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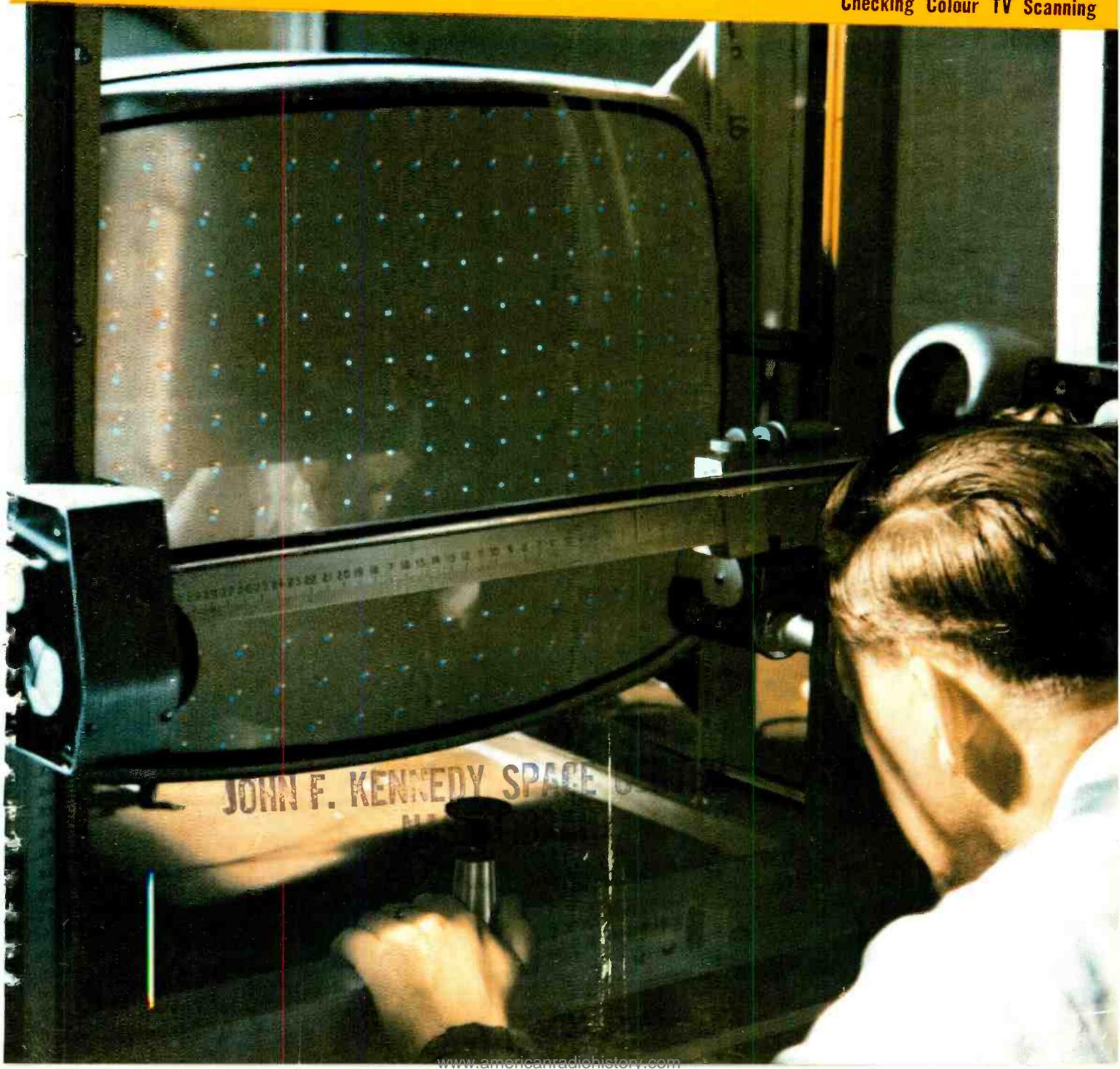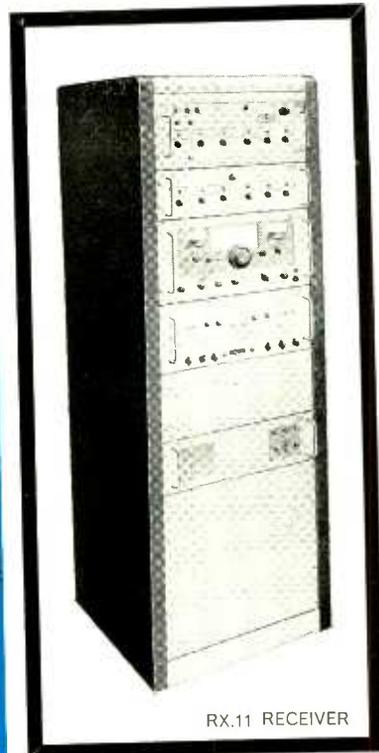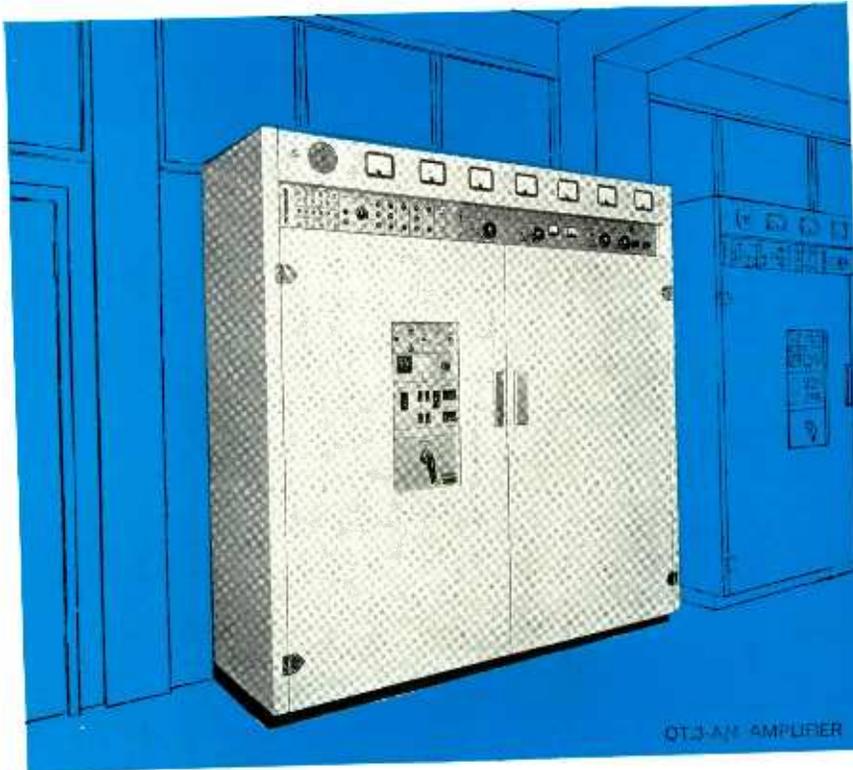
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MARCH 1967

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The Wisdom of the Specialist

WHAT are we to do about specialization? The problem is particularly acute in electronics, with its exponential rate of development. The danger is, of course, that the individual specialists (as represented, for example, by the professional groups of the institutions) are becoming so isolated from each other that communication between them may break down altogether. Then there is the law of diminishing returns from their efforts, expressed by the cynical old adage: " a specialist is a man who learns more and more about less and less until he ends by knowing everything about nothing." But we must have people working at the frontiers. Specialization is the price we have to pay for excellence.

