 98-105.
6a. "Some measurements on the effects of interchannel intensity and time difference in two channel sound systems" by D. M. Leakey. *J. Acoust. Soc. Am.*, 1959, *31*, 7, pp. 977-987.
6b. cf. Figs. 2 and 8(b) loc. cit.
6c. "Further thoughts on stereophonic sound systems" by D. M. Leakey. *Wireless World*, 1960, 66, 4, pp. 154-160, 5, pp. 238-240.
7. "Versuche zür Ortung von Intensitäts — Stereophonie" by K. Wendt. *Frequencz*, 1960, *14*, 1, pp. 11-14.
8. "Stereophony: the effects of cross-talk between left and right channels" by H. D. Harwood and D. E. L. Shorter. B.B.C. Engineering Monograph No. 52, 1964.
9. "The effect on stereophonic reproduction of frequency-dependent crosstalk between left and right channels" by H. D. Harwood. Fourth International Congress on Acoustics, Copenhagen, 1963, Paper N35.
10. "Stereophony: the effect of interchannel differences in the phase/frequency and amplitude/frequency characteristics" by H. D. Harwood, W. I. Manson and D. E. L. Shorter. B.B.C. Engineering Monograph No. 56, 1964.

Circuit Ideas

As announced in last month's issue, a regular feature on original ideas in circuitry which have been found practical is to be started in *Wireless World*. Presented in the form of short notes, the items will be essentially functional "bricks" which somebody has found useful at some time. Performance, originality of realization and economy of components will be the most important criteria. Readers are invited to contribute to this series: the more ideas we get the better will be our selection.

Letters to the Editor

The Editor does not necessarily endorse opinions expressed by his correspondents

Loudness Control for a Stereo System

Mr. Lovelock's article in your June issue raises an old bogey which I naively thought had been buried by most British engineers many years ago. I refer, not to the author's excellent and useful thesis on achieving an accurate gain control law, but to the notion that our hearing system's non-linear loudness /frequency behaviour justifies an interference with response when reproducing music at various levels.

Of course, we all know about Fletcher-Munson and Robinson-Dadson, etc, and it is true that l.f. acuity declines with falling sound pressure level; though the h.f. end is different, and latest research does not support a general rise in output of the sort given by Mr. Lovelock's circuit. However, the point is that applying the inverse of these curves to sound reproduction is completely fallacious, because the hearing mechanism works the way it does in real life, with music loud or quiet, and no one objects. If 'live' music is heard quietly from a distant seat in the concert hall the bass is subjectively less full than if heard loudly from the front row of the stalls. All a 'loudness control' does is to offer the possibility of a distant loudness coupled with a close tonal balance; no doubt an interesting experiment in psycho-acoustics, but nothing to do with realistic reproduction.

In my experience the reaction of most serious music listeners to the unnaturally thick-textured sound (for its loudness) offered at low levels by an amplifier fitted with one of these abominations is to switch it out of circuit. No doubt we must manufacture the things to cater for the American market, but for goodness sake don't let readers of *Wireless World* think that the Editor endorses the total fallacy on which they are based.

Two final points. Your contributor recognises the need for all inputs to have a fixed reference level if a loudness control is to work consistently, but overlooks the fact that this is not synonymous with all programme material offering the same peak amplitudes; this would be quite wrong if applied to both chamber music and full orchestras. Also, while preset gain controls are desirable, the one on the gramophone pickup input cannot conveniently cope with the wide range of mean recorded levels found on commercial discs.

JOHN CRABBE
Editor, *Hi-Fi News*

The author replies:

Mr. Crabbe raises a point of perennial controversy in the matter of variation of amplifier response with volume. It was because I was aware of the difference in opinion on this matter that a switch was fitted which allowed a variation of volume without adjustment of frequency characteristic. By a touch of his finger the user may select that condition which he finds most pleasing, and I still think that the question should be settled by subjective pleasure rather than by pure theory.

In any case, I would question the correctness of the theory advanced by Mr. Crabbe. Chamber music was written for performance in the intimacy of a room, and the condition which places the performers on a large platform, and amplifies the sound electronically into the far reaches of an auditorium is itself artificial. An audience gathered with the performers in a 'chamber' will hear at a level not greatly removed from that heard by those in the orchestra stalls of a large concert hall, and due allowance is made for this in the difference between studios in which chamber music and symphonies are recorded.

Mr. Crabbe himself admits that when no compensation is coupled to the control, it is in effect a 'distance' control. If the listener wishes to transpose himself from the expensive orchestra stalls to the much cheaper gallery, he is, of course, at liberty to do so. The difference in price should indicate which is the preferred choice however.

Mr. Crabbe's experience is quite different to mine. It was because two professional musicians both advanced the boost controls on my amplifier when reducing gain that I feel it desirable to have an automatic facility. The amount of boost on my circuit is not derived from theory, but from the amount which they advanced the controls for a 20dB fall in gain. I am sorry that Mr. Crabbe did not give a reference to the 'latest research' which he cites.

Incidentally, the emitter and collector symbols of the second BC109 in Fig. 6, are shown reversed.

R. T. LOVELOCK

'How Important is Detection?'

In his reply to my letter Dr. Macario misquotes me. I do admit that a diode requires a volt or two to make it appear linear but I do not admit that it requires a low source impedance. In the days of valve receivers the diode was normally fed from a tuned circuit with a dynamic resistance of the order of 100kΩ. Early transistor receivers used much lower values because of the poor back resistance of the early semiconductor diodes and the use, for economy reasons, of the same diode to feed a low resistance a.g.c. line. With modern silicon diodes the back resistance and the peak inverse voltage are so high that the source dynamic resistance can again be high and therefore the source voltage high.

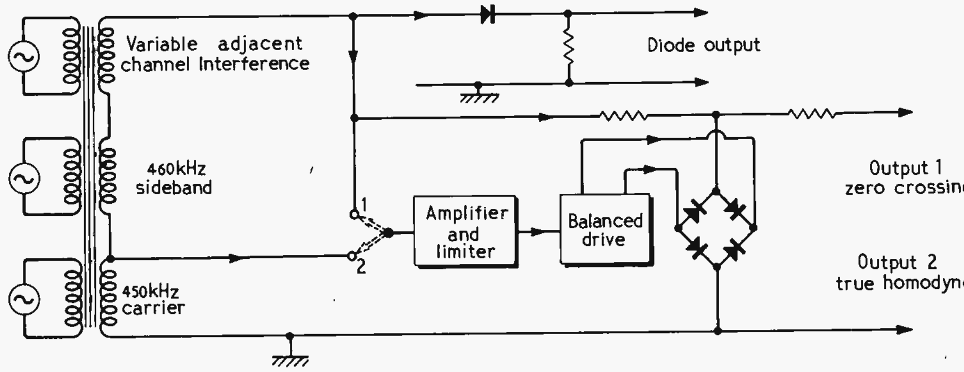
Dr. Macario appears to suggest that his circuit has a high input impedance. The input resistance will be about 2.7k Ω because there is a resistance of this value feeding into the virtual earth of the first amplifier.

The main difficulty is one of definition. Dr. Macario describes his zero crossing detector as a homodyne, e.g. he says "The *homo*dyne does not have a separate oscillator and is described below" (page 53 March). In my previous letter I was also referring to Dr. Macario's circuit when I used the word homodyne. Unfortunately, Dr. Macario is now (June "Letters") quoting others, e.g. N. M. Rust *et al* who tested a homodyne which was different in principle from the zero crossing detector. They used a "Homodyne receiver into which an artificial carrier identical in frequency and phase with the original is introduced" *(J.I.E.E.* 88, Part III, 1941).

D. G. Tucker in a very complete review paper *(J.Brit.I.R.E.*, April 1954) says "The homodyne and the synchrodyne are systems of demodulation for amplitude modulated signals; they use a local oscillator synchronised in frequency to the carrier of the wanted signal . . . The synchrodyne was, in fact, only an up-to-date homodyne." We are agreed that these are identical with clean undistorted signals but Dr. Macario claims that his receiver uses an audio filter and that this "works as well as or better than narrowing the i.f. bandwidth". This is true of the homodyne of Tucker and Rust but it is not true of the zero crossing detector as Dr. Macario will find if he injects a large interfering signal. The zero crossing detector generates a square wave which is always (say) positive whenever the incoming signal is positive and vice versa, however much the signal is distorted. The square wave opens and closes the diode bridge and shorts out the incoming signal whenever this is (say) negative and passes it through when positive. This is identical to a half-wave rectifier regardless of phase shift or phase modulation.

The difference can be clearly demonstrated by a simple experiment using two generators to represent the signal and a third to provide a variable frequency and amplitude interfering signal. The two generators are set to convenient frequencies, say 450 and 460kHz, with equal amplitude. These represent a distorted a.m. signal with one sideband completely missing and the carrier halved. This arrangement has been chosen because the analysis is easy and in the textbooks. The envelope is half sine waves exactly like a full-wave rectifier with a resistive load.

With the switch in position 1 the circuit is Dr. Macario's zero crossing detector and the output half sine waves is exactly the same as that of the diode. If the interfering generator is now switched on both suffer the same



distortion. With the switch in position 2 the circuit is the true homodyne as defined by earlier writers and the output is a sine wave as was the original a.m. envelope before distortion. The interfering generator now produces interference which can be removed by an audio filter even when the interference is larger than the desired signal. This is not true of Dr. Macario's circuit.

Without doing the experiment it is clear that the circuit arrangements must be very different. With the switch in position 1 and without interference, the signal to the squaring circuit is $\cos 2\pi f_1 t + \cos 2\pi f_2 t$ which gives an average frequency

$$\frac{f_1+f_2}{2}$$

i.e. 455kHz in this case with abrupt phase reversals at each envelope zero.

In position 2 there is one frequency only, the carrier, 450kHz, into the squaring circuit. This is the true homodyne.

To sum up, there are three circuits. Two of them, the ordinary diode and Dr. Macario's zero crossing circuit, are envelope detectors and both suffer distortion during selective fading and are seriously affected by adjacent channel interference from large signals. The third, the true homodyne, is very much less affected but is not used because of the difficulty of generating the necessary carrier.

M. D. SAMAIN
University of Salford,
Lancs.

I feel that Dr. Macario has not adequately answered the comments made by Mr. Samain and myself. The point at issue is the direct equivalence between the homodyne and the more simple diode detectors. Dr. Macario's explanations are not acceptable as they are based on quite erroneous reasoning, the mainstay of his reply being the difference between the two curves he shows as $E_v(t)$ and $E_z(t)$. The error in his reasoning lies in the choice of the expression $e_v = \cos(\omega_c t + \phi_c + \psi)$, for the zero crossing signal. The result of this is to attribute, to the zero crossing signal, a sense of phase modulation which is opposite from that which exists in the received signal. The correct expression for the zero crossing signal is $e_v = \cos(\omega_c t + \phi_c - \psi)$, and if this is used to derive a curve for $E_z(t)$ under the conditions quoted by Dr. Macario, the result is identical with $E_v(t)$. That $e_v = \cos(\omega_c t + \phi_c - \psi)$ is the correct expression to represent the zero crossing signal can be readily verified by comparing its expansion as $e_z = \cos(\omega_c t + \phi_c)\cos\psi + \sin(\omega_c t + \phi_c)\sin\psi$ with the product form of $e_a(t)$ which is:—

$$e_a(t) = a\cos(\omega_c t + \phi_c)\left[1 + \frac{m_u}{2}\cos(\omega_m t + \phi_u - \phi_c) + \frac{m_l}{2}\cos(\omega_m t - \phi_l + \phi_c)\right] + a\sin(\omega_c t + \phi_c)\left[\frac{m_l}{2}\sin(\omega_m t - \phi_l + \phi_c) - \frac{m_u}{2}\sin(\omega_m t + \phi_u - \phi_c)\right]$$

(This was not printed very clearly in my previous comments and the terms of the second part of the expression have been rearranged to emphasise this particular point.)

I have had the opportunity to observe Mr. Samain's experimental tests and I can confirm that at no point in the circuit did its behaviour differ from that which was expected. The simulation of selective fading was most effective and produced the type of envelope distortion expected, the output of the homodyne following this quite faithfully.

I can only conclude once again that there is nothing inherent in the circuit described by Dr. Macario which can explain his subjective assessment of its performance under selective fading conditions.

E. A. HARMAN,
Bolton, Lancs.

Using f.e.ts in Pre-amplifiers

The article by Mr. D. B. G. James on a simple f.e.t. pre-amplifier in the April issue has brought to the fore the use of these unipolar transistors in entertainment equipment. An earlier article by Mr. Ridler (Sept. 1967) illustrated the usefulness of the f.e.t. in preventing a current surge through a tape head. But I do not quite agree with the recent article in the reasons for the use of f.e.ts. It is true that they exhibit a noise figure generally somewhat lower than a bipolar transistor, but only with source impedances of one megohm and somewhat higher, especially for audio frequencies. The equivalent input noise voltage for a 5dB noise figure device, as calculated from

$$v^2 = kT\,R_s(NF-1)\Delta\mu$$

gives an r.m.s. noise voltage of about 13μV for a 20kHz audio bandwidth. This means the first stage has a signal-to-noise power ratio of about 47dB for a 3mV input signal. This is rather poorer than present designs. Since the preamp only has a gain of unity at 1kHz, the noise produced by the second stage is also relevant and the preamp as described would have a signal-to-noise power ratio probably about 45dB (for 5dB *NF* devices). The circuit could be modified for use with crystal or ceramic pickups to give a high signal-to-noise ratio. For the above reasons I feel that f.e.ts are properly applied only in such uses as low cross-modulating r.f. amplifiers and mixers, high-level variable gain circuits, and high-impedance circuits, to mention a few. A conventional bipolar low-noise transistor with equal noise figure but an optimum source impedance of 1kΩ would have an equivalent noise voltage of about $\frac{1}{3}\mu$V. Hence the signal-to-noise power ratio could be potentially better by around 30dB. The de-emphasis employed in most pre-amplifiers affects the weighted noise figure by a similar amount for both pre-amplifiers.

The snag is that whereas most magnetic cartridges have a d.c. resistance of something near 1kΩ, most manufacturers rate them for impedances of 47 to 100kΩ, for several reasons[1].

(a) The self inductance of the cartridge has a reactance less than 47kΩ even at the highest audio frequencies.

(b) Larger currents would flow at lower impedances and reduce the stereo separation of many cartridges.

(c) These devices can be used both for valve and transistor circuitry.

Thus there is a considerable necessary mismatch between cartridge and amplifier, and some difficulty in obtaining a low enough background amplifier noise for serious enthusiasts.

Earlier designs for transistor preamps[2,3] obtained worthwhile reductions in noise level, and I cannot quite understand why, items (a) and (b) cannot be eliminated by proper pickup design. However, I know very little about design problems in this field, and accordingly I propose two alternative suggestions.

Audio frequency parametric amplifiers[4] will give low noise figures (0.15-0.5dB) at relatively high input impedances (100kΩ-1MΩ) and the amplifier noise is then somewhat equivalent to the Johnson noise of the resistive component of the cartridge impedance. These amplifiers are somewhat complex in that they will require a pump oscillator of about 1MHz. Zener diodes with low reverse leakage current work well as voltage variable capacitances because of the abrupt junctions. A second suggestion (and probably just as reasonable) is to construct the stereo pickup with capacitive transducers. An r.f. bridge circuit as used with high-quality capacitor microphones, could be used to decode the output. The pickup arm could contain the two orthogonal stereo capacitor bridges and buffer transistors which would actuate a remote detector. The unbalance caused by the stylus pressure could be bucked out by variable capacitance diodes controlled by a

[1] see for example *W.W.*, Jan. 1965, p. 2
[2] *W.W.*, Dec. 1961, p. 621
[3] *W.W.*, Aug. 1963, p. 376
[4] *Proc.I.E.E.E.*, Feb. 1963, p. 298.

sort of very low frequency (10Hz) automatic balance. With the help of integrated circuits in the pickup arm the device might weigh less than a conventional cartridge (or part of the circuit could be used as the counterweight). Such a system would effectively be a parametric amplifier in which the normal small signal behaviour in terms of a time varying capacitance (sinusoidal) is replaced by a capacitance whose variation in time is caused by the stylus motion. Noise could theoretically be brought to a very low limit because the Brownian motion of even the lightest stylus assembly is miniscule, compared to the modulation of the groove. The amplifier background noise would be low enough even for those who meticulously remove each speck of dust from the disc!

JOHN VANDERKOOY
Royal Society Mond Laboratory,
Cambridge.

Demonstrating A.C. Theory

There is an important qualification in the last paragraph of Mr. Assenheim's article on "Demonstrating A.C. Theory" in the June issue ". . . this method of demonstrating the action of a.c. circuits is readily accepted by students as they are often familiar with the way in which a stroboscope works".

What if they are not?

Since Mr. Assenheim refers to three of my articles which have appeared in *Wireless World*, perhaps I could mention two others to which he does not refer? One, in *Electronic Engineering* of July, 1951, described a strobing technique which applied the results of the sampling process to a c.r.o. to draw a phasor diagram which slowly rotated. I found that the demonstration was not as helpful to students as I had hoped—I was illustrating one mystery by a process just as mysterious as the original phenomenon. I soon abandoned it. The second took the form of a letter which appeared in *Wireless World* of December, 1963. This described a low-frequency alternator: a coil rotated at 6 rev/min in the magnetic field of an Eclipse Major Magnet. I think the coil at that time had 500 turns. Now my coils have 2,300 turns. At this speed I can generate a sinusoidal voltage with a peak value of about 300mV.

Students generally learn about simple alternators before they study a.c. circuits. This demonstration shows the action in slow motion. Subsequently, the alternating voltage induced in the rotating coil can be applied to C and R in parallel and moving-coil centre-zero meters show the expected phase difference. The capacitor need be only $100\mu F$ if a $50\text{-}0\text{-}50\mu A$ meter is used.

The original alternator has grown beyond the stage in which it was described in the letter of December, 1963. There are now three coils on a shaft, which can be set to have any desired angle between them. Each coil has its own magnet, slip-rings and brushes. The system can be used for teaching the action of a single-phase or a three-phase alternator, star- or delta-connected or the coils can be co-planor and connected in series so as to act as a single-phase alternator with a larger output.

Once students have seen the alternator in action, if it is sometimes more convenient to use a "black box" low-frequency oscillator than the more space-consuming alternator, they seem to be brain-washed into accepting the black box. No doubt the alternator could brain-wash them into accepting Mr. Assenheim's strobing meter also.

The fact that I did not mention the use of the alternator in the articles to which Mr. Assenheim refers, was simply due to a desire to keep the articles as short as possible.

I was interested in the reaction of one elementary class to the alternator: they saw the to-and-fro motion of the pointer of the centre-zero meter showing the alternating e.m.f. induced in the rotating coil. Their problem was to relate this movement to the usual sine wave. In their view, once a graph had been drawn from A through B to C, it should then be drawn from C through B back to A.

To overcome this difficulty, we arranged to drive the coil at a speed of one revolution per minute (a more sensitive microammeter was required). Readings were taken every 5 seconds and the class drew a graph. Ultimately, they were convinced by the graph they themselves had drawn.

A class which does not appreciate the relation between a sine wave and the motion of the pointer of the meter may not find Mr. Assenheim's demonstration very helpful. (I am not denying its usefulness to more advanced students).

There are, it seems to me, some occasions when the strobing technique fails and when it is necessary to work at a 'genuine' low frequency. The most important feature of a transformer is the alternating flux. In a demonstration which I have not described previously, it is possible to have centre-zero meters showing primary and secondary currents, and, more important than these, compass needles showing the reversal of the flux. Another demonstration possible at low frequencies is the use of a compass needle to show the rotating magnetic field due to 2-phase currents in coils with their axes at 90°.

In view of these applications, I would say that the strobing technique is complementary to the use of very low frequencies.

T. PALMER
Richmond, Surrey

F.E.T. a misnomer?

If it is not already too late, might I suggest that the use of the name "field effect transistor", to describe a semiconductor which relies upon the variation of conductivity in a transverse electric field to obtain the desired effect, be reviewed. The device is most certainly a field effect device, but most certainly is not a transistor.

Transistor action takes place across two separate junctions, whereas in an f.e.t. there is only one actual junction between gate, whether insulated or not, and the other two electrodes.

Again, by definition, the transistor is a current controlled device. How therefore, can you have a type of transistor which being voltage controlled defies this definition?

One basic parameter of the junction transistor, is transconductance, gm is defined in terms of only one circuit variable, emitter current. In an f.e.t., gm is defined in terms of two circuit variables, drain current and gate-source voltage.

Since the introduction of the field effect transistor, so-called, the junction transistor has been renamed "bipolar transistor" and I have seen an f.e.t. described as a "unipolar transistor", surely a contradiction in terms!

I offer no alternative name apart from field effect semiconductor or field effect device but at least if the word transistor was removed from the title, I am sure a lot of confusion would be removed and also a transistor could revert to being simply a transistor.

While on the subject of initials and names, the m.o.s.t., which is a field effect device, could be misconstrued as not being one, and how do you get your tongue round the word made up of the initials m.n.s.t. which are almost bound to be used for the metal nitride silicon transistor, which is not a transistor?

A. F. WILLIS
Bracknell, Berks.

Is it not time for the field effect transistor to be given a name of its own? Its various sub-species (IGFET, MOSFET, JUGFET, MNSFET, and even MTOSFET) may be memorable, descriptive, and printable, but they are a distinct impediment to conversation.

If we follow the convention of marrying a descriptive Classical prefix to the generic "-istor", we need only seek as far as a Latin verb which describes the operation of the device nicely—"pervellerc", to pinch. Hence, "pervistor".

JOHN KERSHAW
W. Malvern, Worcs.

Ultrasonic Dispersers

May I draw attention to an erroneous statement in the article "Radar Pulse Compression" (May issue) by Brian Wyndham referring indirectly to Marconi monolithic diffraction delay lines?

The statement beginning at the bottom of column one on page 123, says that these devices operate 'in the 10kHz to 100kHz range, a region not of particular interest to the radar engineer'. In fact most of our work has been with a sweep of 25MHz centre on 60MHz and work is going on (for R.R.E.) at much higher frequencies. It is entirely for radar.

The precision and linearity of the dispersive characteristic of these diffraction-grating devices is far greater than it is for ultrasonic strip delay lines or any other dispersive device being made at present.

W. S. MORTLEY
Research Division
Marconi Company, Great Baddow, Essex.

The author replies:

I think Mr. Mortley has mis-interpreted the meaning I intended to convey which was to show that ultrasonic dispersers have been designed for use at receiver intermediate frequencies and that others have been designed more specifically for the lower frequency range between 10kHz and 100kHz.

The delay lines to which he refers, operating at 60MHz, would come under the category of those working at receiver intermediate frequencies, and I do, of course, accept his comment on these.

BRIAN A. WYNDHAM

London I.E.A. Exhibition

A selection of the products seen at the recent Olympia show

Given sufficient time and adequate stamina, anyone involved in electronics, either professionally or as a devotee, could not fail to find something of interest at the 1968 International Instruments, Electronics and Automation Exhibition held at London's Olympia from May 13th to 19th. There were nearly 1,000 stands occupying 250,000 sq ft of floor space, and a fair number of the 112,000 visitors must have found that the exercise of trying to cover the whole show was exhausting, to say the least. Some visitors felt that it is a pity, in view of the very diverse interests in this rapidly widening industry of ours, that the show was not arranged in divisions of activity for their convenience. Some of the major company groups were split into separate stands according to their activities and if this trend could be extended to the exhibition as a whole, the professional engineer at any rate, who usually has a specialized interest, would have the opportunity of concentrating his attention on one or two sections of the exhibition, in much greater comfort.

Since electronics is increasingly playing a part in all manufacturing processes it became necessary to import large pieces of machinery to the exhibition in order to show automation at work. Where this was not done, demonstrations of a frivolous nature were sometimes employed making it difficult to appreciate the real purpose of the equipment.

Although not specifically a components show, several manufacturers of discrete devices were exhibiting. The production of active and passive components is now the work of the physicist and metallurgist with diffusion techniques and thick film deposits replacing coil winding and capacitor manufacture. The sight of a relay with its mechanical switching and comparative greed for operating power seemed almost like looking at a museum piece after studying, through a microscope, complete multi-stage circuits on a silicon chip only a few millimetres square.

Another feature which the visitor could not help noticing was that every measuring instrument worthy of being labelled up-to-date must seemingly be provided with a digital readout. Even the analogue scale of the ordinary service testmeter has its days numbered it seems, and with it must go the conventional car speedometer. Both of these items were to be seen in a digital version. That the exhibition was a success has been agreed by the organizers and exhibitors and although it was not expected that sales would be made "over the counter" it was revealed that several million pounds worth of orders had been placed directly. Records were broken in terms of numbers visiting the exhibition, including nearly 10,000 from overseas.