Fortunately there are several negative-feedback mechanisms opposing the gain in specialization. Advanced techniques tend to become absorbed in general practice and eventually are superseded by others. The people working on them consequently have to shift their ground—or perhaps move to entirely different fields if economic pressure is severe enough—and so, by force of circumstances, broaden their knowledge. At the same time the natural tendency of the human mind to categorize new knowledge and form generalizations ensures that the *theory* arising from a new technique becomes integrated with an existing body of theory. Then, by the nature of engineering it is often necessary for specialists to work together on the building of a system. The communication barriers are broken down by the sheer necessity of making the thing work.

Systems engineering could, in fact, be the means of building bridges between the different islands of technology. It would be nice to think that systems theory (engineering theory independent of particular kinds of hardware) is doing this already. But, ironically, systems theory has itself become the province of specialists of the most exclusive kind—academics and like-minded people who get intellectual satisfaction in creating for themselves closed little worlds of pure abstraction by cleansing engineering techniques from the contamination of the crude business of making things work. Control theory and network theory are two notorious examples. In such circumstances systems studies are not likely to be very successful in achieving integration. However, one lives in hope.

The educational world is, of course, very much aware of the problems of specialization. Unfortunately educationists seem to be tackling it in a way which goes against human experience and is therefore unlikely to be successful. They take the view that the student ought to have a broad basic training in principles common to all engineering before he becomes a specialist, so that he will be well equipped to cope with any situations he may have to face in the future—hence the C.E.I's common examination for membership of its 13 constituent institutions. But how much of this initial broad training will really stick? Human beings, from the moment they are born, acquire knowledge and wisdom by progressing in easy stages from the particular and concrete (e.g. how to get food and comfort) to the general and abstract (e.g. studying philosophy). If you try to teach them general principles before you have given them a multitude of practical examples—try to put the wisdom before the knowledge—you will get nowhere.

The intelligent electronics specialist discovers with delight that he can use the narrow but familiar concepts of his own field as analogies to help him understand more general phenomena in physics and mechanics. Such flashes of insight, in which one suddenly becomes aware of relationships between different worlds, are the stuff of which true education is made. It is this knowledge possessed by the mature specialist which provides one of the richest soils for developing the wisdom that is supposed to characterize the complete engineer. Perhaps one day our educators will find the means for developing it. Meanwhile the specialists must continue, officially, as specialists.

Colour Receiver Techniques – 3

A Million Spots Before Your Eyes

A LOOK AT THE PICTURE TUBE IN A MODERN COLOUR TELEVISION RECEIVER
TO SEE HOW IT WORKS AND HOW IT IS DRIVEN BY THE RECEIVER ITSELF

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

SINCE J. L. Baird set up his first flickering colour-television demonstration in 1928, many forms of display have been proposed but only one has achieved common commercial use. This in the " shadow-mask " cathode-ray tube to be described below. If you are interested in the other types, you will find a full account in " Fundamentals of Display Systems " by H. H. Poole, Macmillan, 1966.

You can get an idea of what the colour tube in a commercial receiver looks like from Fig. 1. A typical modern commercial tube on its own is shown in Fig. 1 (a) while in Fig. 1 (b) it appears fitted with the various accessories that will be mounted on it in the receiver.

Fig. 2 illustrates the principles on which this type of tube operates. Basically, as Fig. 2 (a) shows, *three* electron guns in the tube neck fire separate electron beams towards a phosphor coating on the inside of the front glass screen. (Many will recognise this as a refinement of the monochrome picture tube where a single gun fires a single beam towards the screen). Between the three guns and the screen lies a perforated metal screen with a regular pattern of holes in it. This screen is called a " shadow mask "—which gives rise to the name applied to this type of tube. Now, in a black-and-white television tube the inside of the screen is coated with a single continuous film of phosphor which glows " white " when struck by the electron beam. In the colour tube, on the other hand, three separate phosphors are used which, when struck by an electron beam, give rise to red, green and blue light respectively. These phosphors are not coated evenly over the screen, but are arranged in a mosaic of discrete dots, with one red, one green and one blue dot opposite each hole in the shadow mask.

The three guns in the colour tube are arranged so that their electron beams, as they sweep across the screen to produce the picture display, all converge on the holes in the shadow mask. Opposite each hole in the mask three separate phosphor dots (to glow red, green and blue) are deposited on the screen. As the three beams pass through a hole in the mask, they separate again as shown in Fig. 2 (a) and each falls on its corresponding phosphor dot. Thus one gun called the " red " gun activates all the " red " dots; another, the " green " gun, all the " green " dots; and the third, the " blue " gun, all the " blue " dots.

Fig. 2 (b) shows the shadow-mask and phosphor-dot screen arrangement

Fig. 1. Typical modern 25-in colour television receiver tube (Mullard A63-11X): (a) tube alone; (b) neck of tube complete with associated coils and other fitments.

*Newmarket Transistors Ltd.

in more detail, illustrating the regular cluster of three phosphor dots lined up with each hole in the shadow mask. The diagram shows the beams as being thin enough to pass through only one hole, but in practice the electron beams will cover about five holes of the shadow mask and activate the corresponding five triads of phosphor dots.

You can get an idea of the number and size of the phosphor dots from the mask hole spacings used. In a typical 25in tube, the mask holes are spaced on a 0.75mm grid, i.e. 0.030in apart. This means that the phosphor dots are about 0.010 inch in diameter and almost touching one another. With a usable screen area of about 20in × 15½in as in a 25in tube, this gives rise to about one-third of a million each of red, green and blue dots. Now you can see the explanation of the cryptic title of this article. (With a 19in tube, mask holes are spaced 0.025in apart, giving rise again to a million phosphor dots on the useful screen area of about 16in × 12½in).

When not activated by the electron beams, the phosphor dots all have the same creamy appearance as the phosphor on a monochrome tube. Thus it is not easy to distinguish a colour tube just by looking at it from a distance when the receiver is switched off. Close up, however, you can see the dot grain structure.

As the holes in the shadow mask represent only about 25% of the mask area, only a quarter of the electrons from each gun reach the screen. The three guns together therefore have about 75% $(=3 \times 25\%)$ beam transmission as compared with a single-gun monochrome tube. This is compensated for by working at a higher e.h.t. voltage, but it gives rise to a problem of heat dissipation not found in the monochrome tube. As the mask absorbs so many electrons, it gets hot. Out of a typical mean beam current of 1mA in total from the three guns, the mask captures ¾mA, which with the 25kV e.h.t. commonly used is converted to about 20W heat dissipation.

In the next section we shall go on to give some details of the structure of the modern shadow-mask colour tube, but at this point you should note that these tubes currently use electromagnetic deflection and electrostatic focusing, as in black-and-white practice. In the colour tube, however, the need to ensure that the three beams converge on the correct phosphor dots calls for an additional "convergence" arrangement using a combination of dynamic electromagnetic and static magnetic deflection.

TYPICAL MODERN COLOUR TELEVISION TUBE

Fig. 3 illustrates diagrammatically the main constructional features of a modern colour television tube. A triple-gun assembly in the neck can be seen firing three separate beams of electrons towards the shadow-mask. After they pass through the mask, the electrons activate the array of red, green and blue phosphor dots on the inside of the front glass screen.

The screen is rectangular and of approximately 4 : 3 aspect ratio. Earlier colour TV sets used a 21in diameter round-faced tube, but the modern trend is towards rectangular tubes.

In the U.S.A. and Japan, a variety of rectangular tubes have been used, with diameters varying from 6in through 9in, 11in, 15in, 19in, 23in up to 25in. In the U.K. indications are that, initially at least, only two tubes will be popular: a 25in (21in × 15½in), such as the Mullard A63-11X or Thorn-AEI V3508A, and a 19in (16in × 12½in), such as the A49-11X or V3509A.

Different phosphors are used for the screen dots. The green and blue are normally zinc cadmium sulphide, silver activated and recently the red phosphor has tended to be a rare earth such as yttrium orthovanadate, euro-
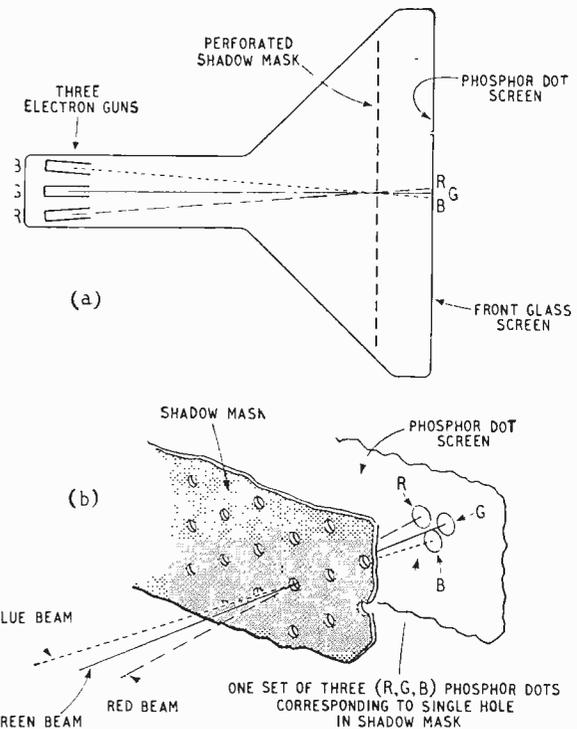
Fig. 2. Simplified diagram showing principle of operation of shadow mask in three-gun colour tube: (a) beams from three "colour" guns converging on shadow mask and diverging to screen; (b) close-up of shadow mask and screen.

pium activated. The phosphor screen is aluminised as in monochrome tubes, thus making it possible to dispense with ion traps in the electron guns. The tubes are fitted with special rim-bands, making them implosion proof. For the screen cerium-oxide type glass is used, eliminating the discoloration that is caused in ordinary glass from the X-rays arising from the 25kV e.h.t.

The shadow mask itself is 0.006in thick steel, mounted about 0.6in from the phosphor screen. As it gets hot in use, it is mounted so that it does not buckle, and as it expands, moves along the line of the electron beams so that the hole alignment with the screen phosphor dots is not impaired.

Modern colour tubes are compact "ninety-degree" type. This means a 90° deflection from one corner of the screen to the diagonally opposite corner (about 80° horizontally and 60° vertically). This wide angle makes possible a short tube about the same overall length as the screen width. The first generation, round-faced colour tubes, being only 70° deflection, were relatively much longer.

The neck diameter of these second-generation rectangular tubes is about 37 mm (just under 1½in) as compared with the 2in diameter common with the old round 21in tube. The importance of this lies in the lower deflection power possible with the narrower neck, round which deflection coils can be closer to the electron beams.

Other significant external features of the shadow-mask tube can also be seen in Fig. 3(a). A metal band at the front round the screen is fitted with mounting lugs and serves to support the tube (which weighs a not inconsiderable 38 lb or so on its own). An external "aqua-

dag " conductive coating on the outside of the tube flare forms a capacitor with the final anode coating on the inside of the glass.

Except for e.h.t., electrical connections to the tube are via pins at the end of the tube neck, which are internally connected to the guns, orientated in the neck as shown in Fig. 3(a). The tube is operated with the blue gun uppermost. The guns are of identical construction as illustrated in detail in Fig. 3(b) for the blue gun. Electrons emitted from the cathode k (with internal heater h-h) pass through control grid g, and are focused by the first anode a_1. They then pass through the accelerating second anode a_2 (common to all guns) to the commoned final anodes a_3 and a_4. Note that a_3 and a_4 are internally connected together and to the shadow-mask and screen. (It is worth noting also that, in American practice, g is known as g_1, a_1 as g_2, a_2 as g_3 and a_3, a_1 as " final anode ".)

Apart from the various electrodes indicated, the guns also include metal polepieces to be aligned with external coil and static magnet assemblies for adjusting beam convergence at the shadow-mask. Fig. 3(b) shows how these

convergence polepieces are positioned in a single gun.

Fig. 3(c) gives in a tube cross-section some detail of the blue lateral convergence arrangement. Only one external magnetic assembly is used and this controls the lateral position of the blue beam.

Fig. 3(d) gives more detail of the internal radial convergence polepieces in a cross-section of the complete tube neck covering all three guns. Varying the external magnet field moves the electron beams in and out from the tube axis. A separate external magnet assembly is associated with each of the three beams.

VOLTAGES APPLIED TO COLOUR TUBE

As mentioned earlier, except for the e.h.t. which is applied to a stud on the tube flare, voltage connections are made via pins at the end of the tube neck. Fig. 4(a) shows the B14G-JEDEC B12-244 standard 14-pin base currently used, with the separate stud connection for $a_{3,4}$. One significant point about the electrode connections that should be noted is that pin 9, taking about 5kV to a_2, has two blank pins on either side for safety isolation. This is the only e.h.t. connection to the base pins.

Fig. 4(b) shows how the various internal electrodes in the three guns connect with the base pins and e.h.t. stud. It also shows typical bias and signal voltages to be expected at the various electrode pins.

The three tube guns have separate cathode heaters, brought out to one pair of base pins. Fig. 4(b) shows them in series for ease of illustration, but they are usually paralleled in practice, and require 6.3V a.c. Total heater current varies with different makes from 0.9 to 1.3A.

The three separate cathodes—k_G, k_B, and k_R—in Fig. 4 each have in use a d.c. potential of about + 250V with respect to ground. They are usually d.c.-coupled to the luminance (video) output valve anode, whose mean d.c. voltage is controlled by a brightness potentiometer in its grid stage. This luminance output valve also supplies to the tube cathodes a 5Mc/s wideband a.c. signal up to 130V peak-to-peak. The design of the luminance drive to the tube must take into account that the stray capacitance of the cathodes total about 15pF.

The three control grids—g_B, g_G, and g_R—in Fig. 4 receive 1Mc/s wideband a.c. signals, up to 180V peak-to-peak, from the colour-difference output valves. These signals are superimposed on d.c. bias voltages of around 150V applied directly to the control grids from preset potentiometers. Each grid has a stray capacitance of around 7pF, and the external circuit resistance from any grid to its cathode must be kept to less than 750kΩ.

The first " accelerating " anodes—a_{1B}, a_{1G}, and a_{1R}—have separate preset d.c. bias voltages of around 300-500V applied to them. Each anode has a typical stray capacitance of 7pF.