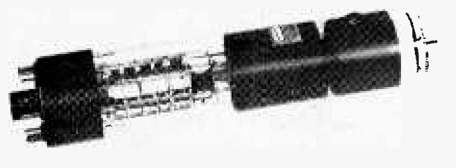
Although no attempt has been made to report on the whole of the exhibition, and large custom-built type systems have been excluded because of their very specialized interest, brief descriptions are given in the following pages of some of the newer items and those of a unique nature.

Alpha-numeric Video Waveform generator

An evacuated glass envelope, 283mm long and 57mm in diameter, containing an electron gun at one end and 64 alpha-numeric characters printed on an 8 × 8 matrix on a target at the other end are the principal components of this alpha-numeric-video waveform generator. Manufactured by Thorn-AEI under the Brimar banner and called the Monoscope, the tube (type V3119) is the forerunner of a family of such devices that will be released in the future. The target is held at a potential of some 1.2kV and is scanned by an electrostatically deflected and focused electron beam. The raster is arranged so that it is just large enough to cover one character. Other deflection voltages allow this miniature raster to be positioned over any desired character in the matrix in a non-sequential fashion, i.e. random access. In close proximity to the target there is a cylindrical electrode called the collector that is held at a slightly higher voltage than the target; the potential difference between the two electrodes is about 3V. The electron beam in scanning the required character releases secondary emission electrons that are attracted to the collector. The secondary emission from the printed character is lower than that from the surrounding target surface; consequently, when the electron beam is actually directed on to part of the character, the target current falls. The target current change is converted into a voltage change across a load resistor giving a video output voltage corresponding to the character being scanned. The tube plugs into a B144 base; the collector connection is made via a CT7 side contact and the target is made off to a top cap. To produce the character raster the Y plates require 9V and the X plates 6.5V; to scan the extremities of the matrix the voltages required are 90V Y and 55V X. The tube, which has a standard 6.3V, 0.3A heater, provides a typical peak video output of 5 μA. Thorn-AEI Radio Valves and Tubes Ltd., 7 Soho Square, London W.1.

WW 369 for further details

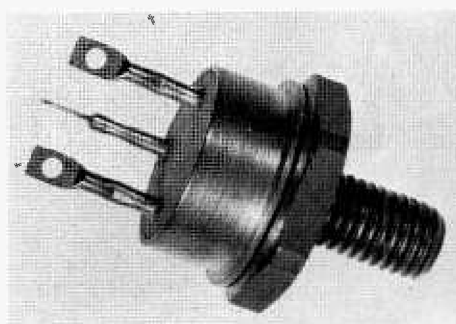
Video waveform generator



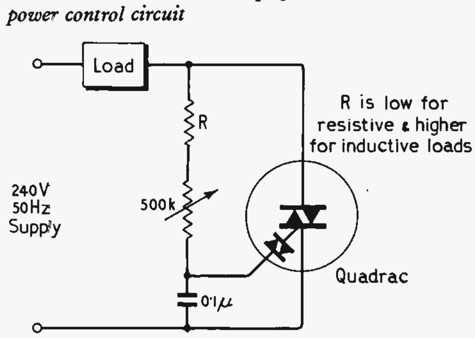
Economical A.C. Power Control

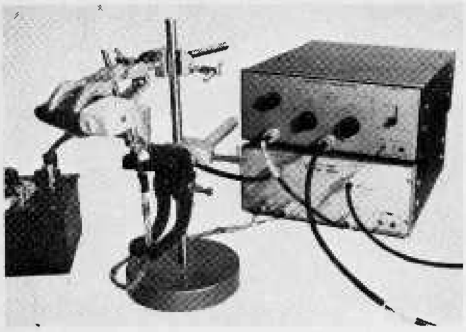
The s.c.r. and triac are well known, but less well known is the Quadrac. This unit is an a.c. switch (triac) with a built in triggering diode. Made by Electronic Control Corporation of America and marketed in England by Claude Lyons Ltd., these units can control very large alternating currents at 240V, 50Hz with the simplest circuitry. The basic control circuit is shown in the diagram. The case of each Quadrac is electrically isolated, eliminating a number of mounting problems. Two types are available—swedge mounting (press fit) and T0-3 mounting. Devices are available for controlling 40A at 200-700V and these are housed in an isolated case with stud. Quadracs are also sold as triacs i.e. without the trigger diode. The price list starts at £2 9s 8d (for one off). Claude Lyons Ltd., Valley Works, Hoddesdon, Herts.

WW 377 for further details



This new a.c. unit can be employed in an economical power control circuit





Measuring the heat in a torch beam by coherent detection

Coherent Detection

A range of instruments for the recovery of repetitive signals immersed in noise was show by Brookdeal Electronics, the 400 series. Their phase-sensitive detector type 411 has a frequency coverage of 1Hz to 1MHz without any tuning or adjustment, and it has the ability to recover signals more than 70dB below noise level. Internal time-constants from 1ms to 10s give equivalent bandwidths of 300Hz to 0.03Hz. Gain is 10V d.c. from 1V r.m.s. in-phase input. In the same range, Nanovolt Pre-amplifier type 431 is a low-noise pre-amplifier for use with signals of nanovolt level from low source resistances. It has two switched input configurations giving a noise-match to source resistances from 10Ω to 5kΩ. Its frequency range of 1Hz to 100kHz can be reduced by the use of high- and low-pass filters. The 431 is battery operated (three PP9 batteries) and has a gain of 60dB. An impression of the effectiveness of the nanovolt pre-amplifier was conveyed by a demonstration on the stand where, in conjunction with an experimental nanowatt four-terminal bridge, it was measuring the heat developed in a resistive element when located in the light beam from a small pocket torch. Brookdeal Electronics Ltd., Myron Place, Lewisham, London, S.E.13.

WW 357 for further details

Phasorscope

Direct and continuous visual comparison of two phasors, representing the modulus and phase angle of two test signals compared with a reference, is possible using an equipment produced by Feedback Ltd. The instrument will measure phase and gain in the frequency range 30Hz to 10MHz with a resolution of 2° (phase angle) and 0.5 to 2dB (gain)

The signal generating section of the instrument consists of a three stage, amplitude stabilized *RC* oscillator with four outputs. One of these outputs is amplified to 2.5V r.m.s. and fed to an attenuator with a range of 59dB in 1dB steps; this is the reference signal representing 0°.

The other three oscillator outputs are at 0°, 120° and 240° and are fed into three identical demodulator circuits. Simultaneously the signal to be measured is also fed to these demodulators and each demodulator produces an output proportional to the phase relationship of the reference and measurement signals. These outputs drive deflector coils symmetrically disposed about the neck of a 12cm diameter c.r.t. and the beam is consequently deflected to a point proportional to the magnitude and direction to the sum of the deflection currents and therefore indicates the phase and gain performance of the system being tested with respect to the reference signal. The incoming signal to the demodulators is interrupted at 2Hz by a reed switch, thus giving a repeated beam deflection between the tube centre and the phasor point. Up to two inputs may be fed to the instrument and can be selected by a panel mounted switch or by an internal reed relay operating at 1Hz; this allows a comparison of two test signals to be made instantly. Under these conditions intensity modulation can be applied to one of the input channels, providing a dotted display for identification purposes. A variation on the display allows the two phasor points only to be shown —without return to zero—or with switching between the two phasor points.

Phasorscope from Feedback Ltd.

Significant figures from the published performance data are: frequency range 30Hz to 10MHz in six overlapping bands with a setting accuracy of ±5% and a stability of 1% per 24 hours; output impedances, switch selected, 50, 75 or 600Ω. Feedback Ltd., Crowborough, Sussex.

WW370 for further details

Absolute Position Measurement

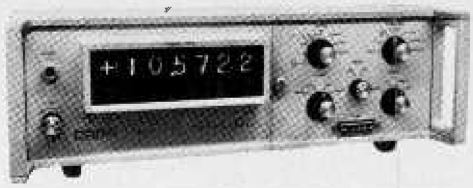
A linear position indicator shown by Moore Reed (Industrial) Ltd., uses an advanced electronic information-processing and logic system to give absolute position (not normally achievable with simple incremental/counting systems). Based on a technique devised at the National Engineering Laboratory, it uses a linear optical scale which moves relative to a fixed photoelectric detecting system. Resolution is 0.001 mm with scale lengths up to 1 metre or 0.0001 in with scale lengths up to 36 inches. Position is indicated digitally on a decimal display and the system includes a means for electrically shifting the datum from which displacement is measured.

The scale carries three optical gratings, of 1000, 100 and 10 lines per inch respectively, and for each of these gratings there is a light source on one side and two photocells on the other side. Each photocell observes the moving grating through a fixed short length of grating of equal pitch, so that as the scale moves the quantity of light incident on the cell varies cyclically. The cells are positioned so that for each grating there are two signals, one displaced 90° in phase relative to the other. (Each cell also has a drift compensating photocell associated with it, so there are in fact four cells for each grating, 12 for the whole scale. These "sine" and "cosine" signals are fed to a resistive matrix to produce five derived signals of different phases, and since each cycle of these signals has two zero-crossing points, there are 10 zero-crossing points spread out in time for each cycle of light-intensity variation and therefore for each grating-line of movement. The zero-crossing points are detected and fed into a logic circuit which identifies 10 unique states, and from these the appropriate signals for the decimal display are obtained. For displacements beyond the range of the coarsest grating (10 lines/inch) the system uses rotary digitizers linked by gears and driven by a rack and pinion from the linear scale. Moore Reed (Industrial) Ltd., Walworth, Andover, Hants.

WW353 for further details

Stable Digital Voltmeter

Exceptional stability is an outstanding feature of a digital voltmeter recently introduced in Britain by Dana Laboratories U.K. The makers give a guarantee that the instrument will remain stable for one year without re-calibration. Known as the



High stability voltmeter

type 5700, the d.v.m. has six-digit resolution and its accuracy is claimed to be ±0.001% of full scale, ±0.0025% of reading. The instrument will measure 1 to 1000 V d.c. and a.c. (both with 10μ V resolution) and also has a millivolt range, 10-1000 mV (with 0.1μ V resolution), and a resistance range of 1-10,000kΩ (with 10mΩ resolution). Noise rejection claimed is normal mode, at least 80dB for 50Hz and above; common mode, at least 150dB for 61Hz and below. Dana Laboratories U.K., Bilton Way, Dallow Road, Luton, Beds.

WW363 for further details

Miniature Pen Recorder

An addition to the range of Rustrak pen recorders supplied by West Instrument Ltd. is a miniature model with 8 recording channels. (Previous

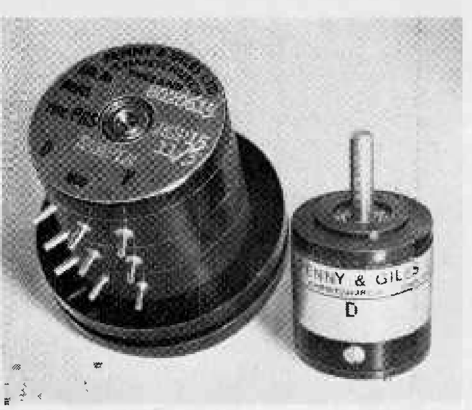
Pen record with 8 channels

models of this size have had only 4 channels.) It is available with 6V, 12V, 24V, or 48V pen actuators, and the chart speed can be up to 46 metres per hour. The charts use pressure-sensitive paper. Response time is 10ms for a full step change of input signal! Size of the instrument is 140mm × 89mm × 114mm (deep). West Instrument Ltd., The Hyde, Lower Bevendean, Brighton 7, Sussex.

WW 364 for further details

Conductive Plastic Potentiometers

Potentiometers for position measurement just introduced by Penny & Giles provide infinite resolution and good reliability by virtue of having elements made of conductive plastic. Standard linear types available have resistance ranges from 500-20,000 ohms (linearity 1.0-0.2%) to 2,000-200,000 ohms (linearity 0.1-0.01%) with a resistance tolerance of ±10%. Power dissipations are, respectively, from 1.2W to 8.0W. Mechanical travel is 360° in all cases. The company will also supply non-linear types, with standard trigonometrical or more complex functions, to special order. These can be made with resistance tolerances graded as required over the length of the track. Taps can be provided, either extremely narrow ones intended to be used as voltage reference



360° rotation potentiometers.

points and introducing minimum disturbance into the output voltage slope, or somewhat thicker, low-resistance, ones for applications where heavy currents have to be drawn. Penny & Giles Rotary Potentiometers Ltd., Mudeford, Christchurch, Hants.
WW 365 for further details.

Logic Systems Simulator

The Farnell Logic Systems Simulator consists of a plinth, a power supply and a range of modules. A manual is supplied which leads students from simple logic functions and an introduction to binary arithmetic, through step-by-step exercises to more advanced logic techniques. A Boolean treatment of most of the problems is given and the appendices contain a section covering Boolean algebra with derivation of identities and De Morgans theorems. Apart from the immediately apparent tutorial value, this system provides a means by which industrial problems may be simulated for trial and analysis. A system design may then be copied from the simulator using industrial components with the sure knowledge of its successful operation on completion.

There are two signal levels used in the system. Logic '1' is −6 volts (tolerance −4 to −7 volts) and logic '0' is 0 volts.

The new range includes half adder, gated binary, decoder, shaper and generator modules and will now allow "full adder", "code conversion", "reversible binary counter", "add-subtract counter", "reversible shift register", "decade counter", and "excess three" experimentation. Individual modules cost between £3 and £5 10s, and the binary to decimal decoder costs £15. Farnell Instruments Ltd., Sandbeck Way, Wetherby, Yorks.
WW 376 for further details

Constant Current Charger

DEAC have produced a charger for use with nickel-cadmium cells which can charge from one to 20 cells, series connected, up to 5Ah capacity. The charging rate is selected by a slide switch and is adjustable over the ranges 0-50mA and 0-500mA. A potentiometer in conjunction with a calibrated meter provides fine adjustment. The circuitry of the charger is safe against short circuit and reverse polarity connection. An automatic timer gives a controlled charging time, so the instrument can be left unattended once the start button has been pressed.

Constant current charger.

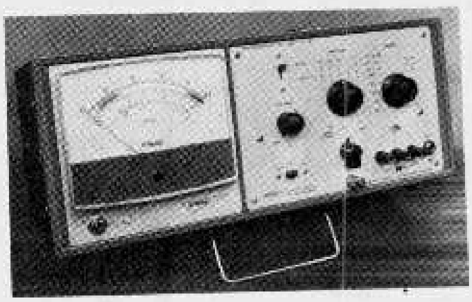
The unit, requiring a 220/240V a.c. 50Hz supply, measures 17.78 × 20.95 × 16.82cm and weighs 2.7kg. The price is £25 ex works. DEAC (Great Britain) Ltd., Hermitage Street, Crewkerne, Somerset.
WW 375 for further details

High-power Battery

Ever Ready now supply five battery types capable of delivering substantial currents without fall-off due to polarization. The HP2 and HP11 are the best known of the 1½V cells (equivalent to the U2 and U11), and there are two smaller cells, HP16 and HP7. A very useful addition to these four is the HP1, a 12V battery for electronic equipment. It measures 13.3×6.8×13.6cm, weighs 1.55 kg and can supply up to 4A. It costs 19s 6d. Ever Ready Co. (Great Britain) Ltd., Ever Ready House, 1255 High Road, Whetstone, London, N.20.
WW 374 for further details

Semiconductor Test Set

The Dymar instrument system is well known and requires little in the way of introduction, suffice to say that it consists of a meter and power supply housed in a case that will accept a wide variety of plug-in units. The latest plug-in unit is a semiconductor test set that will evaluate the main parameters of p-n-p and n-p-n transistors, diodes and zener diodes. Biasing facilities are continuously variable and are monitored on the meter during the setting up procedure. A single switch transfers the meter to the "read" position and then the wanted parameter is indicated on the meter. The d.c. parameters that can be measured are: I_{CO} for bias voltages between 0 and 250V; the meter ranges for this are between 100μA and 10mA f.s.d., and V_{CO} for bias currents of 0 to 40mA, with meter ranges from 10 to 250V f.s.d. The two a.c. parameters accommodated are measured at 1kHz with a collector voltage of 12 and at collector currents of up to 0.5A. They are h_{fe}, with meter ranges between 10 and 100 f.s.d., and R_{IN}, with meter scales from 100Ω to 10kΩ.

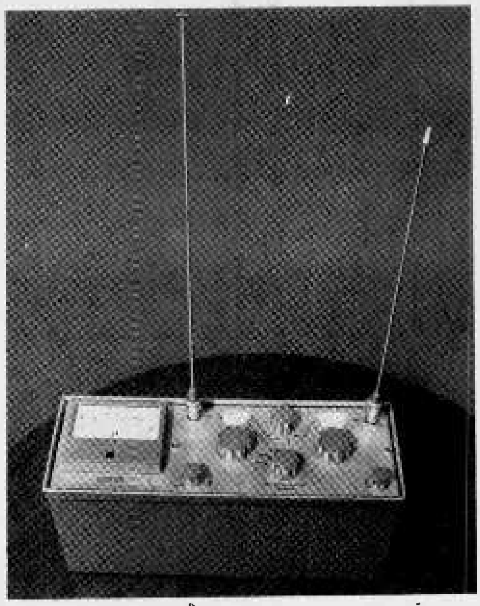


Semiconductor test set.

Zener voltage can be measured up to 250V at bias currents between 0 and 40mA. Dynamic impedance, R_Z, of zener diodes, is evaluated at 1kHz with bias currents of up to 40mA—meter scales 10 to 100Ω f.s.d. Dymar Electronics Ltd., Rembrandt House, Whippendell Road, Watford.
WW372 for further details

Field Strength Meter

Prestel are marketing a field strength meter, Type MC16, which is sensitive to signals from 2.5μV up to 1V. Tuning is continuous on v.h.f. frequencies from 40 up to 230MHz and on u.h.f. from 47 up to 900MHz. There are four measuring ranges, the lowest having a full scale deflection of 100μV. Signal feed is through two asymmetrical coaxial input terminals at 75Ω, but a u.h.f./v.h.f. transformer allows matching to a 300Ω source. The unit is frequency accurate to 2% and a loudspeaker allows for audible detection. Power is supplied by 7×1.5V batteries and this is stabilized by a zener diode. Batteries can be checked on the main meter. Prestel s.r.l., Corso Sempione 48, Milan, Italy.
WW 373 for further details



VHF/UHF field strength meter.

Versatile Microcircuit

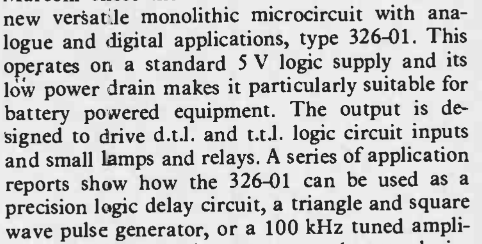
Marconi chose the I.E.A. Exhibition to launch a new versatile monolithic microcircuit with analogue and digital applications, type 326-01. This operates on a standard 5 V logic supply and its low power drain makes it particularly suitable for battery powered equipment. The output is designed to drive d.t.l. and t.t.l. logic circuit inputs and small lamps and relays. A series of application reports show how the 326-01 can be used as a precision logic delay circuit, a triangle and square wave pulse generator, or a 100 kHz tuned amplifier. Available now in TO-5 cans, the new device will shortly be supplied in other encapsulation styles including dual-in-line versions. The price is expected to be £1 15s each for large quantities.

The Marconi Company Ltd., Chelmsford, Essex.
W.W. 351 for further details

Zinc-air Battery

A product of their research in fuel cells made its appearance on the stand of Energy Conversion Ltd. in the shape of a zinc-air primary battery which was the equivalent of a 12 V 25 Ah lead acid battery. In terms of watt-hours per lb weight, however, the zinc-air battery is many times more efficient. Experimental prototype E-17 weighs

Discharge characteristic of zinc-air battery.



A prototype zinc-air battery.

only 1.36 kg and measures 9.5 × 13 × 13.5 cm, and it has a capacity of 24 Ah (to 11 V) at the 15-hour rate. The basic advantage of fuel cells over their secondary-type counterparts is that they require no electrical power source for re-energizing. In the case of the E-17, re-energizing can be achieved quickly and simply by manually replacing the spent anodes with fresh ones, thus greatly extending mission times. Another outstanding advantage of zinc-air batteries is their ability to deliver their store of energy at high discharge currents while maintaining the on-load voltage reasonably steady to within 90% of total discharge. Energy Conversion Ltd., Priestly Road, Basingstoke, Hampshire.

W.W. 350 for further details

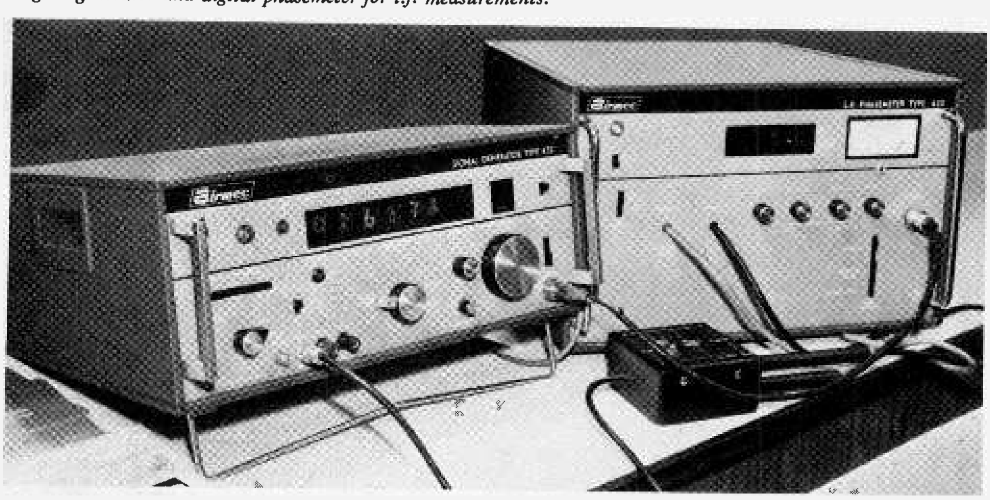
Low-frequency System Testing

Two compatible instruments for making l.f. measurements on such things as servo systems are the Signal Generator type 422 and the Digital Phasemeter type 423, both shown by Airmec Instruments. The signal generator, which provides sine, square and triangular waves, has a frequency range of 0.005Hz to 50kHz in seven decades. The frequency can be changed continuously by a large 'spin' control wheel and is indicated by a 6-digit in-line display. A fine tuning facility allows coverage of ±0.05% of the selected frequency. Accuracy is claimed to be better than 2 parts in 10^5 at the high frequency end of each range (better than 2 in 10^4 at the low end) while frequency stability is said to be better than ±1 part in 10^4 per 30 minutes after warm-up and better than ±1 part in 10^5 per ±10% mains supply change.

The digital phasemeter operates over the same frequency range, giving a 4-digit indication of the phase angle between the zero-crossing points of two signals applied to the high-input-impedence probes (10M Ω, 10pF). Phase range is 0-360°. Input levels can be in the range 100mV – 100V r.m.s., and the level differences between signals for which the phase reading remains unaffected are a 30 : 1 range for ±0.5° accuracy and a 10 : 1 range for ±0.1° accuracy. Airmec Instruments Ltd., High Wycombe, Bucks.

W.W. 367 for further details

Signal generator and digital phasemeter for l.f. measurements.



Smooth Resistance Control

Three versions of a 1 W rating trimming potentiometer with operational advantages over previously available types were shown by Colvern Ltd. Measuring only 11 × 11 × 10 mm, two of the models have printed circuit terminations and the third is for bush mounting, although all three are still under development. Using a resistance element produced by the cermet process, the controls have infinite resolution as distinct from the step function of wire wound types and they can be produced in a resistance range of 100 Ω to 1M Ω. The resistance tolerance at present is ±20% and the contact resistance variation is 3% of resistance value. Angle of effective rotation is 250 deg. Colvern Ltd., Spring Gardens, Romford, Essex.

W.W. 354 for further details

Component Ovens

Uniform performance characteristics over wide range of ambient temperatures for DO-7, TO-5 and TO-18 type semiconductor components are facilitated by a self-regulating component oven only slightly larger than the component itself, shown by Jermyn Industries. The oven, called Klixon, consists of a cylindrical insulated heating element which, in addition to the component leads, has a pair of terminals to supply power to the heating element. Components can be inserted into the oven cavity without the use of special tools and are retained by a plastics cap. A stable thermal environment is maintained by the self-compensating nature of the material used, despite any variations in line voltage. In warming up from −55°C, thermal equilibrium is established in three minutes. Jermyn Industries, Vestry Estate, Sevenoaks, Kent.