In Fig. 4 you will see the second anodes, a_2, of the three guns are internally connected together. A preset d.c. voltage of about 4.5kV applied to the a_2 pin provides
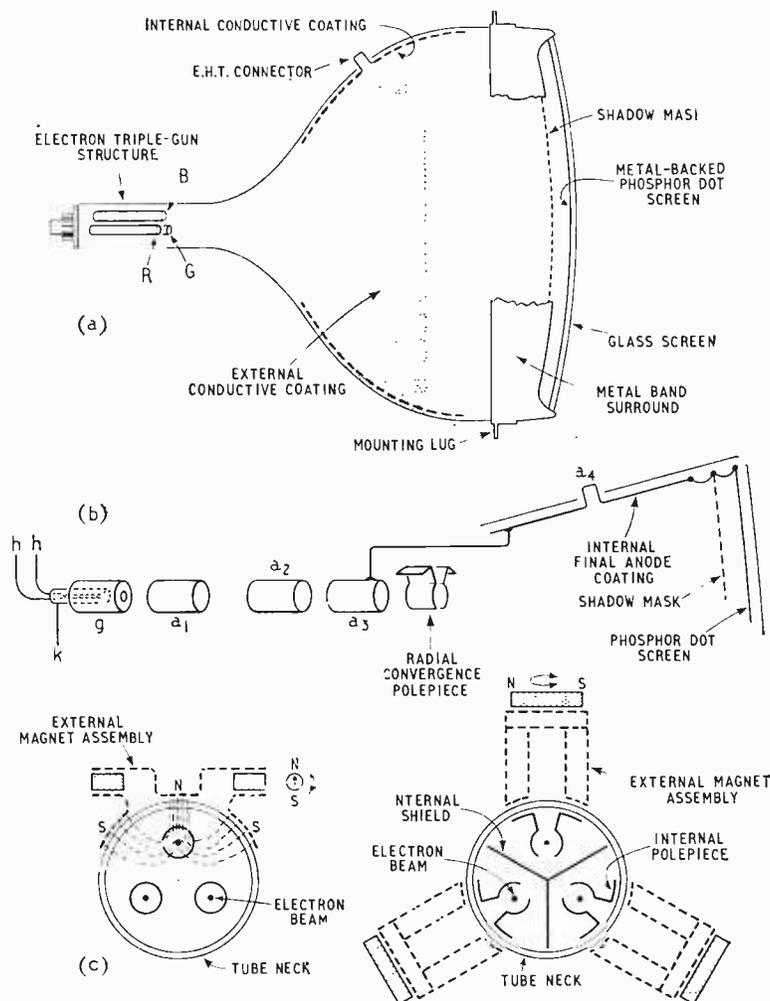

Fig. 3. Simplified diagram of the internal elements of a colour tube: (a) overall sketch; (b) exploded diagram of blue gun as typical of each of three guns; (c) blue lateral convergence assembly in cross section diagram of tube; (d) radial convergence polepieces also in cross section.

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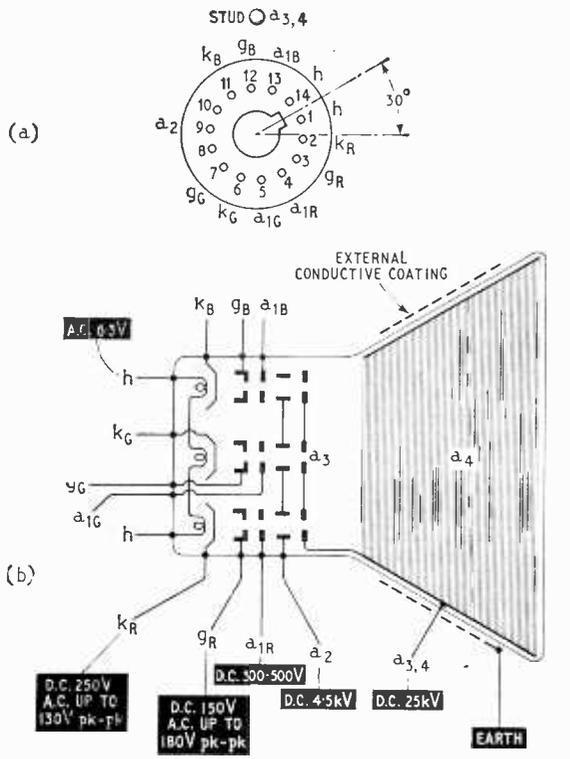
Fig. 4. How voltages are applied to colour television tube: (a) diagram of tube base showing identification of pins; (b) tube electrodes with typical applied voltages, a.c. and d.c.

a single focusing control for all three beams. This second anode voltage usually lies at between 17 and 20% of the final anode voltage, and the tube design requires that the external circuit resistance from a_2 to k does not exceed 7.5M.Ω

The final anode, $a_{3,4}$, in Fig. 4(b) comprises three anodes a_3, commoned in the gun assembly, internally connected to a conductive coating on the inside of the tube flare and to the shadow-mask and phosphor screen. The external electrical connection is via a stud through the glass on the flare to the 25kV d.c. e.h.t. supply. The a_4 internal conductive coating forms a capacitance of 2,000pF through the glass with the external conductive coating. By earthing the external coating, this capacitance can be used to smooth the e.h.t. supply.

CURRENTS APPLIED TO COLOUR TUBE

Currents applied to coils around the colour tube neck are used to control beam deflection and convergence. Normally three separate adjustable coil assemblies for deflection (scan), radial convergence and blue lateral convergence are used, in overall appearance and location somewhat like the sketch in Fig. 5(a).

Reduced to essentials, the component coils lie around the tube neck as shown in Fig. 5(b). In the deflection yoke, the field coils are positioned vertically and receive sawtooth sweep currents from the field timebase and adjustable d.c. from the preset vertical shift control. The line coils in the yoke lie horizontally and receive from the line timebase a sawtooth a.c. drive and adjustable d.c.

from the horizontal shift control of the receiver.

The coil orientations in the radial convergence yoke can also be seen in Fig. 5(b). Each gun has associated with it a pair of coils with magnetic field axes tangential to the tube cross-section, i.e. at right angles to the electron beams. The coils in each pair receive parabolic convergence-correcting currents, one from the field and the other from the line timebase.

Finally in Fig. 5(b) will be seen the basic arrangement of the separate blue lateral convergence coil, whose axial field points vertically downwards directly into the blue electron beam. This coil receives a parabolic current from the line timebase only.

In the three sets of coil assemblies described, the deflection yoke sweeps the three electron beams in unison over the screen; the radial convergence yoke adds compensating deflections to each beam separately away from the screen centre to keep the three converging properly at the mask holes all over; finally the blue convergence yoke adds horizontal compensating deflections away from the screen centre to provide special additional corrections for the blue beam on its own.

STATIC MAGNETIC FIELDS APPLIED TO TUBE

In the scan deflection system, it was noted above that d.c. shift was achieved by direct currents in the deflection yoke coils. In the convergence system, however, " d.c.
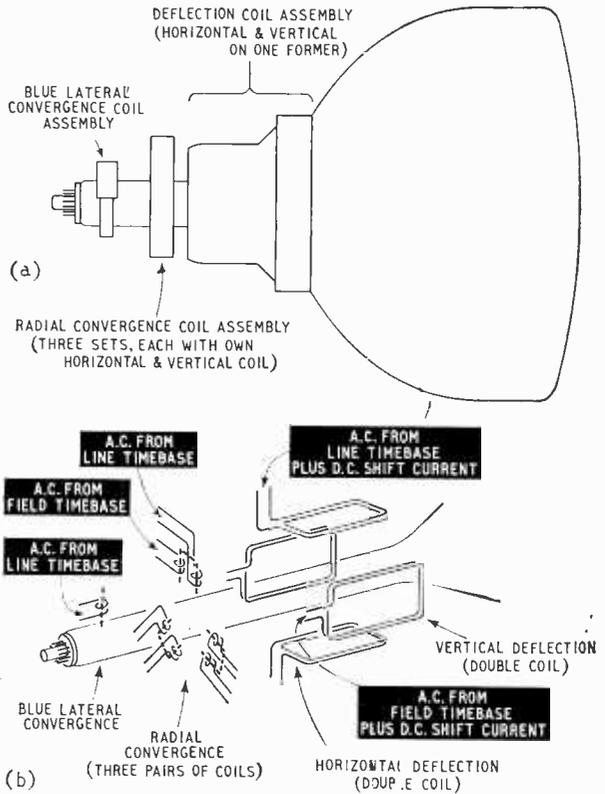
Fig. 5. How currents are applied to colour television tube: (a) outline sketch of coil assemblies through which control currents are passed; (b) diagrammatic representation of tube coils with applied currents, a.c. and d.c.

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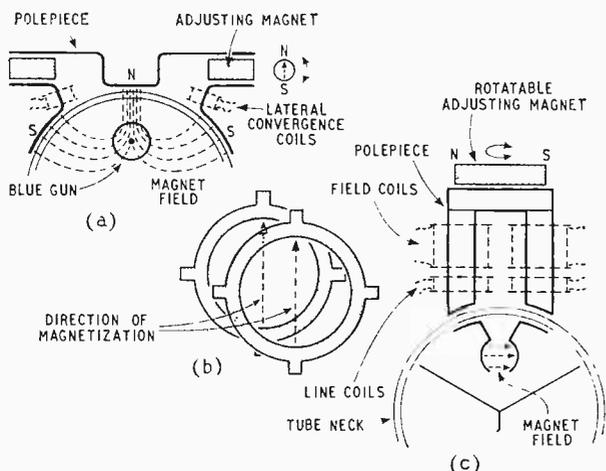
Fig. 6. Permanent magnets used to control electron beams in colour tube: (a) blue lateral convergence magnet details; (b) purity magnet details; (c) radial convergence magnet details (one gun out of three).

shift," i.e. adjustment of the initial settings of each of the three beams at the screen centre, is by means of adjustable permanent magnets around the tube neck. These magnets fall into three main sets, as indicated diagramatically in Fig. 7. Before we consider these, it should be remembered that the earth's magnetic field also affects the beams. For this reason, the tube is always operated with the axis horizontal. In addition, the blue gun is always arranged on top, because the blue image has least luminance and produces least visual distress when it is in error. With the red and green guns symmetrically underneath, they have similar convergence errors which can be most effectively compensated in a symmetrical arrangement. To reduce the spurious effects of stray ambient magnetic fields, an additional precaution is the magnetic metal shell which covers the tube from near the neck up to the screen, also indicated in Fig. 7.

Starting in Fig. 7 with the blue convergence magnet nearest the tube base, you find this magnet arranged so that its field points directly into the tube axis, and affects the blue beam only. In practice, it is an integral part of the blue lateral convergence coil assembly. Fig. 6(a) shows a typical arrangement in cross section across the tube. Adjustable magnets in sleeves act on fixed polepieces to produce a presettable magnetic field radially in towards the tube axis through the blue beam. Shifting the adjustable magnets varies the strength of the magnetic field through the electron beam and shifts the blue beam horizontally.

The second " purity " magnet assembly in the middle in Fig. 7 is in effect a magnet which can be shifted round the tube neck to produce a field of preset strength in any direction at right angles to the tube axis. This field acts on all three beams simultaneously. The arrangement is called the purity magnet because it is used to line up the beams at the centre of the screen so that when they pass through the mask hole they each fall on their correct colour phosphor dot. This ensures that the corresponding colours are " pure "; e.g. the red beam activates only the red phosphor dots. The purity magnet assembly usually takes the form of two rings as in Fig. 6(b), magnetized along a diameter. By offsetting one from the other, their fields can be made to aid or oppose each other, so that the overall field strength inside the tube neck can be varied. Also, by rotating the two magnets

together round the neck, the direction of the field can be varied. This makes it possible to shift the three beams together radially and tangentially, to the required trajectory for colour purity.

The third permanent magnet assembly in Fig. 7 comprises three " radial convergence " magnets shown ideally located round the tube neck nearest the screen. These are arranged with the help of polepieces inside the tube so that each magnet affects only one beam. In any one beam the magnetic field acts at right angles to the beam and to the radius on which the beam lies from the tube axis. As a result, if the strength of the field is varied, the beam is shifted radially out or in from the axis. This enables each beam to be controlled independently to ensure that they all converge exactly at the shadow-mask. Away from the screen centre, it will be remembered, convergence at the mask is further ensured by the radial convergence coils described earlier. The radial convergence magnets, therefore, not unexpectedly, are found combined physically with the radial convergence coils in a single assembly. Fig. 3(d) earlier gave an outline of the complete assembly. Now in Fig. 6(c) you can see fuller details of the arrangement for one gun. An adjustable permanent magnet is incorporated in the core of the convergence coil assembly which acts through internal polepieces to produce a transverse field to displace the electron beam radially. By rotating the magnet, its effective strength is varied and the beam can be shifted in or out from the tube axis. In practice, the radial convergence magnets are used for separate adjustment to make the three beams converge at the screen centre.

Colour purity can be rather easily upset by stray magnetic fields. For this reason, it is necessary, before adjusting convergence and purity magnets, to " degauss " or demagnetize the tube. This is done by saturating the whole assembly of coils, magnets and screens with an a.c. magnetic field which is gradually reduced to zero. Practically, this is done with a large coil of wire, energized from the mains, which is moved about near the tube and then slowly withdrawn to a distance.

COLOUR TUBE COMPLETE ASSEMBLY

We have discussed individually the various accessories to the colour tube proper. Fig. 7 is designed to show how all these fit together. It gives a composite silhouette sketch diagram of a complete colour television cathode-ray tube as installed in the receiver. Mounting lugs, attached to the metal band round the tube just behind the screen, support the tube. Behind the metal band, a metal screen magnetically shields much of the tube flare, and on the flare itself you can see the final anode connection stud contact. Working along the neck from the screen you come first to the deflection yoke, then the radial convergence assembly of coils and magnets. Next comes the double purity magnet followed by the blue lateral convergence assembly, just in front of the tube

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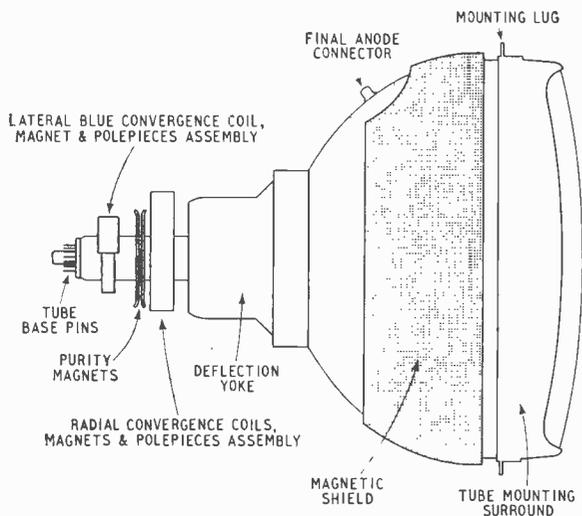
Fig. 7. Composite sketch diagram of complete colour television cathode-ray tube as installed in receiver with all fitments attached.