W.W. 355 for further details

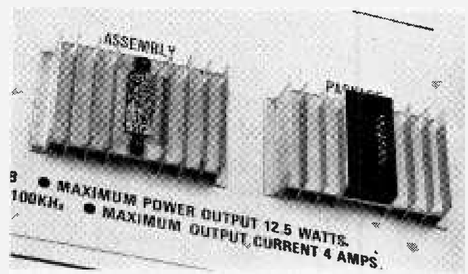
I.C. Voltage Regulator "Diode"

A two-terminal device, the LM103 Regulator Diode, shown by National Semiconductor, is intended to function as a zener diode, but is physically an integrated circuit containing four transistors (one an f.e.t.) and a resistor. The purpose of the circuitry is to produce a sharp breakdown characteristic—and in fact the makers claim that it is ten times sharper than in single-junction zener diodes at low voltages. Operating voltages, V_z, range from 2.4V to 5.6V. For a device in the middle of this range a typical change of reverse breakdown voltage, for 1mA I_C 10mA, is 50mV. Maximum forward current in all types is 100mA and maximum reverse current 20mA; maximum power dissipation is 250mW. The device is encapsulated in an hermetically sealed modified TO-46 can. National Semiconductor, 11-15 Betterton Street, Drury Lane, London W.C.2.

WW 366 for further details

12.5W Thick-film Amplifier

Using a d.c.-coupled circuit with a class B complementary output stage, this amplifier will deliver 12.5W r.m.s. into a 3 Ω load with an r.m.s. input of 70mV. The construction method employed is interesting in that the encapsulated hybrid thick film amplifier is mounted directly on



Welwyn Electric's a.f. amplifier.

to the heat sink, producing a nicely compact unit; the photograph shows the amplifier before and after encapsulation. The generous heat sink dimensions allow operation in ambient temperatures of up to 70°C, although the output has to be derated by 100mW/°C above 25°C. The amplifier may be used with supply voltages of up to −18−0−+18V, if required, this can be derived from a 36V supply. The maximum output power dissipation is given by (V_s)/5R *load*, where V_s is the supply voltage (18V max.).

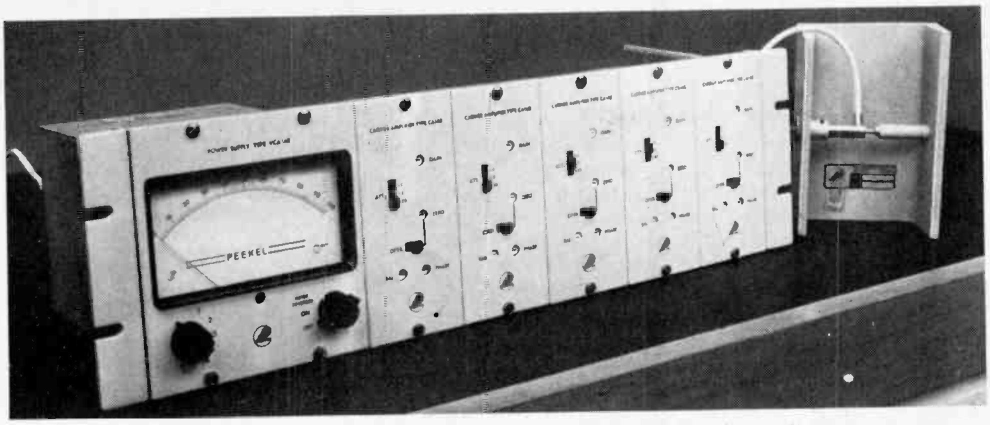
The output of the amplifier is 3dB down at d.c. and 100kHz. Because of this extended frequency response, the amplifier, when used in audio applications, should be operated with a low frequency roll-off to eliminate risk of damage to the load under no-signal conditions because of amplified d.c. offset voltages and low frequency transients. This can easily be achieved with an externally connected 8 μF capacitator which will lift the lower 3dB limit to 20Hz.

The amplifier, which has been designed for audio and servo applications, measures 123.8 × 76.2 × 26.67mm overall and costs in the region of £11 for "one offs". Welwyn Electric Ltd., Bedlington, Northumberland.

WW 361 for further details.

Small-signal Amplifier

A compact transistorized carrier-amplifier, the Peekel CA148, has been specially designed for operation with inductive displacement transducers and supplies a d.c. output voltage. Five of these amplifiers can be plugged into a common power supply chassis, VCA148, which also houses a moving coil meter which can be switched to the output of any of the amplifier modules. A complete assembly of one power unit and five amplifiers is suitable for mounting in a 19-in rack. In operation, a 1 kHz oscillator supplies a voltage to a Wheatstone bridge and the unbalance voltage of the bridge is fed to the carrier-amplifier with symmetrical input via an attenuator. Following amplification and phase-sensitive detection the signal is passed to a d.c. amplifier and finally via a low-pass filter to the output teminals. The bridge supply voltage oscillator can be synchro-



Peekel VCA148 chassis complete with five amplifier modules coupled to demonstration strain gauge.

nized with other CA148 units to prevent beat effects. Gain is continuously adjustable to give a full output of 1 V from inputs of 1 mV to 500 mV (0.02 mm to 10 mm using a Peekel type B60 transducer). Features include phase adjustment of 0.160deg, zero drift ±0.6% per deg C and accuracy 0.5% of full output. Bridge supply voltage is 5 V r.m.s. symmetrical with amplitude stability better than 0.02% per deg C. All outputs may be short-circuited without damage to the equipment. Peekel Laboratorium voor Electronica N.V., Alblasstraat 1, Rotterdam.
W.W. 356 for further details

Universal Bridge

The internal rechargeable battery in the latest bridge from Wayne Kerr (Model 221 Mk III) not

Widerange bridge from Wayne Kerr.

only allows measurements to be made in remote locations but also makes possible measurements on components in equipments connected directly to mains earth. The detector and associated null indicating meter are intended for operation from 50Hz to 30kHz, although measurements with source frequencies of up to 100kHz are possible with reduced discrimination.

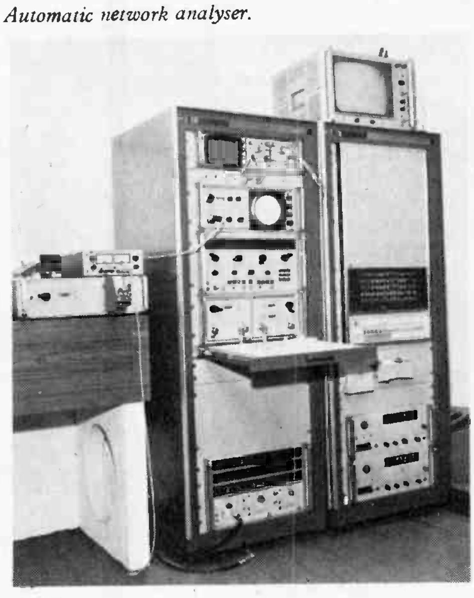
The internal frequency source normally operates at 1592Hz ±1%, thereby simplifying calculations as the angular frequency is 10^4 radians per second. However, 1kHz instruments can be supplied to special order if required.

Measurement ranges are 50μΩ to 50kMΩ, 0.0002pF to 11.1μF, 5nH to 100MH and 0.02nmhos to 111mmhos (+ or −), all to an accuracy of 0.1%. A feature is the provision of an 0.1C and an 0.1G multiplier facility, enabling small loss terms to be measured with accuracy. In addition to measuring resistive and reactive terms simultaneously, of any two-terminal device, third and fourth terminals are available for connection to screened components, lines, filters, etc. If required, long measurement leads can be employed with negligible loss of accuracy. Also a component on a printed circuit board can normally be measured without disconnecting it from its associated circuitry. The company hopes to introduce a low impedance adaptor unit in the near future that will extend the ranges of the instrument to 20μΩ, 2nH and 5F. The Wayne Kerr Co. Ltd., New Malden, Surrey.
WW 360 for further details

Computer-controlled Network Analyser

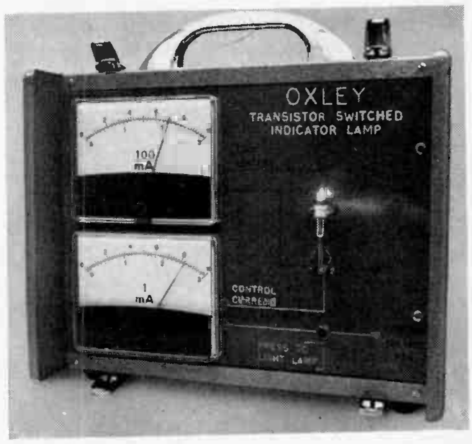
Automation is applied to measurement and calculation in the Automatic Network Analyser, Model 8540A, just introduced into the U.K. by Hewlett Packard. Designed for measuring the transmission and reflection characteristics of devices and networks at frequences from 110MHz to 12.4GHz, it comprises a signal source for applying excitation to the network, a measurement unit basically for measuring signal amplitude and phase at required points in the network, and a small digital computer (with an 8,192-word store) for both controlling the analysing equipment and processing the data obtained from the measurements into the form required by the user. To operate the equipment all that is necessary is to feed into the computer a FOR-TRAN programme for the particular device under test, connect the device to the analyser and press a button to start the measurement procedure. For example, the analyser might be programmed to measure reflection coefficient at a number of frequencies and the computer could calculate from this at each frequency the v.s.w.r., the return loss and the mismatch loss. The frequency range of the signal source is divided into four bands and within each band 1,000 discrete frequencies can be selected; these can be swept through at a rate of 100 frequencies per second. Output data from the analyser can be presented either in analogue form, on a c.r.o. or X-Y plotter, or digitally, for example as a table produced by a teleprinter in a desired format. Measurements that can be performed besides those mentioned include insertion loss, gain, isolation, attenuation, phase shift, phase and amplitude non-linearities, group delay, impedance, admittance, and s, g, h or z parameters. Hewlett Packard Ltd., 224 Bath Road, Slough, Bucks.
WW 368 for further details

Automatic network analyser.



Low-drive Current Indicator Lamp

An indicator lamp that requires approximately only 800μA of drive current was shown by Oxley Developments Co. Ltd., of Priory Park, Ulverston, Lancs. A transistor housed in the base



Low drive-current lamp.

of the unit acts as an impedance converter; the performance of the unit can be judged from the photograph.
WW 362 for further details

50MHz Counter

A general purpose counter useful in the range 20Hz to 50MHz and capable of measuring frequency, period, period average, ratio and time interval, with totalize and scaling functions, has been announced by Racal. The counter, type 815, has three inputs that are brought out to three b.n.c. front panel connectors labelled as channels A, B, and C.

Input channel A has an associated three-position attenuator (0, 20, 40dB) and can accommodate a maximum input of 250V r.m.s. before running into overload and presents an impedance of 1MΩ shunted by 15pF. The d.c.-coupled start channel B and the stop channel C will trigger at ±0.1V to ±100V into 100kΩ at a maximum rate of 10MHz; trigger level, sensitivity and polarity selection controls are provided.

During frequency measurement the input is fed to channel A and the required gate time selected; this can be from 1ms to 10s in decade steps. A self-checking facility is incorporated during which the counter operates at 10MHz for the gate time selected. Period and period average can be measured from d.c. to 10MHz and the number of periods averaged can be selected in decade steps from one to 10^4. In this case the B input is used. The ratio of two frequencies times a multiplier can be found by connecting the higher frequency (up to 50MHz) to channel A and the lower (up to 10MHz) to channel B. The multiplier can be one to 10^4 as selected, again in decade ranges. Start-stop time interval measurement is possible using one channel only or by using a signal on one channel to start the counter and another on a different channel to stop it. In either case the range of the instrument is 0.1μs to 9.9×10^6s. An oscilloscope bright-up pulse is available at the

50MHz counter.

rear of the counter to show the start and finish of the measurement period. In the totalize mode, up to 10^7 events/sec can be handled and the display shows the number of events divided by a pre-scale multiplier which can be from one to 10^4 The scaled output, when in the scaling mode, is available at a b.n.c. rear panel connector; the multiplier again can be from one to 10^4.

The internal timebase operates at 5MHz with a stability of $\pm$ 5 parts in 10^9/°C and an ageing rate of +2 parts in 10^8/day. Six cold cathode tubes provide the readout; the least significant indicator also shows Hz, kHz, MHz, S, μs, etc. Racal Instruments Ltd., Dukes Ride, Crowthorne, Berks.

WW 371 for further details

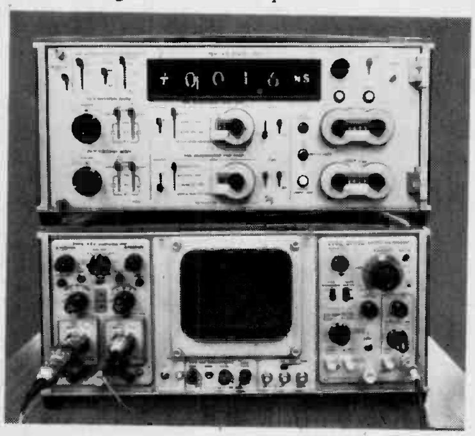
'Scope-Digital Unit Combination

No attempt will be made to go into this Tektronix combination in great detail as the facilities it provides are extremely diverse. It consists of the type 568 oscilloscope and the type 230 digital unit, forming a comprehensive measuring system designed for use in automatic test equipments or as an automatic equipment on its own with a suitable programming unit or as a conventional normally operated bench unit.

The basic oscilloscope unit houses an 8 × 10cm display c.r.t. with a final anode voltage of 3.5kV, an amplitude calibrator and power supply arrangements. This frame accepts all the series two and three X and Y plug-in units. For operation with the digital unit a variety of plug-ins offer Y amplifiers with sensitivities from 5mV/cm to 200mV/cm and risetimes from 0.35μs to 0.7μs. Timebases for use with the digital unit offer sweep ranges from 200ps/cm to 1s/cm.

The type 230 digital unit provides a numerical indication of the information being displayed on the 568 oscilloscope at the rate of up to 50 indications per second. It can be externally programmed and provides outputs in b.c.d. form for subsequent printout or computer analysis. The digital presentations can designate voltage measurements, time-difference measurements between similar pulses and time difference measurements between percentages, or voltages, of pulse amplitudes.

Tektronix digital unit and 'scope.



Time measurements can be made on either of the two oscilloscope channels between points manually or externally programmed by the user or between a point on one channel and a point on the second channel, also programmable.

If desired the beginning and the end of the particular portion of the trace being measured can be delineated by bright-up markers. Upper and lower measurement limits can be set in, and three front panel lights indicate in-limits, above-limits or below-limits each time a particular parameter is measured. An associated rear-mounted socket relays the same information to associated equipment.

Although all the functions of the instrument (and only a few have been mentioned) can be controlled from the front panel, greater flexibility and resolution is possible with external programming. Tektronix U.K. Ltd., Beaverton House, Station Approach, Harpenden, Herts.

WW 359 for further details

F.E.T. Transistor Tester

One of the instruments in a new range of test equipment being shown by Comark was an f.e.t. transistor tester, type 185. This is believed to be the first service instrument of its kind for measuring the static and dynamic characteristics of f.e.ts and m.o.s.ts. It will measure drain cur-

Compact appearance of the Comark f.e.t. tester.

rent from 1 μA to 30 mA in 10 ranges for varying gate and drain voltages and it indicates the pinch-off voltage for any drain voltage in the pinch-off range. Mutual conductance can be measured in 8 ranges from 10 μA/V to 30 mA/V f.s.d., the driving signal being 500 Hz square wave at 100 mV p-p. The polarities of the drain and gate supplies are separately reversible so that both enhancement and depletion f.e.t. and m.o.s.t. of n-channel and p-channel may be tested. Overload protection is incorporated. Three PP4-type batteries provide the drain supply at 2.7mA plus f.e.t. current and three Mallory TM115s supply the gate current. The 185 measures 16 × 13 × 9 cm and weighs 1.1 kgm. Price £50. Comark Electronics Ltd., Gloucester Road, Littlehampton, Sussex.

W.W. 352 for further details

Digital Voltmeter

Digital Systems Ltd have designed their Integrating Voltmeter type 555 to meet the requirement for a low cost instrument of medium accuracy. Three-decade display over the three ranges 5V, 50V and 500V is accurate to less than ±0.4% of full scale. Linearity is given as better than ±0.4% full scale. The meter can be calibrated by

Low cost digital voltmeter.

switching to the internal 5V zener reference source. Zero offset is better than ±1 count. Input terminals are isolated from earth and on balance input impedance is greater than 1 × 10^{10}Ω. Figures given for average off balance impedance are 0.8MΩ at 5V, 8MΩ at 50V and 80MΩ at 500V. Common mode rejection from a.c. 50Hz is better than 60dB. The voltage to be measured charges a capacitor for a fixed time and this charge produces pulses proportional in number to the input voltage. The instrument can be used as a 3 decade counter with external reset. The pulses to be counted are fed into the + and the reset into the − socket. Modern techniques using i.cs have kept the size down to 8½ × 4¼ × 7in and the weight is 5lb 4oz. Power requirements for the unit are 110-120V or 220-250V a.c. 50-60Hz. Digital Systems Ltd., The Square, London, Road, Horndean, Hants.

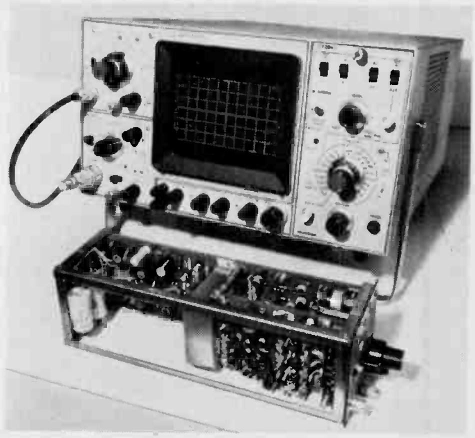
WW 378 for further details

Transistorized Oscilloscope System

Someone at the Solartron factory was overheard to say that the successor to the CD1400 oscilloscope system was twice as good as its predecessor, so it was called the CD2800. This is a frivolous comparison between two instruments which are, in fact, compatible. The new CD2800 which was on display at the exhibition is fully solid state when used with the new modules CX2841 and CX2843 but its main chassis will also accept all the CD 1400 modules. By this means users of the existing CD 1400 can take advantage of the improved display offered by the specially developed dual-beam c.r.t. run at 10kV. The CX2841 Y amplifier incorporates a compact signal delay circuit having good pulse response characteristics. Bandwidth is 25MHz at up to 10mV/cm and 5MHz at 1mV/cm. This sensitivity may be used on both channels simultaneously. Features of the CX2843 timebase enable the leading edge of pulse waveforms to be observed, and transient investigation or photographic recordings to be made by single shot operation. The Solartron Electronic Group Ltd., Farnborough, Hants.

WW 358 for further details

Solartron oscilloscope system CD2800.



Versatile Transistor Voltmeter

A simple but effective a.c. measuring instrument which exploits the theory that current drawn by a class B output pair is proportional to the input signal

*By G. W. Short**

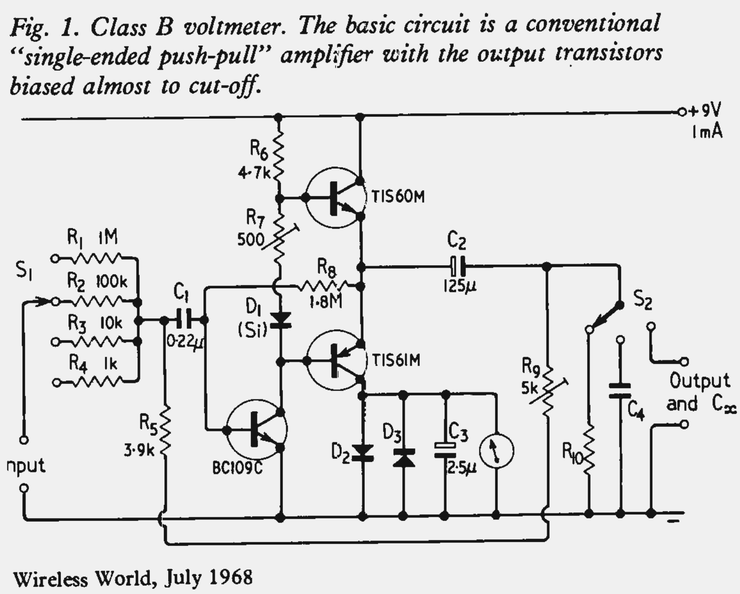
If the quiescent current of a class B output pair is made very small, as it can be with silicon transistors, then a meter connected to read the collector current of one of the output transistors indicates the amplitude of the input signal. Linearity can be made good by applying negative feedback. The transistors do the necessary rectification, so no rectifier diodes are needed, the amplifier can be used as a general-purpose low-power amplifier, and the voltmeter is easily adapted to measure capacitance and frequency. Large output currents are easily obtained, so that robust, inexpensive meters can be used, and the basic circuit is flexible and easy to adapt for meters of different f.s.ds.

Circuit design

Design is perfectly straightforward. Fig. 1 is just a transformerless "single-ended push-pull" amplifier with a few minor modifications, and it is adapted in the same straightforward way. The starting point is the meter f.s.d. current. The meter is driven by the lower transistor of the class B pair, and it registers half the average current delivered to the load resistance R_{10}. The amplifier must therefore be able to deliver a peak current of 2.8 times the meter current if the meter is to be used with sine-wave signals. To be on the safe side, it is advisable to design for greater peak currents, say ten times the meter f.s.d. so that reasonably spiky waveforms can be handled without distortion. This fixes the load resistance R_{10} and this in turn fixes the current in the driver stage, which must be at least equal to the peak base current needed by the output pair. In order to keep gain and linearity high, R_6 should be as large as possible, which implies using high-gain output transistors. The transistors specified have a current gain of 100 or more, and are readily obtainable in complementary matched pairs.

* Amatronix Ltd.

Fig. 1. Class B voltmeter. The basic circuit is a conventional "single-ended push-pull" amplifier with the output transistors biased almost to cut-off.



The driver transistor should also be a high-gain type: the BC109C has a small-signal current gain of around 600. Overall gain is therefore large, and this enables plenty of negative feedback to be applied to stabilize and linearize the voltmeter.

In Fig. 1, feedback is taken via R_5 and the preset R_9, which is the sensitivity adjustment. This is parallel feedback and it has the effect of reducing the input resistance severely. The "voltmeter" is, in fact, a current meter, but it is turned into a voltmeter in the usual way by putting multiplier resistances (R_1-R_4 in Fig. 1) in series. Their value must not be too low, or the feedback will be reduced when the meter is connected: the minimum practical value is 1kΩ as shown. The input resistance of the amplifier is ignored when calculating multiplier values.

Sensitivity and linearity

Experience with the Fig. 1 type of circuit shows that a reasonable compromise between gain and linearity can be obtained by designing for an input current of 100μA r.m.s. In meter jargon, this corresponds to a sensitivity of 10kΩ per volt. This is not particularly high, but it is an easy matter to add a pre-amplifier if needed. The component values in Fig. 1 were chosen to enable the amplifier to be used with a Model 7 Avometer, which has an f.s.d. of 2mA d.c. For this meter current, R_{10} should be 100Ω, but the circuit can be used with other meter f.s.ds over a wide range by choosing a value for R_{10} to suit the meter. The value required goes up with the meter sensitivity; thus a 200-μA meter, which is about the most sensitive which can be used without serious loss of linearity, calls for a load of 1kΩ, and a 20-mA meter, which can just be driven by sine waves without distortion, requires a 10Ω load. The use of a meter with a sensitivity greater than 200μA would necessitate changing other component values as well as R_{10} in order to preserve linearity.

For all these meters, the range multipliers are the same; also the resistance of the meter movement can be ignored unless it is abnormally high. The usual meter movement drops not more than half a volt at f.s.d, and this much is permissible.

Multipliers R_1-R_4 in Fig. 1 give ranges of 100mV to 100V. The error due to non-linearity is about 5% at one-tenth f.s.d. for meters of 1mA and over, and perhaps as much as 10% for the most sensitive meter (200μA). Whether this is negligible depends mainly on the scale length; with a small meter it is usually much less than one scale division.

Linearity is affected somewhat by the setting of the bias adjuster R_7; best results are obtained by setting R_7 so that the meter just begins to indicate current with no input signal. This adjustment can be dispensed with, at the price of a small loss of linearity, by substituting a germanium gold-bonded diode for R_7.

Diodes D_2 and D_3 are included for meter protection, and are selected as described by T. D. Towers.† If desired, protection for the transistors can be provided by a pair of silicon diodes (parallel, reversed polarity-connected) between the left-hand plate of C_1 and the negative rail. R_4 should be adequately rated to pass large overload currents.

Capacitance and frequency measurement

If the amplifier is given a capacitive load the meter current becomes frequency-dependent. With S_2 in the mid-position, a suitable capacitance C_4 is switched in place of the load resistance and the meter becomes a frequency meter when driven by signals of constant amplitude and waveform. By the same token, the meter can be made to indicate capacitance by applying a fixed frequency and connecting the unknown capacitance across the output terminals (S_2 in right-hand position).

Strictly speaking, the negative feedback should be disconnected for these measurements, but leaving it in makes setting-up easier at the cost of wasting the first tenth of the meter scale. For frequency measurement, select a value for C_4 which gives an impedance equal to R_{10} at a convenient full-scale frequency. The meter is then a linear frequency meter to this scale, if it is first of all set up by switching S_2 to the "voltmeter" (left-hand) position and sufficient signal of the unknown frequency is applied to produce full-scale deflection.

For capacitance measurement, select a frequency which gives full-scale deflection for some convenient capacitance such as 1μF, set up as before, and then connect the unknown capacitance with S_2 in the right-hand position. For these measurements the range multipliers may be used in the usual way to facilitate setting up. For frequency range-setting it is necessary to change C_4 for each range.

It may be convenient to bear in mind capacitance measurement when selecting R_{10}. If, for example, one has a convenient 1000-Hz fixed-frequency source, the temptation to make R_{10} 159Ω will be overwhelming. (The reactance of 1μF is 159Ω at 1kHz.)

The meter can be used at frequencies of 10Hz to at least 100kHz, with good accuracy, and with a compact layout is usable as a voltmeter up to about 2MHz.

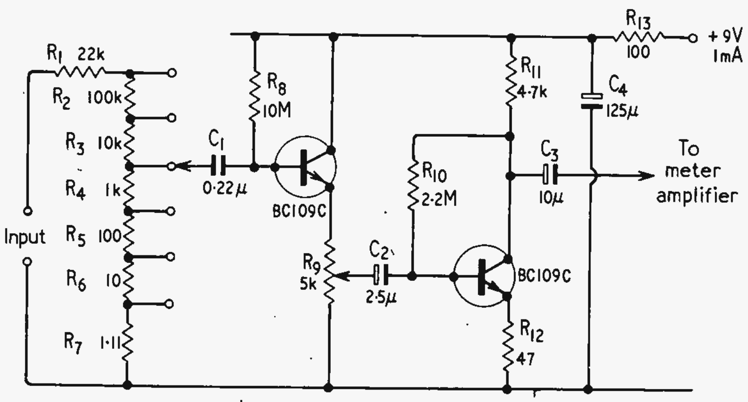
Pre-amplifier

The simple pre-amplifier of Fig. 2 raises the sensitivity to 10mV and presents a constant input impedance of about 100kΩ on all ranges. Useful bandwith is, however, reduced to about 100kHz. Input resistance R_1 protects against overload: the bandwidth is slightly increased without it. The 5kΩ potentiometer R_9 is an optional "extra", but is useful for keeping the needle near full scale when making adjustments which call for finding a maximum. It may also be calibrated for use as an auxiliary range multiplier.

Range multipliers on the main amplifier are, of course, omitted when a pre-amplifier is used. The input resistance of the pre-amplifier can be raised to 600kΩ, with slight loss of accuracy on the second step of the input attenuator (100mV range), by changing R_2, R_3, etc., to 560kΩ, 56kΩ, etc. Higher impedances than this call for a different type of input stage; the choice lies between a compound emitter-follower and a field-effect transistor. At the present time the available f.e.ts are so easily destroyed by overload that ordinary bipolar transistors are preferable.

†"Protecting Meters With Semiconductors," by T. D. Towers, *Wireless World*, April 1968, p. 79.

Fig. 2. Pre-amplifier for 10mV maximum sensitivity.



Liquid Crystal Applications

Devices based on liquid crystals can be employed in all manner of readout applications and could eventually challenge the c.r.t. in television applications. This has become clear as a result of work carried out in the R.C.A. Laboratories in America.

Liquid crystals are organic compounds whose appearance and mechanical properties are those of a liquid, but whose molecules tend to form into large orderly arrays very similar to those that make up such solid crystals as mica, quartz and diamonds.

Experiment has shown that certain liquid crystals can be made opalescent and reflecting by applying a voltage. The temperature range over which this occurs is normally limited to a few degrees at high temperature, but this narrow range can be expanded from below freezing to 100°C as a result of work carried out.

To form a readout component, a sandwich is formed of two clear glass plates separated by a thin layer of clear liquid crystal material. A reflecting and conductive coating is deposited on the inside face of one plate, in contact with the liquid. On the inside face of the other plate a transparent electrically conductive coating of tin oxide is deposited.

When a voltage is applied between the two conductive coatings the liquid crystal takes on the appearance of frosted glass, due to the molecular disruption that occurs. The coatings have the shape of the pattern it is desired to display, or, for moving applications, the coating can be in the form of a matrix. An advantage of this method of display is that the brighter the ambient lighting the more light is reflected from the displayed character. For applications in the dark the display can be edge-lit by a small lamp.

When liquid crystals in their normal form are subjected to temperature they scatter light in much the same way as a solid crystal.

This scattering produces vivid colour changes, from one end of the spectrum to the other whenever the crystals are subjected to temperature changes. This arises from a shift in the normal arrangement of the liquid's molecules and is not permanent. The response can be very sensitive as 0.1°C change can cause the liquid crystals to go through their complete colour sequence.

Liquid crystals have been exploited by Westinghouse Electric International Company for checking the operation of integrated circuits and transistors and for non-destructive testing in general. The materials are simply sprayed or painted on a surface where their colours show the temperature profile and pin-point the location of hot-spots in electronic devices and cracks in metal structures, poor bonding between materials and the like. The liquids are available under the name Spectratherm and have a response range from red to violet of one degree Fahrenheit up to 90 degrees. The ranges begin at any temperature between five degrees below zero (F) and 480 degrees above.

Book and Breadboard Learning

An efficient method for individual education in electronics

by R. Forsthuber, Dipl.Ing., M.I.E.E. and J. Kirk*, M.I.E.E.*

Electronics, one of the fastest growing industries, requires more and more staff, both skilled and unskilled. This demand is all the more urgent when taking into account the other industries which are dependent upon electronic application. With industry itself being short of qualified engineers it is not strange to find that there is a shortage of science teachers, and this gives rise to overcrowded classes, making it difficult to arrange the essential laboratory practice. Also, the laboratories in many schools, catering as they do for the total range of science subjects, are not equipped to provide the facilities necessary to interest and encourage students in electronics.

The writers are responsible for a course, Practronics, which they have developed to aid the study of electricity and electronics. The system is designed to bring the study of these subjects within the range of any school or college.

The System

The system is based on making any table or desk suitable as a laboratory position and to free experiments from the necessity of a mains source. A series of loose-leaf books, a battery-operated laboratory test-set, electronic components and a transparent plastic matrix form the elements of the system.

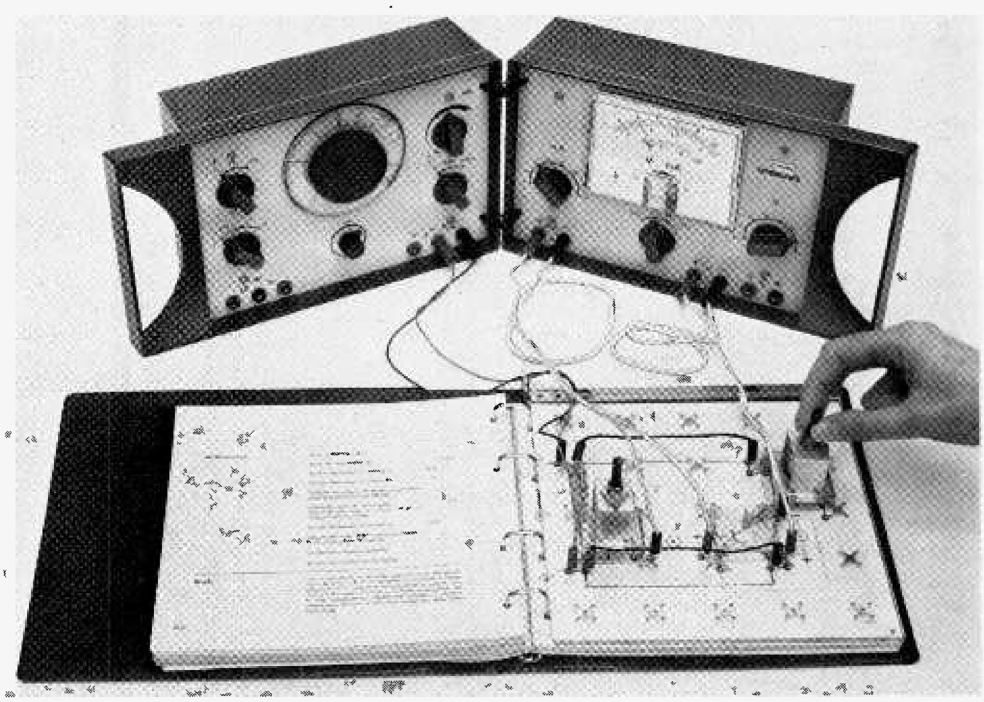
The main idea of the course is discovery. The student is guided through an experiment and, from the analysis of his results, comes to understand theoretical reasoning related to the experiment. Thus the interest of the student is fostered and maintained whilst he learns.

The books carry the information whether this be detailed experimental procedure, the theory, or the tests and problems used to consolidate a student's learning. The transparent matrix can be clipped on to any of the books and is hinged to permit the free-turning of the pages. The electrical and electronic components can be plugged into the matrix to make up any desired circuit configuration. The test-set can be connected to these circuits to provide the student with the normal laboratory facilities.

In practice a student would open the relevant book and begin reading. When it is necessary to do an experiment he would take his transparent matrix and clip it on to the book. The circuit diagram on the page can then be turned into a working circuit by plugging the components into the matrix, the positions of the components being seen to correspond exactly with those on the circuit diagram.

Having built up the circuit the student would then follow the experimental procedure which is detailed on the opposite page. When it is necessary to turn a page the matrix can be lifted, the page turned and the matrix lowered on to the next page. If any change of circuitry is needed this is shown by the use of red lines in the circuit diagrams. The student is guided in a step by step procedure, and at all times he is made aware of the tolerances of his measurements taking into account the tolerances of the components and his laboratory equipment. He is shown how to tabulate measurements and having completed the experiment the results are analysed, and from that analysis the student will draw the conclusions of his experiment. The conclusions demonstrate the significance of the law, theorem or application which is being examined.

An experiment in progress.



The Battery-Operated Laboratory Test-Set

To make any desk top into an "electronics" laboratory the design of the test-set is very important. The laboratory test-set for Practronics contains the following sources and measuring apparatus:

(a) A constant and variable voltage source 0-10 volts.
or A constant and variable current source 0.5mA-2mA.
or A constant and variable current source 4mA-20mA.
(b) A battery source 6V (internal resistance 300 ohms).
(c) A milliammeter 100μA to 300mA in 8 ranges.
(d) A d.c. voltmeter 100mV to 30V in 6 ranges.
(e) An a.c. electronic millivoltmeter 10mV -30V in 8 ranges.
(f) A sine-wave oscillator; 20Hz-20kHz in 3 ranges.
(g) A square-wave generator; 20Hz-20kHz in 3 ranges.

These 7 instruments are combined in the

*Education Dept., N. V. Philips, Eindhoven.

two halves of the test-set. The outputs of the supply and frequency sources, together with the inputs to the measuring apparatus, are all accessible and can be programmed separately on the matrix when the circuit is being built up. Not having to change measuring leads from one point of the circuit to another ensures that the student's full concentration is given to the actual experiment. If the student has to change from the measurement of milliamps to volts or vice-versa, he merely turns a switch.

To build up the student's confidence and develop initiative, problems are given to him both in the form of programmed questions and in the form of circuits to build up. These circuits are not detailed in the same way as the laid down experiments. The student has to use his own initiative to construct the circuit desired. During the course the student builds up a knowledge of experimental practice and to consolidate this, less and less general information is given. This is part of the planned programme of getting the student to fully understand the uses of test apparatus and experimental procedures. The first five books of the course deal with fundamental electricity and the basic theory and applications of semiconductors. Soon two books will be included on integrated circuits.

The Advantages of The System

These can be summed up as follows.

The use of the book as the information carrier gives the best possible opportunity of using colour printing to convey information.

The laboratory test-set is battery-operated and compact; making any desk suitable for use.

The tolerances of the components used in the first part of the course, dc and ac networks, are 1% in the case of the resistors and 2% in the case of capacitors and inductors. This ensures that the results of the experiments will match the theoretical study of the law or theorem. In the study of semi-conductors the tolerances of the components revert to the normal standard ranges. This ensures that the student comes to appreciate the type of component, the standard ranges of components and their use in actual circuitry.

In this way the system allows the student to cover a much greater range of a syllabus than would be possible with the more accepted method of theoretical lectures followed by laboratory work. It is possible that with students realising how interesting the science of electronics can be, more students will take up electronics as a career.

The use of the laboratory test-set ensures that the student will come to appreciate the value of measurement and will be more ready to use the normal measuring instruments which he will find in his work in later years.

The course is not tailored to any specific syllabus but as the books are of a loose-leaf nature a teacher can add pages for which his particular programme may call.

The authors, one a development engineer, the other a technical educationalist, do not claim that the system is perfect, but with this individual learning approach they hope that their ideas will stimulate a greater interest in the study of electronics.

Magnetically-Sensitive Diode

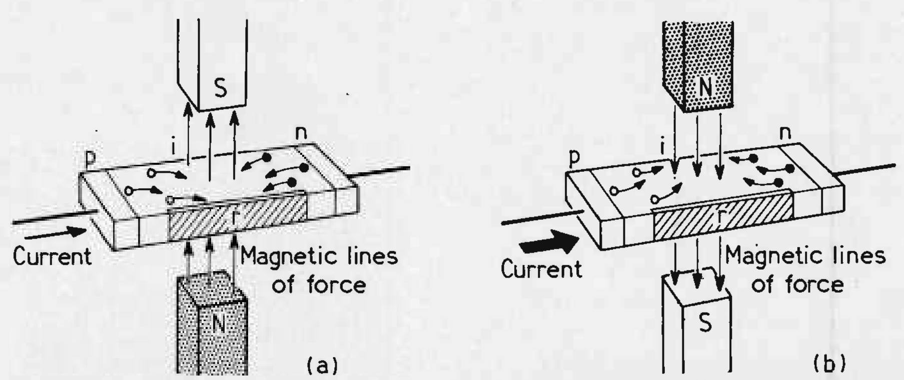
An entirely new semiconductor device, highly sensitive to external magnetic fields which can be used to control the flow of current through the device, has recently been announced by the Sony Corporation, Tokyo. The new device, called the Sony Magnetodiode (SMD) is claimed to have 100 to 1,000 times greater sensitivity, and lower cost potential, than the currently available Hall* elements.

New possibilities of application in magnetically activated control systems have been opened up by incorporating the SMD principle into magnetosensitive transistors and various switch elements. At a demonstration in Tokyo, some practical applications included SMDs as magnetic detectors, proximity switches, non-contact switches and non-wearing volume controls. They were also specified for use in the electric-powered car of the future. The basic structure of an SMD is a rectangular strip-shaped body of substantially intrinsic semiconductor, with low carrier concentration which can be appreciably modulated by injection. Two small regions at either end contain high concentrations of acceptors and donors to facilitate efficient injection into the semiconductor region, the distance between these regions being several times larger than the ambipolar diffusion length. A third region formed into the bulk of the device forms a zone where recombination of the electrons and holes occurs more rapidly than in the remainder of the semiconductor region. The effect of an applied magnetic field on the SMD is indicated in the diagram. It can be seen in (A) that if the field is applied in one direction, the effect is a reduction of current through the device, and in (B), if the field is reversed, the current flow increases.

*Hall element: A magnetic sensitive semiconductor device invented by Dr. Hall (U.S.A.)

The magnetosensitivity of the SMD is explained as being due to the change in the mean effective lifetime of the injected carriers, resulting from their travelling paths being deflected by the applied magnetic field. It is known that the double injection current which flows in a forward biased long p-i-n structure is an increasing function of the effective lifetime for a given bias voltage. When a magnetic field H+ is applied, the paths of injected electrons and holes are both deflected towards the *r* zone, where they will more readily re-combine and cause a sharp decrease of the mean lifetime. This simulates an increase of diode resistance. Conversely, when a magnetic field H− is applied, the injected carriers are deflected away from the *r* zone. Thus the mean lifetime is prolonged and the current will increase, simulating decreased resistance. SMDs are made of a substantially intrinsic germanium strip of approximately 3 × 0.6 × 0.4mm.

The effective "conductivity" of the diode under the influence of an external magnetic field is poor when the lines of force are travelling in one direction (a), and good when the field is reversed (b).



Seen at Hanover Fair

Tuning diodes: press-button mechanisms: novel e.h.t. unit: aerial rotator: distribution amplifiers: 3-D oscilloscope: colour test gear

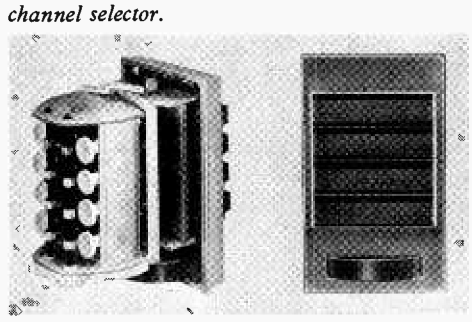
Predominantly an exhibition of home produced equipment, the international appeal of the 1968 Hanover Fair (April 27th-May 5th) had grown to the extent of attracting over 1,000 foreign exhibitors from more than 30 countries. There was a modest sprinkling of British companies in the electronics section plus a purely British group of companies exhibiting collectively in the British Electronics Centre. The electronics section, embracing domestic, commercial and industrial fields, was housed in three pavilions, two of which were two-storey buildings. Something like 1240 stands were in this section (compared with about 950 at the I.E.A. exhibition) and from these a few items have been selected for description, representing a very small part of the overwhelming amount of interesting equipment on display. British products, however, have been deliberately omitted from this survey of the Fair since these are adequately covered by the report in this issue of the I.E.A. exhibition in London, which followed closely afterwards.

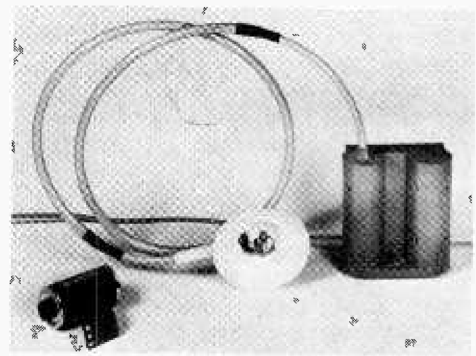
Varicap tuning diodes are becoming commonplace in German transistor television tuner units. Hopt of Rottweil were showing a u.h.f. tuner which measures 75 x 49.5cm and is designed with a twin-circuit tuned bandpass filter coupling the r.f. and self-oscillating mixer stages. The tuner is suitable for use in other countries with similar transmission characteristics and it has a top input frequency of 890MHz. All connecting tags are brought out on one side making it possible for the unit to be soldered directly to a printed circuit. A complementary v.h.f. tuner, which is also tuned by capacitance diodes, measures 77 x 60cm and uses switching diodes for electronic band switching. It has two tuned circuits and at the emitter of the mixer transistor is a contact point for the connection of a u.h.f. tuner. Like its u.h.f. counterpart the v.h.f. tuner can be soldered directly to a printed circuit and both tuners can be connected mechanically to provide a combined v.h.f./u.h.f. unit. On v.h.f. the signal is applied via a high-pass filter to an earthed-base r.f. transistor then via double-tuned bandpass coupling to the mixer transistor. The mixing stage is used as an additional i.f. stage on u.h.f. A separate oscillator is coupled to the mixer capacitively on Band III and combined capacitive/inductive on Band I. On u.h.f., signals are applied via a wideband input circuit which is tuned by the earthed-base connection, and a twin-tuned filter couples the output of the r.f. amplifier to the mixer stage. Signals from the u.h.f. tuner at i.f. are coupled to the v.h.f. mixer transistor via a switching diode. The combined tuner unit covers 470—790MHz (oscillator frequency high) and Bands I and III.

A new tuner unit, displayed by Telefunken of Frankfurt, is diode-tuned also and employs five transistors and six tuning diodes, but in this model the v.h.f. band switching is performed by means of a mechanical slide switch.

The introduction of variable-capacitance tuning diodes has led to the development of more compact preset tuning devices, since a change of channels in tuners using tuning diodes involves only a change of resistance value to vary the voltage across the diode. Two tuning mechanisms for use with varicap diodes were shown by Hopt. The first of these comprises six press-buttons mounted in-line together with six variable potentiometers, one for each press-button. Fine tuning is performed by rotating a seventh larger control which adjusts the potentiometer associated with the depressed button. Once set, the potentiometer does not require readjustment on changing channels. Projections moulded in a staggered formation round the outside of the press-button stem operate a metal bar which can be coupled to a band switch. The amount by which the band switch bar is moved depends on the position to which the press-button key is rotated (i.e., which moulded projection is selected) so that when the press-button key is rotated to the band required, the band and channel selection is carried out by a single press operation. The whole unit measures about 15 x 10cm including a cylindrical indicator scale. The second example is physically smaller and comprises four horizontal rocker-type switches which operate in both switch positions thus providing pre-selection of eight channels. Fine tuning is effected by an edge-type control mounted below the rocker switches which adjusts the selected potentiometer. The makers recommend that this switch unit is particularly suitable for receivers operating on two different standards because the rocker switches can be set so that the alternative standards are each set on one side only. Reset accuracy is said to be 150-200kHz.

Rear and front views of the Hopt 8-way TV channel selector.



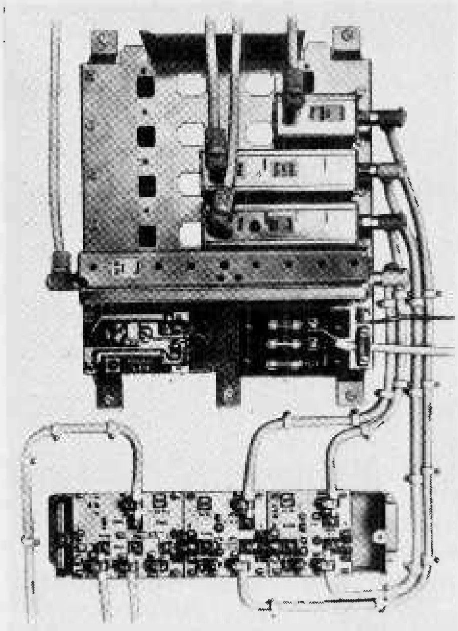


Telefunken's e.h.t. unit for colour receivers compared with a 35mm film cassette.

Varicap diode tuning, according to one British manufacturer, has not been generally adopted in this country because owing to our particular television channel frequency structure it has been recommended by B.R.E.M.A. that image channel rejection should be at least 53dB and preferably 60-63dB. This figure can only be achieved by the use of three tuned signal circuits which would require the use of four diodes (including the oscillator tuned circuit). In Germany where image rejection requirements are not so critical (40dB or less), two tuned circuits are employed involving the use of three varicap diodes in the tuner. It has been pointed out that varicap diodes are not perfect capacitors and that they have a loss factor which increases with frequency. Diodes which obey the same circuit law with a change in voltage have to be selected and any losses which are present are multiplied each time an extra tuned circuit is added, so that in practice it is possible for a three-tuned-circuit tuner using varicap diodes to have a lower Q than one which uses two tuned circuits.