LATERAL BLUE CONVERGENCE COIL, MAGNET & POLEPIECES ASSEMBLY

FINAL ANODE CONNECTOR

MOUNTING LUG

TUBE BASE PINS

PURITY MAGNETS

DEFLECTION YOKE

RADIAL CONVERGENCE COILS, MAGNETS & POLEPIECES ASSEMBLY

MAGNETIC SHIELD

TUBE MOUNTING SURROUND

by a potential of more than about 16kV, the tube and its associated e.h.t. rectifier and stabilizer valves are sources of possibly dangerous X-rays. However, the modern tube with its integral implosion-guard and screen reduces the X-ray level at the front surface of the glass to the safe level of below ½mR/hr. If you have occasion to work inside a set around a colour tube, be most careful to replace all screens around the e.h.t. supply section before switching on.

Flashover between tube electrodes is a greater danger with the 25kV e.h.t. used for colour tubes than with lower e.h.t. voltage monochrome tubes, and much more attention is paid to this feature in colour tube design and servicing procedures.

Anyone who knows the details of a black-and-white tube must realize by now that a colour tube must be a much more costly item to produce, and this is one of the main reasons why, for the present at least, colour receivers must be much more expensive than monochrome sets to the same general specification.

Much research is going on into colour picture tubes other than the shadow-mask type, but at the time of writing none is capable of producing acceptable colour pictures, and it seems that the direct viewing, three-gun shadow-mask type will carry the brunt of commercial television for a long time to come.

Corrections.—In Fig. 4(a) in the February issue (p. 65) the delay line in the luminance section should be shown as 1μsec, not 64μsec. On pp. 63-44 the vision i.f. should be 39.50Mc/s.

base. (This is current British practice, but overseas the purity magnet may be found behind the blue convergence assembly next to the tube base.)

As colour tubes operate with an e.h.t. of around 25kV, and X-radiation can arise when electrons are accelerated

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LITHIUM TANTALATE OPTICAL MODULATORS

ONE of the most efficient light modulators to be known so far relies on the Pockels electro-optic effect (similar to the Kerr effect but applicable to crystals instead of liquids) and has been developed for use with p.c.m. by Bell Telephone Laos. The high-speed optical gate consists of a thin rod of lithium tantalate. Previously, KDP (potassium di-hydrogen phosphate) crystals have been the most frequently used electro-optic material.

To produce 100% modulation, only 1/20 of the power required by KDP is needed, which can conveniently be supplied from a transistor pulse amplifier. Such would require only 10 mW of power giving a drive voltage of 30 V across about 5 pF (for 100% modulation).

The plane of polarization of light pulses (from a helium-neon laser) passing through the crystal is rotated by 90° in the presence of an electrical pulse, allowing light to pass through an analyser to the transmission medium (the light would have previously passed through a polarizer).

The width of the pulses from the helium-neon laser allows four pulses to be inserted during each p.c.m. pulse period, so the maximum potential speed of this optical system is 896 megabits/sec. (This bit-rate, corresponding to a bandwidth of 1.6 Gc/s is achieved using four modulators.)
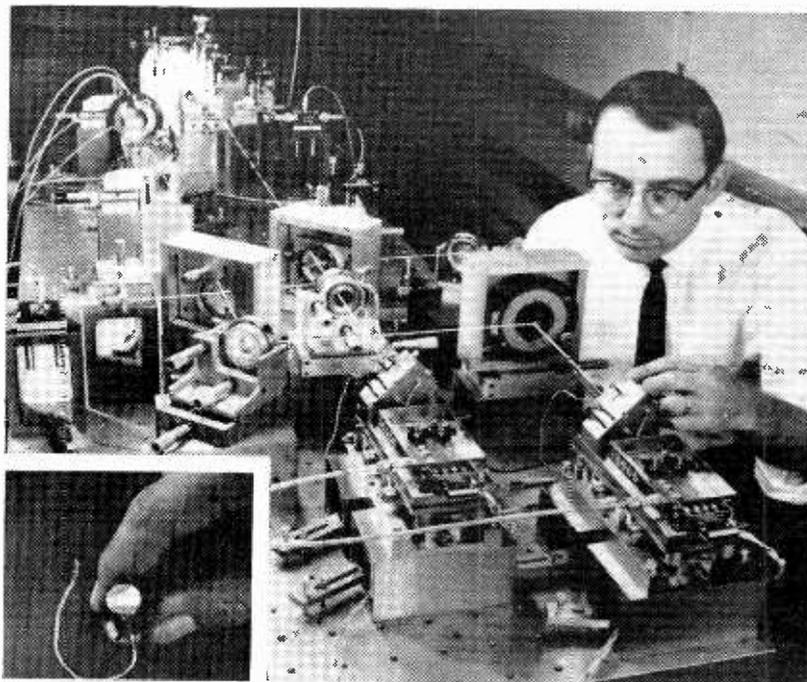
Two signals, pulse code modulated at a rate of 200 million bit/sec by lithium tantalate crystals, are produced by the modulators in the picture. A typical crystal on a copper heat sink is shown in the insert.

WORLD OF WIRELESS

Communal Broadcasting Service

THIS was the title the P.M.G. gave to the proposed v.h.f. local broadcasting service when he was speaking recently at the luncheon of the Radio Industries Club. He announced that about 100 towns had expressed interest in the experiment and that nine will be selected jointly by the B.B.C. and the P.M.G. himself. Three of these stations are to start broadcasting this year and the other six in 1968.

The Government White Paper on broadcasting proposed that these stations, to be provided by the B.B.C., should be operated by local authorities.

The only section of Band II that is so far not being used by the B.B.C. for its v.h.f. sound broadcasting service is that above 94.8 Mc/s, which is at present being used by the police and other civil services. In the Stockholm plan for v.h.f. broadcasting drawn up in 1952 there are allocations for about 140 local area broadcasting stations in this part of Band II. The British delegation to the Stockholm Conference obviously foresaw the need for utilizing the v.h.f. band for local broadcasting.

At the luncheon the P.M.G. called for the co-operation of manufacturers to produce " cheap v.h.f. transistor sets " for sale in the towns in which the experiment is to take place. According to figures he quoted it is estimated that the number of v.h.f. sets in use throughout the country is of the order of only 5M. We question the wisdom of producing a simple set for these local stations; would not the purchaser also want to listen to the existing three B.B.C. services on v.h.f.? If a cheap set is produced the advantages of f.m. will surely be nullified.

E.I.D. Apprentice School

AT the annual prizegiving for E.I.D. apprentices held on 6th January at the Electrical Inspection Directorate Headquarters, Bromley, Kent, it was stated that the number of apprentices now receiving full-time training was 161, and the intake target is now 60 boys per year. Educational requirements for acceptance as an apprentice are that the boy must be studying for G.C.E. " O " levels in mathematics, physics, English, and one other subject and be between 16 and 17 years of age. Although the normal apprenticeship period is four years for National Certificate or City and Guilds courses it is increased to five years where boys wish to complete H.N.D., or other advanced courses. Full electronic training, and basic mechanical engineering practice is given in the new school buildings at Bromley. The *Wireless World* oscilloscope in the photograph was constructed by E.I.D. apprentices. A calibration unit was added to the original design, giving a range of six calibrated square waves at a frequency of 1 kc/s, but with varying amplitudes. Other added features included extending the frequency response of the Y amplifier to 16 Mc/s.
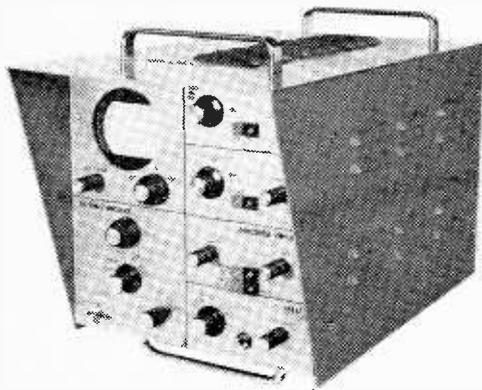
No U.K. Citizens' Band

FOLLOWING recent statements deploring the unlicensed use of walkie-talkie transceivers, rumours of the G.P.O. considering an allocated U.K. citizens' waveband 'have no foundation say the Post Office. Using the experience accumulated by other countries who have found in such bands chaos often results, the G.P.O. add a further argument in support of their decision—that of interference. The instability of cheap imported transceivers can cause interference not only on their fundamental operating frequency if mistuned, but also on harmonics. The G.P.O. suggest that by using professional quality sets the purpose of a citizens' band would probably be defeated, the cost being prohibitive for the average citizen.

U.S. "Public Television"?

IN the U.S.A. a national commission has called for a non-commercial television service run by a government chartered corporation. The service, it was said by a member of the commission, would be encouraged " to rebel, criticize and to protest." The commission, which was financed by the Carnegie Corporation Philanthropic Organisation, predicted the system would eventually include 380 U.S. stations and suggested naming it " Public Television." The progammes they conceive to be of the essence of this public television service are in general not economic for commercial sponsorship. The proposed new service would be financed initially by a 2% tax and later by a 5% tax on sets.

Microwave Integrated Circuits, a new field of components technology primarily concerned with surfaces, is the subject of a three-year research programme just started at the University of Warwick's School of Engineering Science. The Science Research Council has provided a grant of £26,000 to assist the work, which will be directed by M. K. McPhun (formerly with Mullard Research Laboratories). Research will be concentrated on lumped components made in thin and thick films. At microwave frequencies this means that the components must be very small. Conventional thin-film techniques will be used, but dimensions will be of the same order as those in monolithic integrated circuits.

The three annual **awards for apprentices** made by the Telecommunication Engineering and Manufacturing Association were presented at the Association's annual dinner on February 7th. The recipients in the three different grades of apprenticeship, all of whom had submitted an essay on some aspect of their work or training, were A. G. Carter, B.Sc., graduate in training with G.E.C., for his paper " Digital communications systems "; C. W. Evans, B.Sc., student apprentice with Marconi (" Welding in microelectronics "); and Miss Trixie Dayer, technician apprentice at Standard Telecommunications Laboratories (" The preparation of a new semiconductor material for use in telecommunication devices ").

Philips Electrical Ltd., are to hold two trade shows, one in Harrogate and the other in London, as the Earls Court, Radio and Television Show has been cancelled. The **Northern show** will be from 21st-24th August at the Majestic Hotel. The **London show** will be from 4th-14th September at the Royal Garden Hotel.

"Wireless World" oscilloscope as built by E.I.D. apprentices.

G.P.O. Vision-telephone Scheme.—The present greater regional development and the dispersal of industry leads the G.P.O. to expect a demand for new communication techniques. The Post Office are meeting this situation by exploring the possibilities of television links for conferences in two distant centres and also a vision telephone for calls between individuals in booths. Both facilities would make use of the existing coaxial cable network and the microwave radio system now being developed to operate between a nationwide network of towers, of which the 620-feet-high Post Office Tower in London will be the hub. The G.P.O. in the near future is to set up an experimental C.C.T.V. conference link between their Engineering Department headquarters in the City of London and the Research Station at Dollis Hill. Invitations are to be made to business men interested in the practical application of telephone vision conference facilities to take part in experimental, live conferences.

The National Electronics Research Council, of which Lord Mountbatten is chairman, is changing its name and role. Its new name is the **National Electronics Council.** The N.E.C. is to consider and advise the Government on the application of electronics to the national life. The N.E.C.'s new and wider function is to be under the aegis of the Ministry of Technology.

Tripartite Computer Project.—The object of a joint project by English Electric-Leo-Marconi Computers Ltd., the University of Edinburgh and the Ministry of Technology is to provide advanced software for the operation of a multi-access system computer ordered by the Edinburgh Regional Computing Centre. Twenty-five programmers are working on the project of which eleven have been provided by the University. The multi-access computer, to be delivered to the Edinburgh Regional Computing Centre in the summer of 1968, will initially be in the form of a system 4.70 computer and equipment delivered later will provide the multi-access facilities. Access to the computer will be by remote terminals located in offices throughout Edinburgh and as far away as Aberdeen. It is expected that it will have a build up of over 200 users, each with direct immediate access.

Tackling Clutter.—Using a Pegasus computer and an orthodox airfield control radar system, research workers from the University of Leeds hope to increase the accuracy of automatic aircraft radar detection. Each of the effects of clutter will be studied, these being due to the human, environmental and electronic factors. This work will complement research being undertaken in such Government departments as the Royal Radar Establishment.

B.S.I. Conference.—" The expansion of trade through standards, European co-operation, the change to the metric system, safety and reliability " are some of the subjects to be discussed at the British Standards Institution's thirteenth annual standards conference. It will be held at Imperial College, London, on April 13th and 14th.

Automation & Navigation.—A three-day conference, sponsored by the British, W. German, French and Italian institutes of navigation, will be held in Paris from April 26th to 28th. The conference, entitled " Automation as applied to the conduct of craft by sea and in the air," will be open to members of the institutes and invited guests.

I.E.E.T.E. Educational Entry Requirements.—The Institution of Electrical and Electronics Technician Engineers have released particulars of the requirements for membership to the Institution after negotiating with a number of examination bodies. These particulars are given in full in the Articles of Association and summarized in the Institution's official brochure available from the secretary of the I.E.E.T.E., 26 Bloomsbury Square, London, W.C.1.

In the November, 1966, issue (p. 562) it was recorded that **stereophonic test transmissions** took place after the end of the normal B.B.C. Third Programme transmissions. This consisted of a left-channel signal of 250 c/s. The test schedule has now been extended to include right-channel signals (440 c/s). The schedule is as shown in the table. The signals are normally transmitted at a level corresponding to 40 % of maximum modulation (before pre-emphasis). The stereo transmissions at the present time take place only on frequencies of 91.3 Mc/s (Wrotham) and 92.4 Mc/s (Dover).

Time	L	R
23.30	250 c/s	—
23.35	—	440 c/s
23.40	250 c/s (—8dB)	—
23.41	—	440 c/s (+8dB)
23.42	250 c/s (—8dB)	440 c/s (+8dB)
23.43	8 kc/s (—8dB)	—
23.45	—	8 kc/s (—8dB)
23.47	250 c/s	
23.55	mono transmission	

Receiving Licences.—In December combined television and sound licences in the U.K. totalled 13,919,191, a rise of 393,297 during the year. Sound only licences numbered 2,515,993, a fall of 165,162 during the year. Sound licences include those for receivers in cars which rose from 658,200 to 707,606.