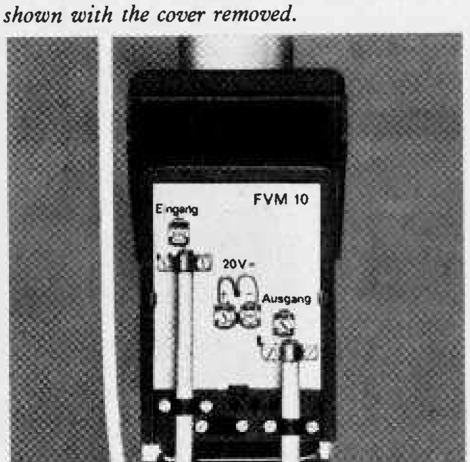
It is generally expected that colour television receivers will become cheaper in time and one significant contributory factor will be the simplification of the circuit design. A new e.h.t. unit shown by Telefunken is designed to lower the cost of colour receivers by using a solid state voltage multiplier for the 25kV final voltage, and the elimination of the shunt stabilizing triode. Regulation is obtained by the conventional method of adjusting the line output valve grid bias with a feedback voltage obtained from rectified flyback pulses. Dimensions of the assembly are quite modest (73 x 70mm) and maximum current is 1mA. The transformer, whose normal output requirement is 30W, should be used in conjunction with a PL509 line output valve and a PY500 boost diode, and the h.t. voltage should not be less than 280V. The makers are aware that the regulation of their new assembly is inferior to that of the parallel triode method, but in the interest of cost-saving, and in the light of field experience with colour receivers, they believe it is adequate and will be adopted generally for future receivers. This same company is also offering a new reflex delay line type VL2 which operates on the reflection principle as an alternative to the rod delay line. The new delay line dispenses with the wire-wound additional delay line required for the exact adjustment of the nominal delay time but instead is fitted with a bifilar-wound output coil. It has a tolerance of the order of ± 5ns which is a considerable improvement on the previous type (± 60ns).

As one would expect there were no dramatic developments in aerial design, but considerable attention appears to have been given to signal distribution equipment. Robert Bosch, of Berlin, was showing a single wideband aerial amplifier type FVM10 into which signals from separate v.h.f. and u.h.f. television, and v.h.f./f.m. aerials could be fed and from which a single amplified output to the receivers could be taken. The amplifier bandwidth is from 40 to 860MHz and gain is from 12dB (Bands IV and V) to 15dB (Band I). Maximum output voltage is 60mV. Power requirements for the amplifier are 20V at 24mA which can be provided by a matching mains power unit type FNT10 via the coaxial feed cable. Versatile configurations of aerial amplifiers on a larger scale were provided by a range of units exhibited by the firm W.I.S.I., of Niefern, all designed to be plugged into a common mains power chassis. Intended for wall mounting, the power chassis incorporates an isolating transformer with 2000V insulation test, and it provides 12V d.c. with ± 4 per cent stability achieved by the use of a Zener diode and transistor regulator circuitry. The amplifier modules themselves vary in size according to the gain required and they automatically pick up their power supply as they are inserted into the power chassis. Separate input and output cables are used for the amplifier modules followed by a combining/splitter network to feed the programmes to remote receiver positions. So many combinations of programme and gain are possible that a table has been prepared by the makers to assist the user in his selection. As an isolated example: a block of 24 flats could be provided with one v.h.f. channel with an amplifier gain of 32dB, two u.h.f. channels with gains of 50dB and 46dB, plus v.h.f./f.m. with a gain of 34dB. Total cost of the equipment for this installation would be about £102.



Modular aerial distribution amplifier (top), and combining/splitter network, by W.I.S.I.

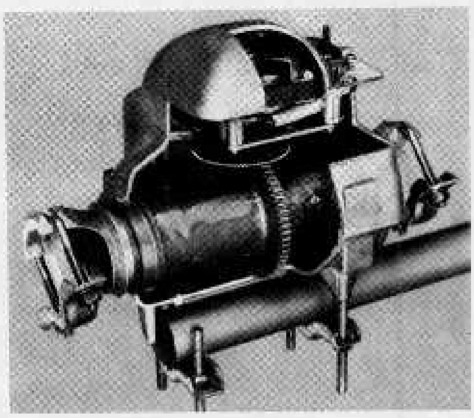
A wideband aerial amplifier by Robert Bosch, shown with the cover removed.



For large u.h.f. aerials with high forward gain the need for careful alignment on the transmitter becomes very important, especially for the reception of colour, since the forward lobe of these aerials is relatively narrow. The greater the gain of the aerial, the more precise does alignment become and in locations where several television transmissions are receivable from different directions this can give rise to receiver aerial siting problems. Fortunately in this country, this difficulty has been avoided in the main by what is known as "co-siting". That is, the main u.h.f. transmitter aerial masts have been designed to carry transmissions from both broadcasting authorities so that all transmissions normally available for a particular locality will be received on u.h.f. aerials permanently pinpointed in one direction.

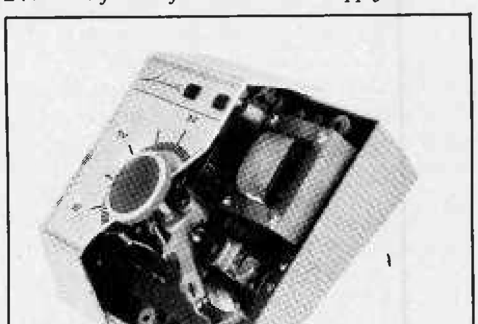
For locations where several television transmissions are available from different directions, the German company Stolle were demonstrating an automatic aerial rotator. This comprises a special aerial mast, mechanically coupled to a small electric motor, and a set-top control box with a single knob and 360 deg scale. The system is so calibrated, that when the control knob is turned, the aerial rotates until it automatically takes up the desired angle indicated on the scale. A neon lamp indicates when rotation is complete. The drive motor operates from 24V via a step-down mains transformer and is sited externally as part of the mast assembly. It is, of course, completely waterproofed. Mains input can be 110V or 220V, 30W. Price of the aerial rotator is about £20.

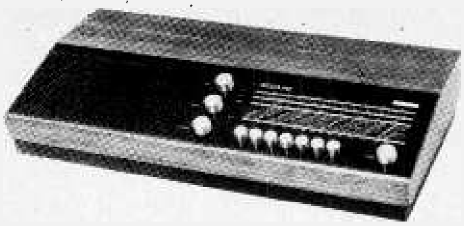
One of the exhibition pavilions was given over to showing products which had earned the German equivalent of the British Design Centre award. In the radio section, this distinction had been achieved by a new range of table radio receivers by Wega, of Fellbach. The cabinets are of unusual design, being constructed in teak and other types of natural wood, measuring 56cm wide by 27cm deep by only 12cm high and presenting an exaggerated long, low appearance. A one-piece scale and loudspeaker grille in a contrasting colour is fitted on the angled front face which slopes very acutely from front to rear (almost flat) which the makers say is just right for modern living. One can read the scale while sitting. This receiver, the Wega 142, employs 9 transistors and 4 diodes and covers the v.h.f./f.m., short-, medium- and



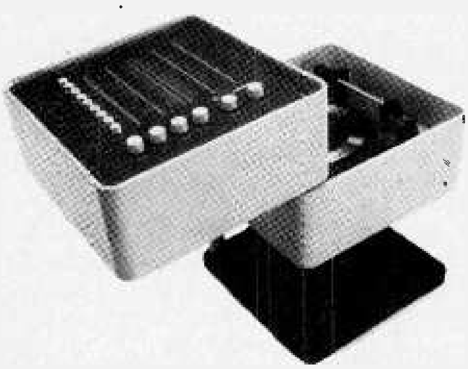
Cut-away diagram of the Stolle aerial rotator mechanism.

Inside the rotator control box can be seen the 24V transformer for drive motor supply.





The award winning design Wega 142 table radio receiver.



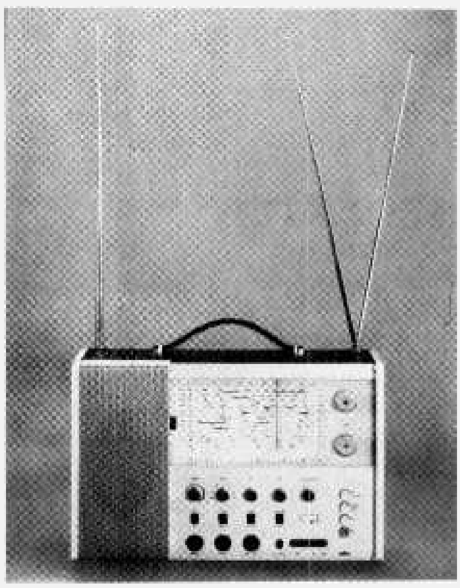
A heavy base provides stability for the swinging units of the Wega stereo system.

long-wave bands, with press-button type band switches. It has an output of 5W which drives a 130 x 260mm loudspeaker. The price is about £34. A compact radiogram, type 3201, in similar styling, is fitted with a stereo record player and provides an output of 2 x 20W. The unconventional styling of Wega products is continued in a stereo music system which consists of two basic units, a record player unit and a tuner/amplifier unit, which they say provides stereo for the individualist. In appearance the system is unusual in that the units are suspended by one corner on a vertical shaft which allows them to be swung round independently for convenience of operation. The cost of this outfit is £188.

Braun, of Frankfurt, were demonstrating what could be described as a portable communications receiver, their model T1000CD Weltempfanger. It operates normally from batteries but it can be fitted with an optional mains unit and it is designed for the reception of speech or c.w. signals on expeditions, in the home or at sea. Reception covers the long-and medium-wave broadcasting bands (100-1600kHz), the intermediate band (1.6-3.5 MHz), and the short-wave broadcasting bands (3.5-30MHz). Also covered are the v.h.f. bands fron 30-250MHz including the f.m. broadcast band (87-108MHz), the amateur bands, plus air and marine navigation transmissions. The TC1000CD is provided with most of the controls and facilities associated with a communications receiver, including variable bandwidth, bandspread tuning, b.f.o., etc. It measures 36 x 25 x 13.5cm and costs about £150. A dozen or so of these receivers at the Fair were arranged in booths for visitors to operate at will. That they were allowed to be handled by all-comers throughout the show period says much for their robustness.

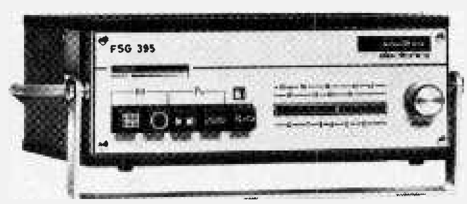
A new servicing instrument being demonstrated by the Nordmende company of Bremen was a colour service generator type FSG395 which for its small size (195 x 80 x 160mm) provides a remarkable range of facilities. It is continuously tunable over the v.h.f. and u.h.f. bands and its basic geometric displays are; crosshatch, vertical lines, horizontal lines and a large circle on a background of dots. In addition, the FSG395 provides a four-colour bar pattern of approximately red, green, yellow and blue representing the four quadrants of the chrominance vector diagram: i.e. (R-Y)90°, -(R-Y) 270°, (B-Y)0° and -(B-Y)180°. Also a grey scale representing the amplitudes of the conventional colour bar pattern. A further facility is the provision of a red raster for purity adjustment. Amplitude of the colour burst signal can be varied for reference generator checks. R.f. output is 20mV on v.h.f. and 3-8mV on u.h.f. and operation is from mains supplies of 110V or 220V. Operational simplicity is achieved by having the display pattern inscribed on the sensibly proportioned function press-puttons. This useful little instrument costs, in Germany, the equivalent of £70.

Users of Tektronix oscilloscopes series 530, 540, 580 can convert their instruments to provide 3-D space forms by the addition of a plug-in adaptor, Model 627, shown by Optical Electronics Inc. on the stand of their German agent Dr.Ing. Nüsslein, of Wedel bei Hamburg. The addition of this unit makes it possible to obtain an oscilloscope-type display in three dimensions which can be viewed from any angle by rotating it with a manual control. The effect of adding a third set of deflection plates is simulated to permit the luminous point to be positioned anywhere within the display *volume*, operating on the principle that if the observer is presented with the retinal images representing a given space scene, then that is the scene he will see. Model 627, which O.E.I. call "Scenadaptor" enables the oscilloscope to generate retinal images corresponding to an arbitrary space display. Solid state circuitry is employed with controllable linear perspective and intensity shading. Operator controls allow for display rotation either continuously or in steps. Three independent deflection input channels are provided; input impedance 1MΩ. Rotation is continuous through 360° in azimuth and three discrete positions in elevation; 0, —15, —30 deg. Polarity reversing switches are provided on all three deflection inputs. Bandwidth is 1Hz to 100kHz in deflection and 60Hz to 100kHz in shading.



Braun's T1000CD communications portable bristles with aerials and controls.

The Nordmende FSG395 colour service generator provides six test patterns.



July Conferences and Exhibitions

Further details are obtainable from the addresses in parentheses

LONDON

July 1–4 — R.H.S. New Hall, S.W.1
Bio-medical Engineering Exhibition
(U.T.P. Exhibitions Ltd., Racquet Court, Fleet St., London E.C.4)

July 17-19 — Whitelands College, S.W.15
Audio Visual Aids Conference
(Nat. Committee for Audio Visual Aids for Education, 33 Queen Anne St., London W.1)

July 29-Aug. 2 — Olympia, W.8
Ship's Gear International Exhibition
(Municipal & Industrial Exhibitions Ltd., 3 Clements Inn, W.C.2)

CAMBRIDGE

July 2-5 — The University
Electronics in the 1970s
(I.E.R.E., 8-9 Bedford Sq., London W.C.1)

July 8-10 — Churchill College
Scanning Electron Microscopy
(I.P.P.S., 47 Belgrave Sq., London S.W.1.)

CANTERBURY

July 8-9 — University of Kent
Optics in Medicine and Biology
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

CARDIFF

July 1-6
Advanced Industrial Measurement and Control
(Exhibitions, Wales & West, Ltd., Holly House, Rhiwdrin, Montgomery)

HARROGATE

July 4 & 5
Technological Forecasting
(B. Taylor, Management Centre, University of Bradford, Emm Lane, Bradford 9)

SWANSEA

July 15-18 — University College
Electrical Contact Phenomena
(I.P.P.S., 47 Belgrave Sq. London S.W.1)

OVERSEAS

July 15-18 — Washington
Design Automation Workshop
(I.E.E.E., 345 E. 47th St., New York, N.Y. 10017)

July 23-25 — Seattle
Electromagnetic Compatibility Symposium
(J. E. Maynard 14589 S.E. 51st St., Bellevue, Washington 98004)

Computing Distortion

Method for low-power transistor amplifiers

by L. B. Arguimbau and D. M. Fanger**

Unlike those of thermionic valves, the non-linearities in junction transistors for low collector currents are highly uniform and predictable, differing hardly at all from one transistor to another. In fact for currents of a milliampere or less the current increases exponentially with voltage:

$$i=i_0\,\epsilon^{(e-e_0)/\gamma} \qquad (1)$$

where i_0 is the collector current for a base-emitter voltage of e_0 and e is the base-emitter voltage. In this equation

$$\gamma=kT/q=0.025 \text{ at } T\approx 290^\circ\text{ K} \qquad (2)$$

where k is Boltzmann's constant, T is the temperature, and q is the electronic charge. If we prefer, eq. (1) can be written

$$e-e_0=\gamma\log_\epsilon\frac{i}{i_0} \qquad (3)$$

It should be noticed that, except for a universal multiplying factor and a direct-voltage bias, the base-emitter voltage needed to change the current by a given ratio is independent of the current magnitude. For currents higher than a milliampere transistors are likely to show a noticeable linear voltage term proportional to current, but this does not contribute to distortion and for most of the present purposes can be neglected.

Distortion produced by the flow of non-linear base current is not readily predictable but can be kept small by using low driver resistance. It is neglected here. We have also neglected any dependence of current on the collector-emitter voltage.

Almost all transistor amplifiers make use of negative feedback in one form or another. In computing distortion in amplifiers involving such feedback we should ask ourselves how much the form of the signal is modified in passing through the amplifier. In the laboratory we answer this question by applying a sinusoidal *input* to the amplifier and measuring the root-mean-square of the harmonics other than the fundamental on the *output*. In practical cases we are interested in this distortion only when the amount is relatively small, perhaps less than five per cent.

At our desks it is much more convenient to ask ourselves by how much the *input* signal must be distorted to produce a sinusoidal output. As long as the percentage distortion is small, the exact nature of the output signal chosen makes very little difference in the answer. In actual practice we are seldom really interested in studying the distortion of a truly sinusoidal signal; rather we are concerned about how much modification is added to a complex spoken or musical waveform. Consequently if the distortion factor is to be meaningful at all it must have the property of not being critically dependent upon the precise form of the waves with which it is measured.

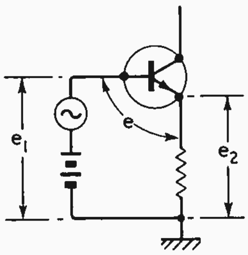


Fig. 1. Rudimentary emitter follower.

These matters can be made more concrete by considering the residual distortion in the emitter follower of Fig. 1. Here

$$e_1=e+e_2=e+iR \qquad (4)$$

We shall set ourselves the problem of computing e_1 for a sinusoidal output when

$$e_2=iR=i_0R\,(1+a\cos\omega t)$$

$$e_1=e+i_0R\,(1+a\cos\omega t) \qquad (5)$$

where a is the fractional variation of current about an average.

We saw earlier in eq. (3) that the base-emitter voltage drop is given by

$$e=e_0+\gamma\log_\epsilon\frac{i}{i_0} \qquad (6)$$

which shows that it is a constant (about 0.6 V for silicon transistors at 1mA), depending on the quiescent current, plus a term $\gamma\log_\epsilon i/i_0$ which changes by γ ($\approx$ 0.025 V) whenever the current changes by a factor of ϵ

The non-linear difference between the output and the input is all contained in the expression

$$e-e_0=\gamma\log_\epsilon(1+a\cos\omega t) \qquad (7)$$

We can find the distortion term by first finding the time average of $e-e_0$ and then the fundamental component. We shall define the instantaneous distortion as the difference between $e-e_0$ and its average and fundamental components.

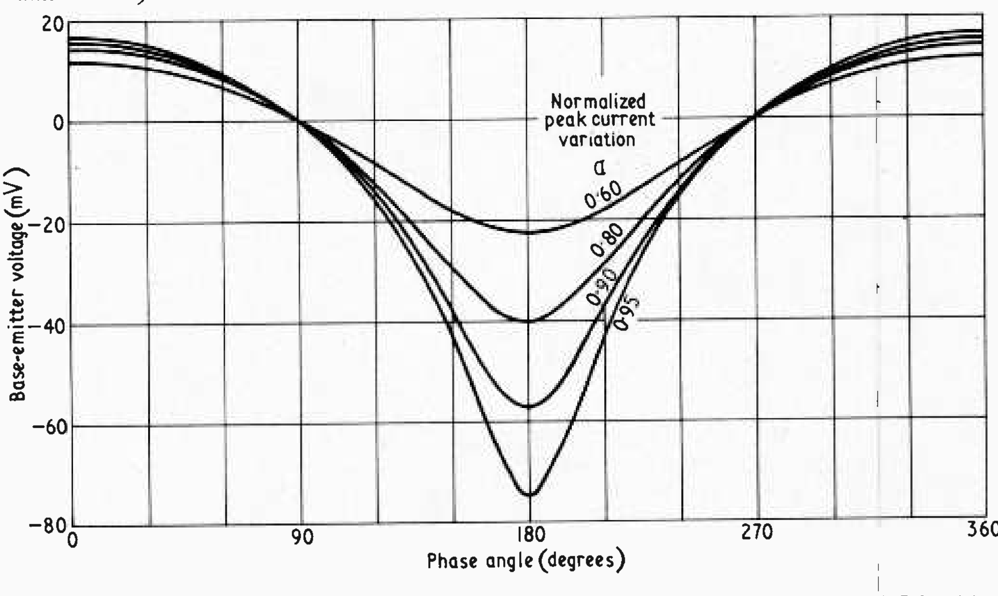
$$d=\gamma\log_\epsilon(1+a\cos\omega t)-\text{Av.}[\gamma\log_\epsilon(1+a\cos\omega t)]-2\,\text{Av.}[\gamma(\cos\omega t)\log_\epsilon(1+a\cos\omega t)]\cos\omega t \qquad (8)$$

Further we shall define the root-mean-square value of this wave as the distortion,

$$\delta=\sqrt{\text{Av.}\,d^2} \qquad (9)$$

All of these quantities lend themselves readily to computer manipulation. We have in fact computed the instantaneous and r.m.s. distortions, d and δ, for a=0.2, 0.4, 0.6, 0.8,

Fig. 2. Base-to-emitter voltage waveform for sinusoidal emitter current. (Voltage taken as zero for unit current.)



*Grason-Stadler Company, U.S.A.

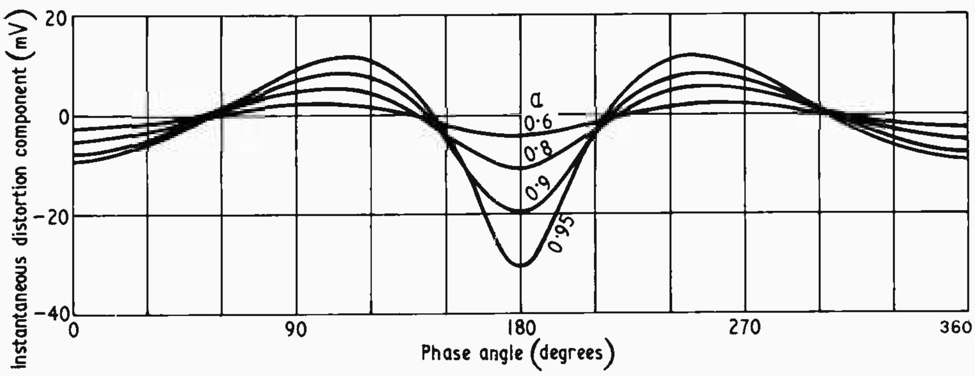


Fig. 3. Instantaneous-total-distortion waveforms. Average and fundamental components have been removed from Fig. 1.

0.85, 0.9 and 0.95, by taking values of the terms in eq. (8) every 5° and averaging them. (For statistical reasons we omitted the value for 180°).

As a check on the results we have also computed them by a series expansion for a values up to 0.8. The two methods agree very closely except for the lowest values of a. There the finite angular spacing chosen in place of true integration made small errors in the fundamental and average components and these resulted in an error of about 20 per cent in the small difference between $e-e_0$ and these components. The curve of Fig. 4 shows the series results for small values, the computer figures for large values of a.

It should be noted that the results come out in millivolts, independent of the current but only depending upon the current ratio, a, a fact that follows automatically from the exponential character of the i-e curve for a transistor junction. The fact that y is a universal constant for all junction transistors makes the result independent of the particular type used.

Fig. 2 is a plot of the actual waveforms of $e-e_0$, the base-emitter voltage, for various values of a. Fig. 3 shows the instantaneous distortion component of these waveforms and Fig. 4 shows the r.m.s. value of this distortion component for various values of a.

It remains to see how these results can be applied.

In the case of an emitter follower such as that in Fig. 1 the difference in voltage between input and output is given by the curves of Fig. 2 *regardless of the numerical value of output voltage.* Thus if the average voltage across R is 6 V and the peak sinusoidal component of voltage across R is 5.4 V, $a=0.9$ and from Fig. 4 we see that the r.m.s. distortion, δ, is 7.4 mV. Hence the distortion factor is $0.0074/(0.707 \times 5.4)=0.00194$ or about 0.2%. Notice again that the distortion voltage itself does not depend upon the value of R or upon the voltages but only on the fractional change in current. Hence the distortion *factor* depends only upon the fractional change in current (its modulation factor if you like) and upon the numerical r.m.s. output.

In case the emitter follower is not directly coupled to the load the fractional modulation of the *total emitter current* must be considered, but the results don't really need a separate treatment if the total current is always kept in mind.

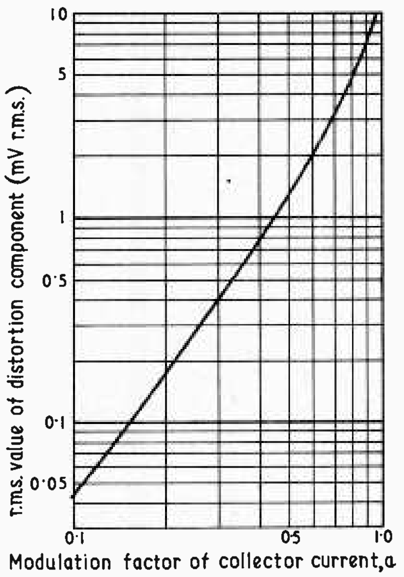


Fig. 4. R.M.S. value of distortion component for various a values.

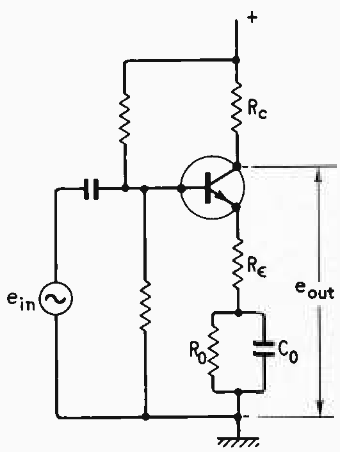


Fig. 5. A simple amplifier stage.

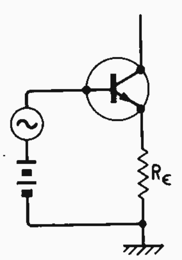


Fig. 6. Emitter-follower corresponding to the amplifier stage in Fig. 5.

In the case of the simple amplifier stage of Fig. 5, the same principles apply. If as before we neglect the effects of base current and of collector-emitter voltage, the alternating output voltage is proportional to $i_\epsilon R_\epsilon$ or to $i_\epsilon R_\epsilon$. Here $i_\epsilon R_\epsilon$ takes the place of iR in the example of the emitter follower and we find the distortion voltage across R_ϵ by looking at the corresponding emitter-follower circuit of Fig. 6, noting the fractional modulation a of the current in R_ϵ, finding the numerical distortion, δ, and comparing this to the r.m.s. signal across R_ϵ. Here we assume an adequate voltage supply so that no negative peak clipping need be considered. We have also direct coupled the output to avoid concern about a.c./d.c. ratios which in this case involve even less worry than in the emitter follower.

In cases involving several amplifier stages and overall feedback, the result may have to be corrected for distortion in earlier stages and for base currents. In any case, the distortion computed as we have for the last stage should be reduced by the appropriate overall feedback factor.

In summary: to achieve low distortion we should keep the fractional modulation of the emitter current comfortably below one and should make the emitter-ground voltage large in comparison to the few millivolts of distortion.

Intelsat Developments

The director of Comsat's Domestic Project Office, Robert Briskman, said in a paper presented at the 1968 I.E.E.E. International Convention and exhibition that the 1000 circuit per satellite capability of Intelsat III satellites will be exceeded shortly. For instance, it is expected that the capacity of the single Atlantic Ocean satellite will be exceeded by as early as 1969. In order to cope with the international demand for communications channels in the network it has been proposed to develop two further satellites that will be known as Intelsat III-½ and Intelsat IV. Intelsat III-½ would be an Intelsat III modified by the addition of larger aerials connected to one of the two spacecraft's transponders which would generate two spot beams of six-degree beam width. It would have almost double the capacity of an Intelsat III.

Intelsat IV would be of new design and over three times the weight of current craft, it would provide in the region of 5000 channels. Whilst on space topics we have heard from the Science Research Council that the third satellite in the Anglo-American space research programme, Ariel III launched on May 5th 1967, has transmitted over 400 million words of data from the five experiments it carries. The satellite was designed and built in Britain, two of the experiments were devised by British Universities, one by the Science Research Council and one by the Meteorological Office.

Technical Notebook

R.F. Power Measurements

The caliometric method of measuring r.f. power has long been in use and consists basically of comparing the heating effect of the r.f. to be measured with that of a d.c. reference in a thermopile or thermocouple. This method is lengthy and it is known that equal amounts of r.f. and d.c. power will not have the same heating effect. Thus an error exists, commonly called the r.f. to d.c. substitution error, which must be evaluated to determine the uncertainty in the power measurement.

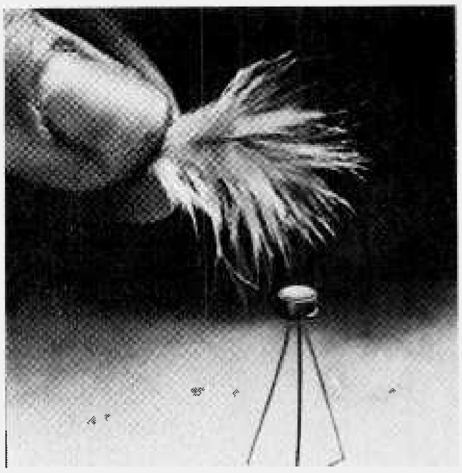
At the National Bureau of Standards Laboratories in America this process has been modified and results in a system capable of determining low r.f. power levels between 10mW to 1W at up to 4GHz with an accuracy better than 0.35%.

The system employs a differential thermopile between the r.f. or d.c. standard loads which has an output proportional to the temperature difference between the loads. This output is used as an error signal in a feedback control system which adjusts the power input to the reference load; greatly reducing measuring time.

At N.B.S. the power measuring system consists of two nearly identical 50-Ω loads mounted asymmetrically in a copper box immersed in a temperature-controlled oil bath. The differential thermopile, consisting of 50 copper/constantin junctions, is also mounted in the oil-immersed copper box together with part of the feedback control system. The control system consists essentially of an operational amplifier and a d.c. power amplifier. Best results are obtained below 1GHz where accuracies of better than $\pm$ 0.26% are possible.

Transistor Transducer

A phenomenon known as anisotropic stress effect has been used to advantage in pressure transducers. A diaphragm is mechanically coupled to the base-emitter junction of a silicon n-p-n planar transistor. When a force is applied to the diaphragm a large reversible charge is produced in the transistor's characteristics. While research is still being carried out, most investigators agree that the phenomenon is due to changes in the energy gap of the junction under stress or by a generation-recombination mechanism. It has



been found that stress applied to a base-emitter junction reduces the current gain of a transistor by as much as three orders of magnitude and also a change in output capacitance occurs.

A transducer manufactured in this way will operate as a conventional transistor enabling force-controlled oscillators, direct f.m. and p.w.m. encoding transducers to be produced. An example of a transducer operating by virtue of this effect is called a Pitran and is produced by Stow Laboratories of the U.S.A., outputs of 1V for 0.25 gm force are achieved.

High-Frequency Current Standard

A high-frequency current standard developed by the American National Bureau of Standards Boulder Laboratories permits the measurement to within one per cent of high-frequency currents from 1 to 100A in the frequency range 1MHz to 1GHz. The new standard is a torque-operated short-circuited-ring electrodynamometer situated between the inner and outer cylinders of a coaxial transmission line, which measures current in the transmission line in terms of the torque exerted against the ring by electromagnetic fields in the line.

Short-circuited-ring electrodynamometers have, in the past, been proposed (without success) as high-frequency current standards because it was thought that the torque-current proportionality constant could be easily expressed in terms of the fundamental quantities of mass, length, time and the permeability of free space. However, some of the basic assumptions which characterized the earlier approaches to the problem of finding the proportionality constant were in error.

Previous attempts at finding this constant were based on the assumption that Lagrange's equations for the energy expression, which describes free space transverse electromagnetic-mode fields due to a filament of current near a filamentary ring, applied. The error associated with this approach is that the ring is not a filament; it is enclosed between coaxial cylinders and the transverse electromagnetic mode theory does not completely describe the system. The new method used to obtain the proportionality constant was based on the resonator action theorem described in the *Quarterly Journal of Applied Mathematics by* W. R. Maclean in 1945, and modified by A. L. Cullen ("A General Method for the Absolute Measurement of Microwave Power" by A. L. Cullen, *I.E.E. Journal*, Vol. 99, Pt.4, No.24 Pp.112-120, 1952).

The new method of determining the torque-current proportionality constant involves first making the electrodynamometer into a resonant cavity by fitting moveable shorting pistons into the ends of the coaxial transmission line which contains the shorted ring.

The cavity thus formed is resonated with the ring in place. The ring is rotated through a small angle, $\Delta\theta$ against the torque, t, which is being exerted against by the fields within the cavity. This results in work, $t\Delta\theta$, being done upon the cavity fields and also results in a change in the total action (period times total energy) of the cavity fields. The pistons are adjusted so as to restore the period to its original value. By the resonator action theorem as modified by Cullen, if the cavity losses are sufficiently small, the work done by the pistons being moved a distance, Δx, against the radiative pressure force, F, must be the negative of the work, $t\Delta\theta$, i.e. $F\Delta x = -t\Delta\theta$. Since the radiation pressure against the pistons is easily determined in terms of current in the cavity, or on the transmission line, the theorem makes possible a convenient means of evaluating the torque acting against the ring in terms of current. At present the new standard is only suitable for primary laboratory applications.

Thin-film thermojunctions

New advances in r.f. power measurement may well result from work on thermoelectri materials developed by Wayne Kerr Ltc The long-term electrical stability of evapor ated films of antimony, bismuth and bismut telluride is being assessed. Examples o antimony/bismuth-telluride thermojunction were recently demonstrated measuring th temperature rise of resistive films dissipatin small electric powers. The thermojunction were deposited on one side of thin mic substrates and the resistive films on the othe side. A typical temperature sensitivity wa 250μV/°C while a typical efficiency wa 11mV per watt of heating current flowing.

Slow Polar Converter for C.R.O.

A simple unit extending the display facilities of an ordinary cathode-ray oscilloscope

by J. A. Gordon, B.A. (Cantab)*

This unit, which is experimental in its present form, can be used to display two voltages on an ordinary c.r.o., with timebase inoperative, in polar or R θ co-ordinates. A spot describes the locus of a vector tip when the latter's co-ordinates are specified in terms of voltages proportional to its radial and angular displacements from a fixed point.

Simplicity and low cost are the keynotes of the prototype described here. A scanning speed of 500Hz was chosen, this being low enough to avoid problems associated with high-speed switching, but on the other hand high enough to accommodate several displays-per-second of the required polar diagrams. Operation at higher scanning speeds than 500Hz might require careful selection of transistors to ensure the correct functioning of each stage.

*Hatfield College of Technology, Herts.

The unit was built using 'surplus' transistors. The only specifications given for these are 30 volt V_{ce}, 50mA I_c and 180mW dissipation. Tr_7 should have low leakage and high gain. Tr_1 and Tr_2 must have sufficient gain for regeneration. The diodes are low current types and each of the diodes D_2 and D_3 should have the same threshold level as V_{eb} for Tr_8 to Tr_{10}.

Referring to the two voltages as V_r and V_θ, if we hold V_r at a fixed value and increase V_θ the spot will move in a circle around the centre of the c.r.t. screen. If on the other hand we hold V_θ constant and increase V_r, the spot will move away from the centre of the screen.

A 30 volt peak square wave, negative going relative to ground, is clipped to give a voltage equal to the radial input signal V_r. A low pass filter next removes the harmonics, and the fundamental sine wave is passed to the phase-shift network, where a 45° retardation and 45° advance give overall 90° phase differences. These two sinusoids are applied to the c.r.o. X and Y amplifiers.

This results in a circle appearing on the c.r.t. screen (if the gains of the X and Y amplifiers are equal). Injecting a spike into the Z or intensity modulation amplifier of the c.r.o. once every cycle, and reducing the intensity of display, will result in a spot of light. Holding the spike in phase with the square wave cycle will keep the spot at a point away from the centre. If a voltage V_θ is made to delay the spike, in a linear manner, then the spot will appear to move round the circle.

To generate the spike, the original square wave triggers a ramp generator and the ramp is compared with the input V_θ in the comparator. The comparator output triggers the spike generator, and this spike is applied to the Z input of the c.r.o.

Very low impedance sources are required for both V_r and V_θ. Direct coupled emitter follower stages with output impedances of 50 Ω or less are ideal.

VR_1 and VR_2 control eccentricity about axes at 45° to the X and Y direction; VR_3 adjusts the height of the ramp; and VR_4 controls the duration of the spot and to a certain extent its intensity.

Fig. 1. Block diagram of converter.

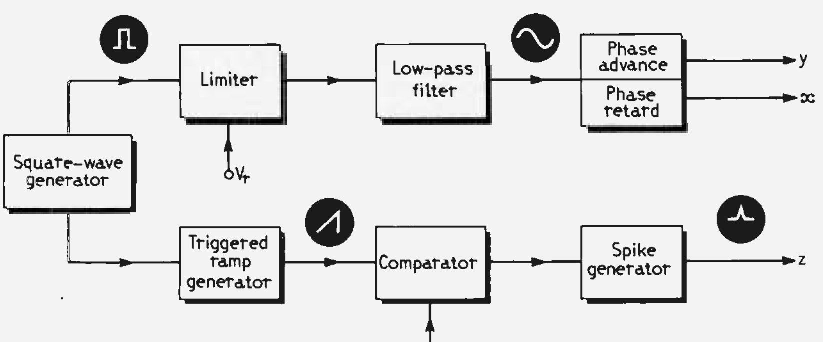
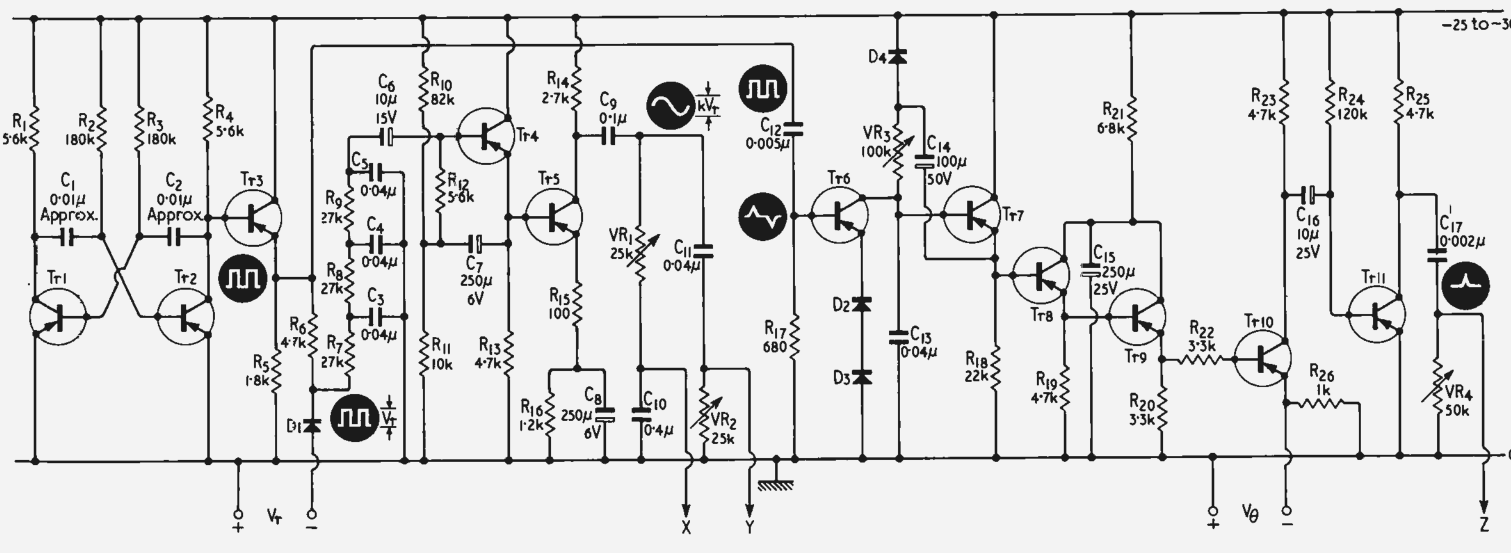


Fig. 2. Complete circuit diagram.



Personalities

Kenneth Fearnside, M.A., F.I.E.E., has joined Plessey, as technical executive of the Components Group. Mr. Fearnside, who is 49, has spent the past 15 years with Smiths Industries Ltd., where since 1961 he has been technical director of the Aviation Division. Previously, he was the Aviation Division's director of research and engineering. Before joining Smiths he had spent four years at the Atomic Energy Research Establishment at Harwell, and a further four years as technical director of Isotope Developments Ltd. A graduate of St. John's College, Cambridge, Mr. Fearnside served during the war in the Radar Branch of the Royal Air Force.

J. Montgomery-Smith

K. R. Sturley, Ph.D., B.Sc., F.I.E.E., who has been the B.B.C's chief engineer external broadcasting since 1963, is to retire in September and has accepted an invitation to the newly-created Chair of Communications at the Ahmadu Bello University, in Zaria, Northern Nigeria. Dr. Sturley, a graduate of Birmingham University where he also did postgraduate research on electrothermal storage problems for his doctorate, joined the staff of Marconi College, Chelmsford, as a lecturer in 1936 and was assistant principal when he left to go to the B.B.C. in 1945. He was the first head of the B.B.C's Engineering Training Department.

Thomas Mayer, B.Sc.(Eng.), F.I.E.E., who has been manager of the Marconi Company's Broadcasting Division since 1963, has been appointed general manager responsible for the components interests of the Company. In his new position he will be directly responsible for the Marconi Microelectronics Division, Specialised Components Division, Hackbridge Crystal Works and for Elliott-Automation Microelectronics Ltd. Mr. Mayer, who is 40, obtained his degree at the Regent Street Polytechnic, London, and joined the Marconi Company as a graduate apprentice in 1948. Two years later he went into the Broadcasting Division as a project engineer mainly concerned with television and f.m. transmitting systems.

T. Mayer

R. G. Williams

Richard G. Williams, M.A.(Eng.), M.I.E.E., has succeeded Mr. Mayer as manager of the Broadcasting Division of Marconi. After graduating at Wadham College, Oxford, he joined the Army Radio School and was commissioned in the R.E.M.E. in 1943. He joined the Marconi Company as a commercial trainee in 1947. In 1949 he became a member of the company's staff in New Delhi; returning to England a year later he joined the sound studio equipment group of the Broadcasting Division. Mr. Williams, who is 47, has been manager (commercial section) in the Broadcasting Division since 1965.

Peter Rainger, B.Sc.(Eng.), M.I.E.E., leader of the team in the B.B.C. Designs Department which, in August 1967, developed the colour television standards converter described in our October 1967 issue, has received an Emmy award from the American Academy of Arts and Sciences. This is understood to be the first Emmy given outside America for technological achievement associated with television. The equipment converts 525-line, 60 fields/second, N.T.S.C. colour pictures into 625-line, 50 fields/second, PAL pictures (or vice versa) by entirely electronic means. Mr. Rainger joined the B.B.C. in 1951 after graduating at Northampton Engineering College.

The appointment of **W. Wharton**, F.I.E.E., as head of the B.B.C's Transmitter Planning and Installation Department is announced. Mr. Wharton joined the Corporation in 1938 as a junior maintenance engineer in the London Control Room. In 1960 he was appointed as head of the aerial section in the Research Department radio group, subsequently becoming head of special studies section television group. He has been head of transmitter planning section, Transmitter Planning and Installation Department since 1966.

Pye Telecommunications Ltd. announce the appointment of **J. C. Turnbull** as a director of the company. He joined Pye on discharge from the Army in 1947 and has been commercial manager since early this year. **H. W. Whelan**, has been appointed home sales manager of the company. After radio engineering training in the Army and a short period with A.T. & E. and Marconi Instruments, he joined Pye in 1954. He has been deputy v.h.f. sales manager for the past five years.

D. Ashby, who joined Marconi Instruments as a technical representative in 1964, has been appointed to the new post of manager (factored products). Mr. Ashby, who is 33, entered the electronics industry in 1956, as a development engineer with Furzehill Laboratories Ltd. The following year, he became a technical representative for that company, and later he was appointed sales manager.

D. Ashby

English Electric Valve Company announces the appointment of J. Montgomery-Smith and M. J. Pitt as assistant sales managers. **J. Montgomery-Smith**, B.Sc., who joined E.E.V. in August last year, graduated in physics from Manchester University in 1956, and then joined the Marconi Company. In 1961 he went to Mullard Ltd. as sales engineer responsible for thyristors and special industrial valves, and in 1963 was appointed commercial product manager of the Infra-Red and Special Semiconductors Department. **M. J. Pitt**, M.I.E.E., joined E.E.V. in 1964 having previously been for six years a senior supervisory engineer (communications) in independent television. For nine years prior to that appointment he was an operations and maintenance engineer with the B.B.C.

M. J. Pitt

Gordon Dickson, recently appointed European marketing manager for Fairchild Instrumentation Limited, is a Canadian who was last resident in England during World War II when he served with the R.A.F. His previous positions within the electronics industry include six years with Philips in Canada, as service division manager with Rogers Majestic Electronic. He was national service manager for Motorola (Canada) and held similar positions with Tektronix Inc and Canadian Westinghouse Corp.

Test Your Knowledge

*Series devised by L. Ibbotson**

2. Properties of waveguides

1. Of the following four structures select the one which is not used to transmit microwave signals:
(a) twin wire transmission line
(b) coaxial cable
(c) high conductivity metal tubing
(d) dielectric rod.

2. The "dominant mode" in a microwave transmission structure is the electromagnetic field pattern which will propagate
(a) with the least attenuation
(b) with the greatest velocity
(c) at a lower frequency than any other
(d) at a higher frequency than any other.

3. For all modes in a waveguide the electric and magnetic fields must satisfy "boundary conditions" at the waveguide walls. These boundary conditions (assuming perfectly conducting walls) are:
(a) an electric or a magnetic field, if it exists at a wall, must meet it at right angles
(b) an electric or a magnetic field, if it exists at a wall, must be tangential to the wall
(c) if an electric field exists at a wall it must be tangential to the wall; if a magnetic field exists at a wall it must meet it at right angles
(d) if an electric field exists at a wall it must meet it at right angles; if a magnetic field exists at a wall it must be tangential to the wall.

4. The dominant mode in a rectangular waveguide has
(a) an electric field only
(b) electric and magnetic fields which are purely transverse
(c) a purely transverse electric field; a magnetic field with a longitudinal component
(d) a purely transverse magnetic field; an electric field with a longitudinal component.

5. The cut-off frequency of the dominant mode in a rectangular waveguide is the frequency at which the wavelength of a plane wave propagating in the medium filling the guide is:
(a) twice the wide guide dimension
(b) half the wide guide dimension
(c) twice the narrow guide dimension
(d) half the narrow guide dimension.

6. Associated with the fields in a rectangular waveguide are wall currents. These currents flow
(a) in the wide walls only
(b) in the narrow walls only
(c) in the inside surface of all four walls
(d) in the outside surface of all four walls.

7. Most rectangular waveguides have a cross-section with internal dimensions in the ratio of 2:1. The choice of this ratio gives:
(a) the greatest ease of manufacture
(b) the least possible attenuation
(c) the greatest possible power handling capacity
(d) the best compromise between power handling capacity, low attentuation and useful bandwidth.

8. A standard rectangular waveguide of given dimensions is not normally used at a frequency greater than twice the cut off frequency of the dominant mode. This is because above this frequency
(a) it is difficult to launch the signal
(b) more than one mode can propagate
(c) the attenuation rapidly rises with frequency
(d) the waveguide radiates energy away through the walls.

9. If we try to propagate in a waveguide a signal at a frequency below the cut-off frequency of the fundamental mode
(a) electrical breakdown always occurs in the guide
(b) no fields will be set up in the guide
(c) fields are set up in the guide, but no wave propagates
(d) a wave propagates in the guide, but with a very large attentuation.

10. The phase velocity of a signal in a waveguide containing no dielectric material is:
(a) 3×10^8 metres/sec
(b) always greater than 3×10^8 metres/sec
(c) always less than 3×10^8 metres/sec
(d) sometimes greater than 3×10^8 metres/sec, sometimes less.

11. The guide wavelength, λg, in any waveguide is related to the plane-wave wave-length in the medium filling the guide at the same frequency, λ, such that
(a) λg is always greater than λ
(b) λg is always less than λ
(c) λg is the same as λ
(d) λg may be less than λ or greater than λ.

12. The possible shapes of cross-section for a waveguide in addition to rectangular are:
(a) circular only
(b) circular or elliptical only
(c) circular, elliptical of H-section only
(d) any shape.

13. If a waveguide of given dimensions is filled with a low-loss dielectric, select which one of the following remains constant:
(a) the frequency range of the guide
(b) the mode cut-off wavelengths
(c) the phase velocity at a given frequency
(d) The guide wavelength at a given frequency.

14. In a coaxial line
(a) only one mode can propagate—a transverse electromagnetic mode
(b) only one mode can propagate—a transverse electric mode
(c) only one mode can propagate—a transverse magnetic mode
(d) transverse electromagnetic, transverse electric and transverse magnetic modes can all propagate.

15. In a strip line the fundamental mode
(a) is transverse electromagnetic
(b) is transverse electric
(c) is transverse magnetic
(d) has longitudinal components of electric and magnetic field.

16. If a waveguide is left open at the end the open end acts as
(a) an open circuit
(b) a short circuit
(c) a matched load
(d) a load giving a moderate mismatch.

Answers and comments, page 239.

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

ESRO II in Orbit

The European Space Research Organization's ESRO II, now called Iris, is now in an orbit very close to the planned one, inclined 97.2° to the equator, with an apogee of 1068km, a perigee of 326km and a period of 89.9 minutes. It was successfully launched on May 16th from the Californian Vandenberg range. This, of course, is the second attempt to get ESRO II space borne, the first attempt last year ended in failure due to a malfunction of the launch vehicle. The orbit will keep Iris in continuous sunlight for 192 days, ideal for its mission to study the energy levels and spectral distribution of solar and cosmic radiation.

The data transmitted from satellite is being received by the American N.A.S.A. organization and the French C.N.E.S. ground stations, the Norwegian station at Tromsö and the stations comprising the ESTRACK network—the latter being in operation for the first time.

Literature Received

"Electrons in Shadow-mask Colour Tubes" is the title of a booklet produced by Mazda for service technicians. The booklet is well written and contains a number of black and white as well as colour illustrations. It is one of a series of "Electrons in . . ." booklets that are available from Mazda Publicity Department, Thorn-AEI, Radio Valves and Tubes Ltd., 7 Soho Square, London W.1. The titles available are: "... Diodes" (1s); "... Triodes" (2s); ". . . Screen Grids and Pentodes" (1s); ". . . Beam Tetrodes" (1s); "... Picture Tubes" (2s); "... Shadow-mask Colour Tubes" (3s 6d).

Two picoameters for measurements in the range 10^{-2} to 10^{-12}A are described in an engineering note received from Keithley Instruments, 28775 Aurora Road, Cleveland, Ohio 44139.
WW380 for further details

Data on selenium rectifiers, selenium surge suppressors, thyristors and general purpose fast switching power transistors manufactured by the Westinghouse Brake and Signal Co. Ltd., 82 York Way, Kings Cross, London W.1, is contained in a series of leaflets published by them.
WW381 for further details

Users of **operational amplifiers** will be interested in a 37-page application note available from Analog Devices, 221 Fifth Street, Cambridge, Mass. 02142, U.S.A. Called "Evolution from Operational Amplifier to Data Amplifier", it discusses common mode errors in various operational amplifier and date acquisition circuits.
WW382 for further details

The **safeguarding of electrical and electronic circuits** using s.c.r. protection systems is the subject covered in the March 1968 *Airpax Technical Journal* produced by Airpax Electronics Inc., Cambridge, Maryland, Fort Lauderdale, Florida. The double threshold electronics delay and the "crowbar" circuit breaker system are discussed.
WW383 for further details

Potentiometric indicating controllers, regulators and indicators, alarm scanners, strip chart controllers, thyristor control units and a range of transducers are described in a short form brochure available from Ether Ltd, Caxton Way, Stevenage, Herts.
WW384 for further details

Mullard have published two new booklets entitled **"An Introduction to Nuclear Radiations and their Detection"** and **"Germanium and Silicon Radiation Detectors".** The first booklet explains what radiation is, how it is produced and how it is detected. The second describes a range of radiation detectors and gives hints and application notes. Mullard Ltd, Mullard House, Torrington Place, London W.C.1.
WW385 for further details

Technical data and application information relating to Keithley Instruments Incorporated's models 300, 301, 301k and 302 **electrometer operational amplifiers** are given as a booklet obtainable from them at 28775 Aurora Road, Cleveland, Ohio 44139.
WW386 for further details

A range of **photoelectric control equipment** and associated light sources are described in a leaflet from Donovan Electrical Co. Ltd., Electronics Division, Birmingham 33.
WW387 for further details

No. 20 in the **educational electronic experiments** series describes a thyristor circuit for light control. Mullard Ltd, Mullard House, Torrington Place, London W.C.1.
WW388 for further details

A **high-quality record turntable** manufactured by the German company Perpetuum-Ebner is described in a leaflet obtainable from their agents in this country Highgate Acoustics, 184-188 Great Portland Street, London W.1. The turntable has a number of interesting features and costs 49gn in this country.
WW389 for further details

Modules containing **s.c.rs intended for relay replacement** where a.c. current through inductive loads has to be switched are covered in a leaflet from Hird-Brown Ltd, Bolton, Lancashire. The modules will handle up to 2A at 240V a.c. at a maximum continuous rate of 100 times/sec with a 50Hz supply: Normally open, normally closed and change over versions are available.
WW390 for further details

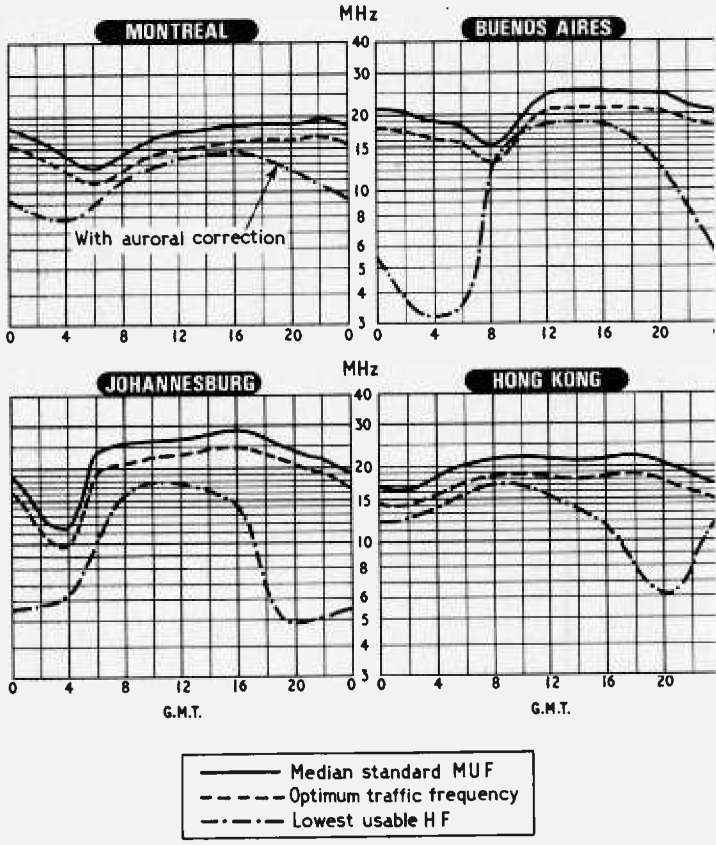
Plugs, sockets, valveholder terminal pins, fuse holders and switches are some of the items included in the radio, electronic and electrical components catalogue of standard parts released by United-Carr Supplies Ltd, Clifton Works, Frederick Road, Stapleford, Nottingham.
WW391 for further details

The latest edition of a catalogue describing equipment in the **Japanese Eagle range** is now available from B. Adler & Sons (Radio) Ltd., 32a Coptic Street, London W.C.1. The catalogue includes details of audio gear, test equipment, teaching kits and electronic components. The catalogue costs 5s, although it can be obtained free by certain organizations.

H.F. Predictions—July

The charts show median standard MUF, optimum traffic frequency and lowest usable frequency for reception in this country. The LUFs shown were calculated by Cable and Wireless Ltd. for specific point-to-point telegraph circuits. Those for high-power broadcasting will be very similar but for amateur transmissions, where e.r.ps are much lower, will be several MHz higher.

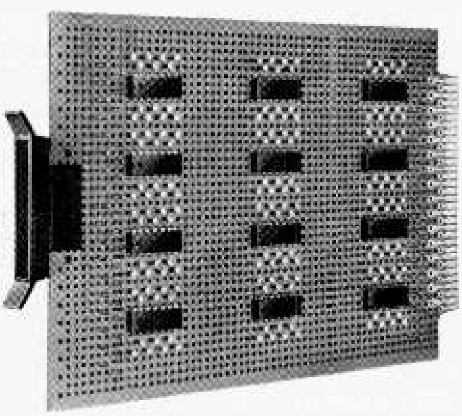
The value of Ionospheric Index (IF2) used for the predictions was 133. It now seems that a more accurate estimate is 124 though this would cause only a slight reduction in MUF. More generally it reflects the relative lowness of the current sunspot maximum period. The actual maximum is not well defined so we can expect the pattern of frequency usage over the past twelve months to be repeated in the coming year.



New Products

Fingerboards

Fingerboards are plain panels pre-punched, made of s.r.b.p., with a 0.1in. matrix which conveniently lines up with the connections of dual-in-line integrated circuits. The fingers are hard gold-plated and the card can be plugged into 0.1in. pitch edge connectors having a similar number of contacts. Standard fingerboards available from Vero Electronics are profiled to fit Ultra edge connectors which are also available from Vero. The standard range of Vero terminal pins for use in 0.052in. diameter holes can be used for anchoring point-to-point wiring on the boards. Vero Electronics Ltd., Chandler's Ford, Hampshire.



W.W. 307 for further details.

Modular Radar System

In producing their S600 system of radar transmitter/receivers, aerials and data processing units, which can be assembled together in many configurations, Marconi have shown great economy and emphatic practical good sense. Careful investigation of military radar requirements showed that the plan radar and height-finder combination is very accurate, and cheaper than other techniques. The result is a combination of four basic transmitter/receivers, and several aerial types. The transmitters operate in the C-, S-, and L- bands at 1 or 2 MW and can be used with different sizes of mobile or static surveillance aerials, and a mobile nodding height-finder.

Each transmitter/receiver employs integrated semiconductor circuitry to achieve compactness and greater reliability, and the newly designed magnetron is vapour cooled. Clutter suppression in excess of 40dB has been achieved by use of two separate cancellation circuits. Signals received are stored and compared with the next set coming in. Any which have not altered in phase are removed. Such cancellation is dependent on transmitter stability, and the use of a new quartz delay cell and a special trigger mechanism have eliminated the need for constant adjustment.

Conventional moving target indicators fail to detect aircraft moving at certain slow speeds, but in the S600 series equipment the pulse repetition frequency of the radar signal is staggered, giving simultaneous operation on two or more pulse repetition frequencies which can be chosen to raise the 'blind speeds' above Mach 2. A pulse discriminator can be employed to reject signals received from other radar systems operating on adjacent radio frequencies by accepting only signals of the correct pulse length and repetition frequency.

The aerials, which between them meet all known requirements, employ an advanced type of feed system known as 'squintless feed', providing accurate signal distribution over the aerial reflector surface and permitting the use of different frequencies. Multiplexers allow several transmitters to be fed into a single aerial. A new feature of this equipment is automatic height extraction from the C-band height finder.

Advanced display facilities are part of the S600 system. High definition cathode ray tubes can be built into a large number of different arrangements.

Also, communication systems, fully compatible with the S600 system can be supplied as part of a comprehensive scheme. Marconi Company, Chelmsford, Essex.

W.W. 320 for further details.

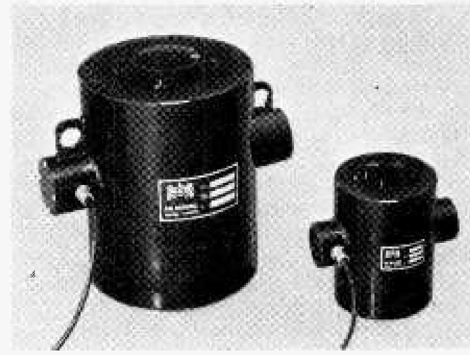
Mouldings Deflash Equipment

Although the point where the metal connecting pins emerge from encapsulated mouldings should be perfectly clean to ensure good contact, there is usually at least 0.3cm of plastics film which adheres to the pins as the mouldings come off the press. A method of removing this flash from all types of thermoset plastic mouldings has been developed by G.I.E., of Ottley, Yorkshire, using their Powerblast mark 1 which is particularly suitable for treating "runs" of transistors. Time taken is approximately 150 mouldings every 60 second cycle. Guyson Industrial Equipment Ltd., North Avenue, Ottley, Yorkshire.

W.W. 309 for further details

Precision Load Cell

The exacting demands of high accuracy load weighing are met by the Bofors (Sweden) load cell LPM–1, designed for measuring loads of up to 50 tons in conjunction with electronic scales. Of sturdy construction, with side-reinforced and hermetically sealed prismatic billet, the cell is suitable for use under adverse industrial conditions and will withstand 100% overload without mechanical damage. Its accuracy is based on the use of high grade foil strain gauges. Calibration can be carried out over a wide range of temperatures using shunt resistance. U.K. agents: Guest Electronics Ltd., Nicholas House, Brigstock Road, Thornton Heath, Surrey, CR4 7JA.



W.W. 316 for further details.

Low-distortion Oscillator

Continuous frequency coverage from 1.5Hz to 150kHz is given by an all-silicon transistor, low-distortion oscillator, model STW150, from H H Electronic of Cambridge. This is a self-contained instrument in an anodized aluminium case with carrying handle, using a horizontal frequency scale with an effective length of 125cm. In addition to the standard built-in stabilized mains power pack, the STW150 can be supplied with nickel cadmium cells, rechargeable from the power pack, or with PP9 dry batteries. Design features include frequency stability of $< 0.05\%$ drift per °C and $< 0.3\%$ for $\pm 10\%$ mains supply variation and 0.05% distortion over the total frequency range. Output voltage is 2.2V r.m.s. at 600Ω with switched, plus continuously variable, attenuation to 60dB. Output voltage variation is $< 1\%$ over the frequency range and square-wave rise time is 1.5μ sec. The instrument measures 293 × 89 × 175mm. HH Electronic, 147 High Street, Cambridge.

W.W. 301 for further details.

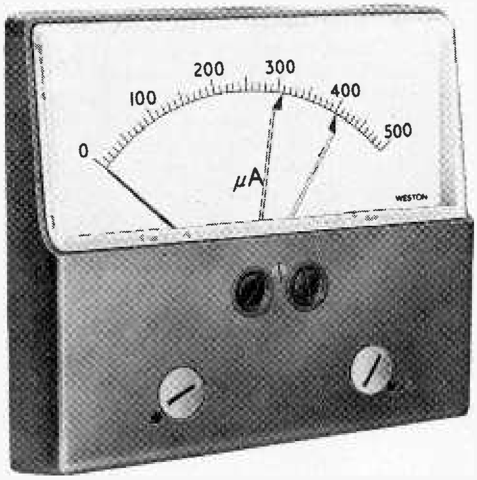
Digital Timers

Two general purpose digital time measuring instruments which employ silicon microcircuits and semiconductors throughout have been introduced by Venner Electronics. The TSA6614 (four digit) and TSA6616 (six digit) are identical except that the former measures 10μs to 1,000 sec, with time units 10μs to 100ms in decade steps, and the six digit instrument 1μs to 10,000 sec, with time units 1μs to 10ms in decade steps. The degree of crystal accuracy is the only other difference in specification. Provision has been made for start/stop from positive or negative contact closures, and contact bounce suppression circuits are incorporated.

Trigger circuits ensure accuracy virtually irrespective of the input signal rise time, so that if required the instruments can be operated by sine waves. Minimum and maximum pulse input amplitudes are 0.5V peak and 250V peak, with maximum d.c. input of 400V. Display time is 0.5 sec to 5 sec or infinite. Power supplies necessary are 100–120V or 200–250V, 40/60Hz. Each type measures 270mm wide, 133mm high and 305mm deep. Weight is 5.7kg. Prices £165 (four digit); £210 (six digit). Print out in 1248bcd form, suitable for the Venner TSA301 serializer, is available additionally at a cost of £50 and £65 respectively. Venner Electronics Ltd., Kingston By-pass, New Malden, Surrey.
W.W. 308 for further details.

Moving-coil Controller

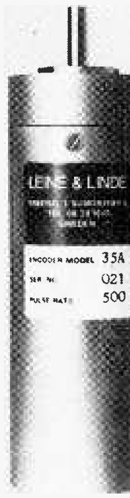
A two-level controller giving an on-off signal plus continuous indication, with the control points fully adjustable over the range of the instrument, has been announced by Sangamo Weston. The controller, model S509, operates photo-electrically; a flat shutter attached to the indicating system interrupts the light falling on two photo-resistive cells which are separately mounted on adjustable arms with set-point indication. The resultant resistance change is detected by a transistor circuit which energizes the corresponding control relay. The controller operates directly off any electrical quantity which



may be measured with a permanent magnet moving coil instrument and provides an on-off signal at the control point-settings. Accuracy of indication, set-point accuracy and minimum set-point separation are all at ±1% of f.s.d. Supply voltage is 200–250V or 100–125V, 50Hz and the control relays are single-pole, change-over contacts rated at 1A non-inductive load at 250V a.c. The controller can be supplied in a variety of relay operation modes. Preferred meter ranges are 0–100, 0–200 and 0–500µA, and 0–1, 0–2, 0–5 and 0–10mA. Other ranges can be supplied on request. Sangamo Weston Ltd., Great Cambridge Road, Enfield, Middlesex.
W.W. 312 for further details.

Encoder for Analogue Measurements

A new miniature optical encoder for registering shaft-angles and rotational movement is announced by Tekmar Electronics of Sweden. Only 35mm in diameter, the 35A encoder provides a simple means of translating rotational movements into electrical pulses suitable for digital display, recorder or further data-processing systems. Typical applications include the measurement of speed and acceleration of motors, tape transports,



and control of machine tools, process control systems etc. The built-in amplifier is designed to provide a high-to-peak signal (2.5V to 10V). The operating principle utilizes the interruption of a beam of light projected through a rotating and a static disc. This system produces four signals phased at 90° which are detected by four light sensors coupled in push-pull. Electrical output of the sensors appears as two signals phased at 90° which can be coupled externally for electronic measurement. The light sensors are designed to view large areas, which, combined with push-pull operation, compensates for errors arising from pattern imperfections, mechanical misalignment, bearing wear, lamp intensity and ambient temperature. Tekmar Electronics Ltd., 7 & 8 Dyer's Buildings, Holborn, London E.C.1.
W.W. 310 for further details.

Ceramic Variable Capacitors

A new metal/ceramic capacitor type UC650/30/150J was recently added to the range of vacuum variable capacitors made by English Electric Valve Co. It has a capacitance range of 30 to 650pF, maximum r.f. peak working voltage of 30kV and maximum r.f. current rating (r.m.s.) of 150A at frequencies up to 27MHz. Operation in ambient temperatures up to 55°C maximum with natural cooling is permissible. Overall length of the capacitor is 307.3mm and diameter 182.9mm. English Electric Valve Co. Ltd., Chelmsford, Essex.
W.W. 305 for further details.

Two New I.Cs

Two new t.t.l. integrated circuits recently introduced by Mullard can, with decade counter type FJJ141 and a numerical indicator tube, form a decade counting unit with storage facilities and read-out. The new circuits are a quadruple bistable latch, type FJJ181, and a b.c.d.-to-decimal converter decoder-driver, type FJL101. Both integrated circuits operate with a supply voltage of 5V, have low power consumption and can be used in counting circuits with speeds up to 10MHz.

Type FJ181 has Q and $\bar{Q}$ outputs, and is designed primarily as a temporary store for binary information. Consequently, with its hold-off ability, it facilitates the storage of a pre-determined number, allows it to be displayed, and maintains the display during the next counting period. The FJJ181 is enclosed in a 16-pin dual-in-line encapsulation.

I.C. type FJL101 incorporates ten output transistors for use as drivers for a numerical indicator tube. Although designed for use in decoding circuits, it is also suitable for d.c. switching of components such as miniature lamps and relays. The FJL101 is also enclosed in a 16-pin dual-in-line encapsulation; its b.c.d. connecting pins are positioned to match the positions of the appropriate pins of the FJJ181.
W.W. 315 for further details.

Solid-state Sweep Generator

A new solid-state sweep and marker generator type 1483B, suitable for the design, testing and alignment of u.h.f. television receivers is now

available from Kay Electric, of New Jersey. Covering the frequency range 440–960MHz, the instrument is provided with two sweep widths: wide range 520MHz, and narrow range 5–60MHz with built-in attenuators and markers. A full 0.5V r.m.s. output is provided over the entire frequency range and sweep width can be varied by a front panel control. Kay Electric Co., Maple Avenue, Pine Brook, New Jersey.
W.W. 314 for further details.

Transistor Curve Tracer

Dynamic characteristic curves of a wide variety of semiconductor diodes and transistors, including four-terminal f.e.ts and m.o.s.ts, can b displayed with a new Philips curve tracer typ PM6507, announced by M.E.L. Employing soli state circuitry, the tracer caters for collecto currents of up to 20A and for diode voltages a high as 3,000V peak. Leakage currents as low a 0.005µA will produce a deflection of 1cm Measurements which can be made are: collecto voltage and current; base voltage and current i common emitter circuit; and emitter voltage an current in common base circuit. Also breakdow voltage and leakage current. Curves are displaye on a 10 x 12cm c.r.t.

Features include variable duty cycle te

pulses to ensure low thermal loading, facilities for displaying curves in families or individually, and the capability of inverting or reversing the display. Operation is from the mains. The M.E.L. Equipment Co. Ltd., Manor Royal, Crawley, Sussex.

W.W. 317 for further details.

New Solder for Industrial Users

A new concept in solder for soldering machines and baths is claimed by Multicore Solders, of Hemel Hempstead. Originally developed to meet the stringent requirements of some U.S.A. electronics manufacturers, the new solder, called "Extrusol", will shortly become available to U.K. users. From alloys compounded under careful control, the solder bars, instead of being cast, form the centre of an extruded trapezium section so that any oxide is retained in the extrusion press. This process also obviates segregation of the metals which often occurs during casting. After extrusion, the bars are enclosed in plastic seals to prevent contamination during the period between manufacture and use. Bars are available in 1lb and 2lb sizes.

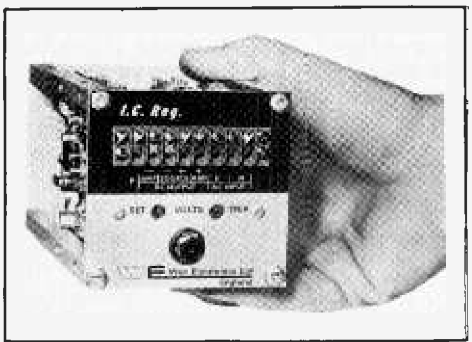
Extrusol is claimed to be substantially free of oxides, sulphides and other undesirable elements. Multicore Solders Ltd., Marylands Avenue, Hemel Hempstead, Herts.

WW 321 for further details.

D.C. Supply Modules

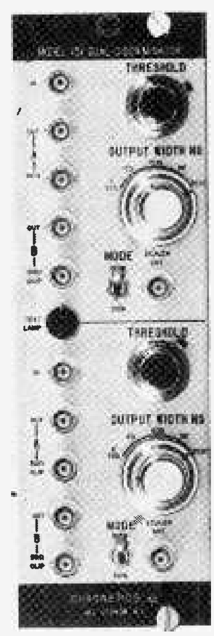
Compact d.c. power supplies in a range of 54 units from 1–30V and 1–5A have been produced by Weir Electronics. These units are designed for working with integrated-circuit instruments and systems, and are provided with current/voltage overload safeguards. Modules are available in three versions; (1) OCAR range (overload current auto reset), (2) CCL range (constant current limited) and (3) OCT range (overload current trip) giving alternative overload protection according to user requirements. All modules can be supplied with or without a device called "crowbar", a high-speed electronic trip operating within 10µs to reduce the output to below 1V. A 7V 1A unit with "crowbar" costs £24. Stabilization is quoted as better than 0.01% for 10% mains supply change, and transient recovery time as less than 0.02% per °C. Instantaneous compensation for supply lead volts drop ensures effective voltage regulation when the load is remote from the supply module. For higher current applications, provision is made for modules to be paralleled. Weir Electronics Ltd., Durban Road, Bognor Regis, Sussex.

W.W. 311 for further details.



Logic System

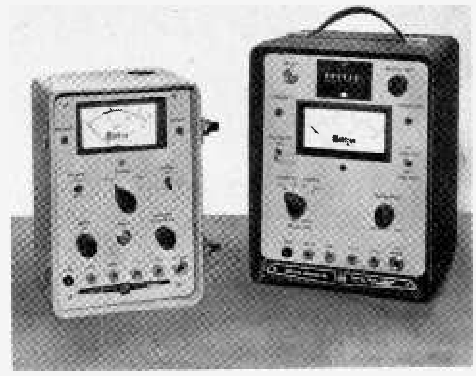
Nanologic 150 by Chronetics Inc., Mount Vernon, New York, is a second generation analogue/digital data handling system for logic and counting applications in high energy physics, capable of operation with random (asynchronous) pulse inputs in excess of 200MHz. In addition to a variety of logic modules, the system includes dead-timeless discriminators, d.c. coupled pulse amplifiers, linear gate and stretcher-hold unit, 100MHz decade prescaler, etc. The selection of functions incorporated in each of the various modules enables a complete logic system to be assembled with, it is claimed, a substantially lower total number of modules than has heretofore been possible. Features include, 200MHz operation, d.c. coupled throughout, ±100V protection for all inputs, continuously adjustable output widths, 1.5ns coincidence resolution, 5ns pulse burst resolution, and temperature coefficient of less than 0.1%/°C. U.K. agents—Claude Lyons Ltd., Instruments Division, Hoddesdon, Herts.



W.W. 303 for further details.

Transient Voltage Indicators

Designed to indicate the presence of voltage transients above a preset selectable level, two new instruments with voltage ranges of 100–30,000V have been announced by Solitron Devices, of New York. Both models are for 115V a.c. mains operation but they also have self-contained, nickel-cadmium batteries and are provided with a charging circuit controlled by a front panel switch. Model V200 indicator employs transitors throughout and features full-scale voltage ranges from 100V to 30,000V direct reading, extendable to 60,000V with an accessory adaptor. Input impedance is 5,000Ω/V and input polarity is selected by a front panel control. The presence of a transient voltage which exceeds that preset level is shown by a front panel indicator, with an accuracy of ±2% of full scale.



Model V210 is similar to the V200 except that this instrument includes a counter for recording the number of times a transient voltage exceeds the preset level. Solitron Devices Inc., 256 Oak Tree Road, Tappan, New York, 10983. U.K. agent: David M. Holmes, 9a High Street, Bromley, Kent.

W.W. 319 for further details

Small Crystal Filters

Exceptionally small crystal filters for v.h.f./u.h.f. equipment have been added to the range of filters made by M.E.L. for fixed and mobile communications equipment. Measuring approximately 3.8 × 1.9 × 1.9cm the new filters occupy less than 16cm³ (1in³) and cover the frequencies 10.4 and 11.5MHz, with bandwidths of 7.5, 15, 30 and 35Hz. They all operate over the wide temperature range of −40 to +80°C with attenuation greater than 85dB in the stopbands. The M.E.L. Equipment Co. Ltd., Manor Royal, Crawley, Sussex.

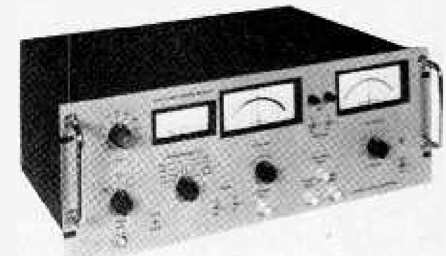
W.W. 322 for further details.

Two-phase Voltmeter

Bridge measurements with simultaneous in-phase and quadrature null detection, and high sensitivity measurements of inductance, capacitance and resistance are possible using a new two-phase sensitive voltmeter by A.S.L. The instrument can also be useful in any application calling for the recovery of signals buried in noise, and where a reference signal is available. Signals as small as 10^{-3} of white noise level and 10^{-5} of mains frequency hum can be recovered. A very high input impedance with low noise is achieved by the use of a nuvistor input stage.

Freedom from ringing is provided by *RC* filters, without phase errors due to filtering, and allowing a fast recovery, an important requirement in bridge detection systems. Overall gain is 120dB plus 20dB in each channel, and sensitivity with a suitable input transformer is typically 0.1nV f.s.d. from a 10Ω source. The in-phase and quadrature components are indicated simultaneously on front panel meters and outputs are available for external recording. A third meter is provided to indicate total signal strength and give warning of excessive overload. Automatic Systems Laboratories Ltd., Construction House, Grovebury Road, Leighton Buzzard, Bedfordshire.

W.W. 313 for further details.



World of Amateur Radio

Four-metre Band Extended. Following negotiations between representatives of the R.S.G.B. and the G.P.O. it has been agreed to extend the 70MHz band used by amateurs in the United Kingdom by 75kHz. The new band is 675kHz wide and extends from 70.025 to 70.7MHz.

The National Eisteddfod of Wales is to be held in Barry during the period August 5th to 10th and to mark the occasion an amateur radio station, using the call GB3NEW, will be operated from an exhibition hall by members of the Radio Society of the Barry College of Further Education. It is planned to issue certificates to confirm contacts rather than QSL cards.

Licence fees

Rumour is rife that a 50% increase in the U.K. amateur licence fee can be expected very shortly. The present fee is £2 per annum for the standard Amateur (Sound) Licence plus an additional £1 per annum for the Amateur (Mobile) Licence. If the fee is increased to £3 or more the time would seem to be opportune for the Post Office to announce that the standard licence fee will automatically authorize mobile operation at no additional cost to the licensee.

Representatives of Canadian amateurs recently met officials of the Canadian Department of Transport to protest against the 400% increase in the licence fee announced, without notice, on April 1st. The amateurs put forward various suggestions for effecting economies in administering the amateur service it having been argued by the government officials that the income received from amateur licences (about $30,000 per annum) was less than one quarter the amount spent on administration. Amateur organizations are preparing briefs to be submitted to the Canadian Cabinet with a request that the very considerable increase, from $2.50 to $10.00 per annum, be reconsidered.

The late Ness Edwards

The British Amateur Television Club owes much of the practical side of its development to the late Ness Edwards, P.C., M.P., whose death occurred early in May. During his term of office as Postmaster General he visited the 1950 R.S.G.B. Amateur Radio Exhibition and was considerably impressed by what he saw on the B.A.T.C. stand. In the course of discussions the P.M.G. discovered that amateur television progress was being thwarted by the reluctance of the Post Office to grant permission for television equipment to be operated on frequencies in the 420-460 MHz band because it was believed that the transmissions would interfere with radio altimeters. On learning of the official objections and listening to arguments advanced by Society and Club officials he arranged for a Hastings aircraft of Coastal Command to carry out a series of tests over London and the Home Counties with two amateur television stations transmitting in the 420-460 MHz band. The tests proved—as had been suspected—that there was no danger of interference to radio altimeters with the result that shortly afterwards the Amateur Television licence was amended to permit operation in the 70cm band. Prior to that date amateur television had been confined to the 1300MHz and higher frequency bands. Today there are about 200 amateur television stations in the United Kingdom with call signs in the series beginning G6AAA/T.

Beacon News

A beacon station is now operational on 145.995MHz beaming north from Thurso, Caithness, Scotland, for auroral reflection investigations. Reports of the reception of signals from the beacon whether by auroral or tropospheric propagation should be sent to the R.S.G.B. Scientific Studies Committee, 28 Little Russell Street, London W.C.1. Plans are in hand to bring a 70MHz beacon into operation shortly.

The Radio Society of Rhodesia (P.O. Box 2377, Salisbury), report that a beacon transmitter (ZE1AZE) is now operating on 69.998MHz with an r.f. output of 30 watts. The carrier is interrupted with 500Hz f.s.k. at 18 w.p.m.

Due to the difficulty of maintaining full operation once the responsible operator had returned to the United Kingdom, the St. Helena beacon station ZD7WR on 28.993MHz closed down in April.

Another Moon-bounce Success. Peter Blair, G3LTF, of Galleywood, near Chelmsford, Essex, added yet another 'first' to his already considerable list of record achievements when he established two-way contact by moon-bounce reflection (earth-moon-earth) with the U.S. East Coast amateur station W2NFA on April 14th. The contact began at 00.20 and ended an hour later; the frequency used being 1296MHz (23cm). A second contact was made the next day. Mr. Blair was using a 15-ft dish with crossed dipoles and reflectors and his transmitter produced an r.f. output of about 100 watts. During the same series of tests he was successful in contacting Dr. Hans Lauber, HB9RG, the Swiss amateur.

Third Party Communication. After many months of negotiation, authority has been granted for amateur stations in the United States and amateur stations operated by United States Forces personnel in West Berlin to exchange third party communications. Eligible West Berlin stations can be identified by call signs such as DL4Q and DL5Q. Third party communication with amateur stations in other parts of Germany is not authorized by the U.S. Government.

R.S.G.B. Exhibition. The annual exhibition organized by P. A. Thorogood, G4KD, on behalf of the Radio Society of Great Britain is to be held at the New Horticultural Hall, London S.W.1, from October 2nd to 5th.

New 2LO. The site of the amateur radio station to operate with the call GB2LO during the City of London Festival, to be held from July 8th to 20th, will be the *Daily Mirror* offices in Holborn Circus, a stone's throw from 107 Hatton Garden the original meeting place of the London Wireless Club and Wireless Society of London in 1913.

Rugby Radio Club, which was affiliated to the Wireless Society of London in 1921, has recently been re-activated under the title Rugby and District Amateur Radio and Electronics Club. The inaugural meeting was held at St. John Ambulance Brigade Headquarters, Regent Place, Rugby, and an invitation is extended to licensed radio amateurs and interested listeners in the area to contact R. T. Craxton, G3IKL, 103 Clifton Road, Rugby, or L. Austin, G3CYH, 12 Whittle Close, Bawnmore Road, Bilton, Rugby, for details of future meetings.

Canadian Radio Teletype. The Canadian Amateur Radio Teletype Group (C.A.R.T.G.) will again sponsor a World Wide RTTY DX Sweepstake during the weekend October 5th/6th. This go-ahead organization is responsible for the operation of VE3RTT (which puts out news and information about radio teletype from all parts of the world) and for *RTTY-News* (published monthly from 85 Fifeshire Road, Willowdale, Ontario, Canada).

Antique Equipment Wanted. Douglas Byrne, G3KPO, who is honorary secretary of the Peterborough Amateur Radio Society, is anxious to acquire wireless equipment, books and periodicals from the 1920 era, as the Society is in the process of forming a museum of wireless antiques. The antiques will be featured on a stand—"Wireless in the Twenties"—at an exhibition to be arranged in connection with a mobile rally on the banks of the River Nene, at Peterborough on September 2nd. Mr. Byrne's address is Jersey House, Eye, Peterborough.

JOHN CLARRICOATS G6CL

Answers to "Test Your Knowledge"—2

Questions on page 233

1. *(a)*. Coaxial cable is used at the lower microwave frequencies. Waveguide is used from about 3GHz to about 30GHz. Dielectric rod is convenient to use for microwave transmission at the highest frequencies. Twin transmission line radiates far too much to be any use above a few hundred MHz.

2. *(c)*. The dominant mode generally has the lowest attenuation at frequencies at which other modes can propagate, but not always.

3. *(d)*. An electric field which terminates at a wall is associated with charge in the surface; a magnetic field tangential to a wall is associated with a current in the surface.

4. *(c)*. The dominant mode in rectangular guide is TE_{10}.

5. *(a)*.

6. *(c)*. The skin depth at microwave frequencies is of the order of 0.001mm. Hence the inside surface of a waveguide must be clean and have a mirror finish.

7. *(d)*. The maximum bandwidth over which the dominant mode can be free from competing higher modes is one octave. This is only achieved if the narrow dimension is half the wide dimension or smaller. Power handling capacity increases and attenuation decreases with increase of the narrow dimension.

8. *(b)*. Since microwave components are designed to operate on the dominant mode, energy in any other mode would not be correctly processed and would set up large standing waves. Where two modes can propagate at a given frequency, energy launched in one mode will inevitably be partly transferred into the other mode.

9. *(c)*. Fields are set up in the guide which fall in amplitude exponentially with distance, but have no phase lag with distance and hence do not propagate energy. The electric and magnetic fields are in phase quadrature, and thus store energy.

10. *(b)*. This fact is not contrary to the principles of special relativity because phase is not a material entity.

11. *(a)*. The formula $1/\lambda^2_g = 1/\lambda^2 - 1/\lambda^2_c$ applies to any waveguide.

12. *(d)*. Some modes of propagation of energy at a given frequency will occur in a high conductivity tube of any cross-sectional shape provided the dimensions are appropriate.

13. *(b)*. The mode cut off wavelengths are all functions of guide dimensions only. The cut off frequencies will of course be different because the dielectric alters the velocity of an electromagnetic plane wave.

14. *(d)*. The dominant mode in coax, is the TEM mode with zero cut off frequency. Higher order waveguide-type modes can propagate at frequencies where the diameter of the outer conductor is a significant fraction of the plane-wavelength.

15. *(a)*.

16. *(d)*. The open end of a waveguide has dimensions which are a significant fraction of a wavelength. Hence an open waveguide acts as a rather inefficient aerial radiating away about $\frac{2}{3}$ of the incident energy and reflecting back the remainder.

Real and imaginary

By "Vector"

Random thoughts from an exhibition

The said exhibition being the I.E.A. But don't worry. I'm not going to trespass upon the territory of my betters by attempting a blow-by-blow description of the equipment on show. What follows will be a hotch-potch of thoughts triggered off by the show; the key word is 'random', or as Roget puts it, chance, indetermination, fortuity, contingence, lottery, raffle, tombola, sweepstake, toss-up, etc. The old stream of consciousness lark in fact.

First, a black mark to the organizers for their handling of the Interest and Function card situation. These cards were thrust on one and all in the exhibition approach corridor and were quite innocuous in themselves—demanding name of firm, area of interests and so on, the sort of information anyone would be pleased to give in the ordinary way. But along the corridor a string of notices carried a strong implication that entrance to the exhibition would be denied unless a completed form accompanied the admission ticket, thereby transforming what would have been a painless voluntary operation into something of a 1984-type edict from Big Brother.

One result of this was that the approach walls were lined with dutiful citizens all trying to make their ball-point pens operate against the earth's gravitational force because there was no level surface available on which to write. Another was to arouse the bolshy in me, so that I reached the barrier (and the final textual threat) with card uncompleted and its owner feeling more than a bit Sidney Cartonish. Anticlimax. The knife did not fall. No questions were asked; I was not hauled off to an underground torture chamber. The whole thing was a bluff.

Now, there is nothing more disconcerting to a martyr than to be done out of his rights; so, safely inside the hall, I filled in the wretched card with fictional data and handed it in. I mention this in case someone at the H.Q. of the organizers is going mad trying to locate a Mr. P. A. Rameter who is a manufacturer of tribifurcated microwidgets.

With that minor chip off my shoulder it's only fair to add that, to this observer at least, the exhibition itself was impressive and a credit to the organizers and exhibitors. These shows involve the dickens of a lot of hard work behind the scenes; a friend of mine who is a company exhibitions officer (but otherwise sound of mind) tells me that a well-stirred-up hornets' nest is a haven of tranquillity compared with an exhibition site on the night before opening. So, caps off, men, and pay due respect to the backroom boys and in particular your own company exhibitions bloke, who, amid all the turmoil, still finds time to utter a prayer that the rival stand just along the aisle may fall flat on its flamboyant fascia at the time of the opening ceremony.

And while we're in this expansive mood, spare a thought also for the staffs of the technical journals who, urged on by cruel editors armed with cats-o'-nine-tails, stagger from stand to stand—all of them—in order that non-visitant readers may get the picture. Thank Heaven I'm 'excused boots' on this chore. An all-electronics exhibition is bad enough, for goodness knows that field is now too wide for any one brain to cope with, but when the widest interpretations of instruments and automation have to be assimilated as well (as at the I.E.A. Exhibition)—enough said!

Any one of the big stands at such an exhibition carries enough hardware and information to keep one busy for several hours. But in these days of massive mergers and gargantuan groups it's pleasant to see the little firms on the perimeter stands still holding their own; picking up the crumbs fallen from the rich man's table maybe, but, let's hope, profitable crumbs notwithstanding. Sheer size does not necessarily equate with efficiency or quality and the little man does an invaluable job in catering for that 'one-off' special requirement which would be economically out of the question for big brother. It would be a sorry day if the chaps on the small stands were squeezed out of business or taken over.

Easily the most significant aspect of the show—to my mind at any rate—was the strength of American representation, which increases every year. Now, make no mistake about it, the U.S. electronics industry means business; our business. It has mounted a three-pronged attack; the first is a direct assault upon European markets with manufacturing plants built here, or on the Continent, to form the bridge-heads; the second, a relatively under-cover operation, is the quiet acquisition of more and more financial interests in European firms. The third (which I strongly suspect but cannot prove) is strictly fifth column stuff. This consists of such tactics as presenting us with a few American contracts; not enough to affect our economy substantially but enough to lull us to sleep with the thought that, after all, British is best and always will be, no matter what.

As I've said before, no hard feelings on these scores. Within the framework of the Big Business code of ethics they are perfectly legitimate tactics. My plaint is that we don't seem to realise that there *is* a war on; we continue to delude ourselves with mergers, pretentious meetings and symposia, interlarded with the adoption of mystic cults enshrined in the name of efficiency, in the pious belief that it will all come right in the end. It will not come right. Even in this computer age there is still no effective substitute for common sense and hard work, and this applies equally at all levels.

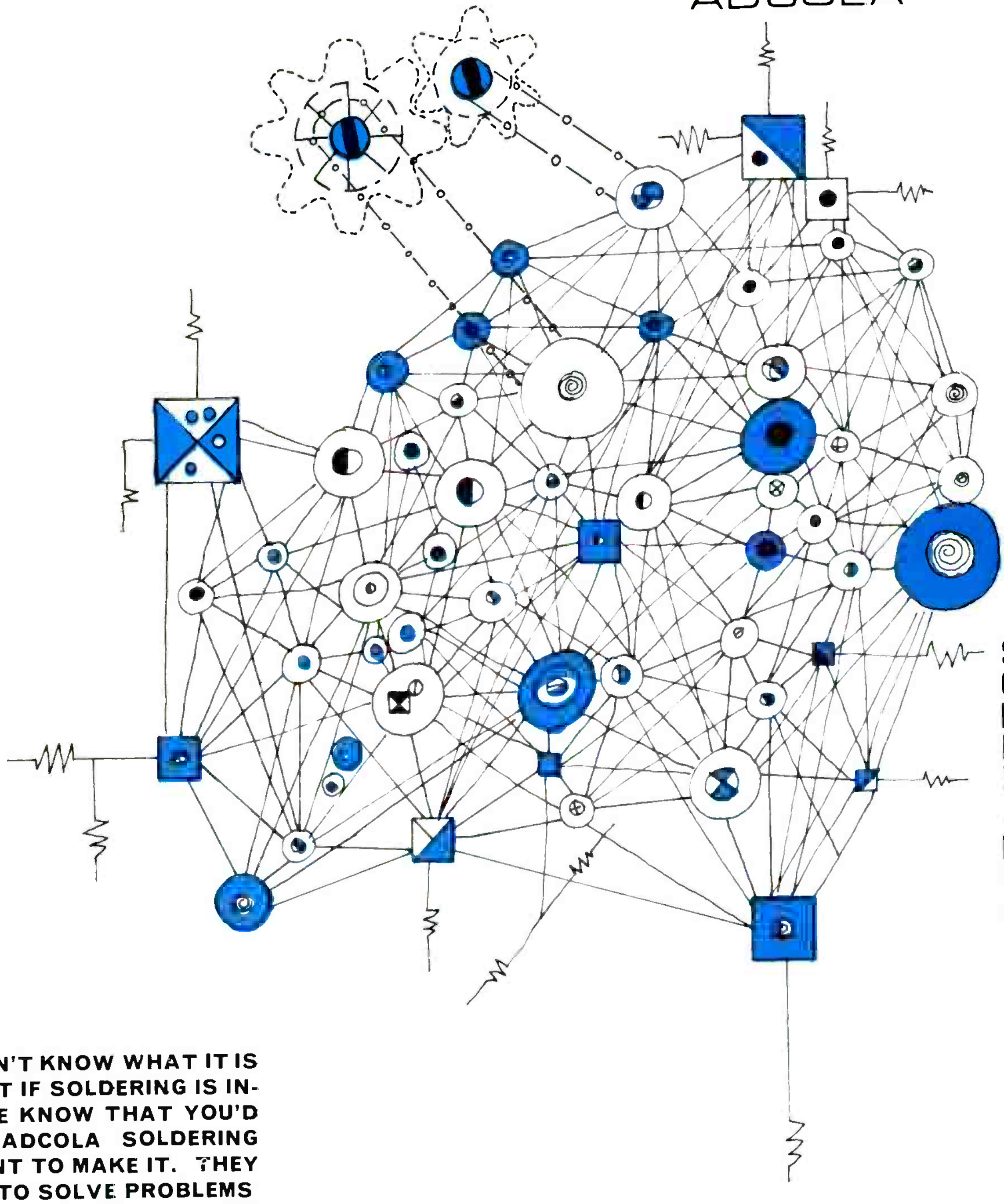
One or two correspondents have upbraided me for the recent sideswipe at the manual P.B.X. telephone situation. While their comments are much appreciated I'm still unrepentant. I know there are P.A.B.Xs available (albeit mostly electro-mechanical) but the fact remains that the vast majority of business organizations still use manually operated boards. So until someone can show me an all-electronic P.A.B.X. which is in very wide use throughout this country I shall continue to maintain that here is potential business which the electronics industry is missing. There may well be excellent British all-electronic P.A.B.Xs on offer but if this is so, the manufacturers have not stirred their stumps to the point of convincing business houses that here is something they can't afford to be without.

Admirable as the I.E.A. exhibition may be in itself, as far as electronics is concerned it is a closed oscillatory circuit, in the sense that both buyers and sellers are largely within the industry. This is fine as far as it goes, but electronics manufacture cannot feed on itself. It is a service industry and its markets lie with other industries and businesses which have no interest whatever in electronics unless it can be shown that such devices will improve their profitability. Such people will not be found at the I.E.A. because they don't think in MHz and dB. We, for our part, blandly expect people from a ladies fashion house (for example) to come to a sudden realization that the manual P.B.X. they use is out of date and to turn up at one of our exhibitions and buy an electronic version. Life for the sales staff would be simple if it worked like that, but unfortunately it doesn't.

Fashion Footnote

Full marks to the exhibitor (American, of course) for tumbling to the fact that even electronics engineers are human. He had a number of long-stemmed dollies walking around the show wearing silver dresses and boots to match. The hem-line was very mini and (it just so happened) embroidered on it at the back was the exhibitor's name. All sales talk ceased whenever one passed a stand. If lady readers want more details of the dress your correspondent is able to describe the hem-line minutely but is hazy regarding the rest.

ADCOLA



SOLDERING INSTRUMENTS.

NO, WE DON'T KNOW WHAT IT IS EITHER, BUT IF SOLDERING IS INVOLVED WE KNOW THAT YOU'D NEED AN ADCOLA SOLDERING INSTRUMENT TO MAKE IT. THEY ARE MADE TO SOLVE PROBLEMS SEND NOW FOR THE LATEST CATALOGUE.

ADCOLA
PRODUCTS LIMITED
(Regd Trade Mark)

ADCOLA HOUSE, GAUDEN ROAD,
LONDON, S.W.4 Tel. 01-622 0291/3
Telegrams: SOLJOINT LONDON S.W.4

NOW! the first oxide-free high purity extruded solder for printed circuit soldering machines, baths and pots

EXTRUSOL®

EXTRUSOL is a new concept in solder for solder machines, baths and pots used in the electronics industry.

EXTRUSOL is a very high purity solder which is also substantially free of oxides, sulphides and other undesirable elements.

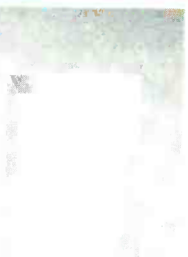
The percentages of impurities in **EXTRUSOL** are considerably lower than those quoted in national or company specifications, thus providing a solder more suitable for use in the electronics industry.

ADVANTAGES OF EXTRUSOL

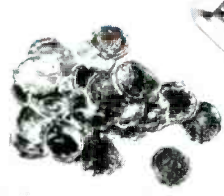
1. Less dross on initial melting
2. More soldered joints per pound of solder purchased
3. Less reject joints
4. Improved wetting of electronic components and printed circuit boards
5. More uniform results

ALL EXTRUSOL IS COMPLETELY PROTECTED BY PLASTIC FILM FROM THE MOMENT OF MANUFACTURE UNTIL IT IS USED

A section of a typical cast solder bar. Note the surface dross and general contamination.



A section of an **EXTRUSOL** bar with the plastic coating removed showing no dross or contamination.



Solder chips which are usually made by dripping solder alloy on to a metal surface.

EXTRUSOL precision made solder pellets individually cut to a standard size from extruded rod.

EXTRUSOL does not only possess better physical appearance, with freedom from oxide and contamination, but the alloys are formulated to contain a much lower percentage of impurities.

EXTRUSOL is supplied in 1-lb. and 2-lb. Trapezium Bars and Pellets in different alloys with strictly controlled tin contents to suit the appropriate soldering machines, baths and pots. Bars are available for automatic solder feed.

Write for details of **EXTRUSOL** and literature about Ersin Fluxes and Chemicals for printed circuit soldering machines, baths and pots.

Multicore Solders Ltd.
Hemel Hempstead, Herts.
Tel: Hemel Hempstead 3636 Telex: 82363

WW—002 FOR FURTHER DETAILS