Manchester University is receiving a grant of £45,000 from the Science Research Council towards the cost of a design study for a **new radiotelescope.** No decision on the construction will be taken until the results of the design study and the detailed cost estimates are available.

Intended to increase the awareness of the technician engineer as to the factors contributing to the **reliability of equipment** a one-day conference is being organized by the Institution of Electrical and Electronics Technician Engineers in collaboration with the National Council for Quality and Reliability. It will be held at Queen Mary College, University of London, E.1, on April 5th. Provisional registrations are obtainable from the I.E.E.T.E., 26, Bloomsbury Square, London, W.C.1. (Fee 30s.).

Colour Television Servicing.—The City and Guilds of London Institute, in conjunction with the Radio Trades Examination Board, has introduced an examination in colour television servicing principles. The first examination to be held in June will consist of a three-hour written paper.

Bath University of Technology is holding a number of courses relating to electronics in the near future. On March 7th a three-day course will start on microwave solid state devices. (Fee £12.) Later in the year a five-day course on transistor electronics will be held in the school of Physics. This is intended to be an introductory course for teachers in schools and will start on August 21st. (Fee £10.) Enquiries to the secretary, Centre for Adult Studies, Bath University of Technology, Ashley Down, Bristol 7.

WHAT THEY SAY

" One of the few comforts in Britain's bleak situation is the outlook for the electronics industry. Despite the overall stagnation of the economy, the forecast for the British market predicts a 3.5% climb next year . . . 1967 should be the best year the electronics industry has yet had."—From a survey of the European electronics markets in *Electronics*, December 26th, 1966.

" About one out of three people in the British electronics and instruments industry is under direct American control." —From the Electronics & Instruments Supplement in the *Stock Exchange Gazette*, January 13th, 1967.

Amateur S.S.B. Transmitter

By C. J. SALVAGE
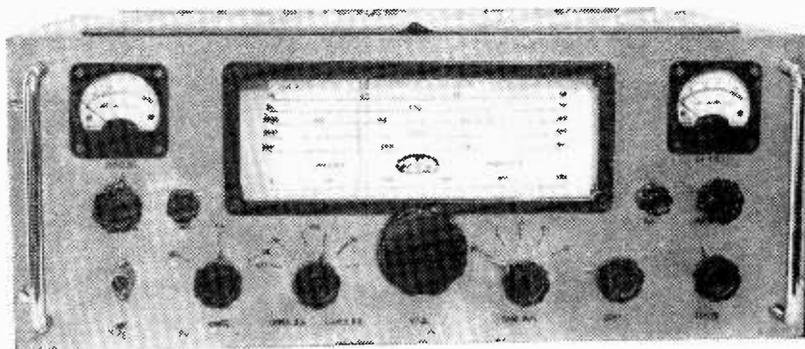
THE increasing use of single-sideband transmissions for commercial and amateur purposes in preference to other amplitude modulated transmissions is now a well-established feature of the communications field. The reason for this is not difficult to understand when one considers that, for a given power amplifier, s.s.b., with a suppressed carrier, gives +9 dB power gain over normal double-sideband a.m. with a carrier. This is more than is given by most beamed transmissions and represents a considerable step up in communication efficiency (or "talk power"). Further advantages are: reduced bandwidth requirements and

C. J. Salvage has been an amateur transmitter (G3HRO) since 1951 and was for some years chairman of the Aquila Radio Club of the Inspection Branch of the Ministry of Aviation. He is a keen s.s.b. transmitter. In the December 1961 issue of Wireless World he described a transistor mobile communications receiver for operation in the broadcast and six amateur bands. Since 1940 Mr. Salvage has been on the staff of the Services Electrical Standards Centre of the Ministry of Aviation Inspection Branch which is concerned with organizing the calibration of prime standards for the Services.

a reduction in noise resulting from more selective operation, an absence of the phase distortion associated with double-sideband transmission and possibility of multiple contacts on a common frequency. This last advantage is achieved by using voice control and by the fact that no carriers are produced which would otherwise cause .eating.

General circuit description

The transmitter described in this article is for use on the five most used amateur bands: 80 m (3.5-3.8 Mc/s); 40 m (7.0-7.1 Mc/s); 20 m (14.0-14.35 Mc/s); 15 m (21.0-21.45 Mc/s); and 10 m (28.0-29.7 Mc/s). The bandwidth needed for the transmitted information is quite small, and this makes possible the use of phasing techniques without resort to frequency changers or crystals. A phasing type transmitter, as here described, produces a s.s.b. signal by phasing, or cancelling, two equal and opposite unwanted signals. The carrier and unwanted sideband are cancelled in one operation in a balanced modulator, leaving the required s.s.b. signal. This is brought about by:
1. producing two r.f. outputs from the amplified variable frequency oscillator (v.f.o.) displaced in phase by 90°.
2. producing two audio outputs from the audio amplifier also displaced in phase by 90°.

The four outputs are combined in two beam-deflection tetrodes to produce a s.s.b. signal at the required frequency, and this is amplified and fed to an output valve which runs at the full British permitted power. By increasing the p.a. supply voltage this rating can be well exceeded for use overseas. With the system employed, no crystals or frequency changers are used.

Voice control (VOX) is used extensively with s.s.b. and enables the

transmitter and the associated receiver to be operated simply by speaking into the microphone. As soon as speech is stopped the receiver automatically returns to the "receive" condition. In order that audio from the speaker will not trigger off the microphone and thus operate the transmitter, an anti-VOX system is incorporated. To simplify the description the circuit is divided into six parts as follows:—

Fig. 1. v.f.o. and multiplier,
Fig. 2. r.f. phase shift network and balanced modulator,
Fig. 3. audio amplifier and audio phase shift network,
Fig. 4. transistorized VOX and and anti-VOX,
Fig. 5. transmitter power amplifier.
Fig. 6. power supply unit.

If required reinsertion of the carrier is possible.

The variable frequency oscillator and multiplier (Fig. 1) comprises an EF80 valve operating in a Colpitts oscillator circuit, separate inductances suitably padded being used to work at $\frac{1}{2}$ or $\frac{1}{3}$ the transmitter frequency. The reasons for running the v.f.o. at the lower frequencies are:
1. to produce higher stability,
2. to prevent pulling the v.f.o. off frequency by the power amplifier.

Details of coils and capacitors are shown in the tables. The 10 pF variable capacitor C_1 is switched across the main v.f.o. variable capacitor on the 80 and 10 metre bands in order to band-spread each band completely across the dial. Mechanical rigidity is essential for stability of the v.f.o. Potentiometer VR_1 is the driver control to the grid of a 6870 valve which acts as a frequency doubler on 80 and 40 metres and a tripler on 20, 15 and 10 metres. The anode circuit of the valve is tuned to the

Fig. 1. Variable frequency oscillator and frequency multiplier. Note that the AB is connected to Fig. 4, x y to Fig. 2.

V.F.O.

MULTIPLIER

R.F. PHASE SHIFT NETWORK

BALANCED MODULATOR

DRIVER

Fig. 2. Radio frequency phase shift network and balanced modulator. Note that the ferrite bead should be nearer to the grid of V6, the driving valve, than shown. Four outputs lead to the audio phase shift network, Fig. 3. The supply voltages for the balanced modulator and driver are 210V and 300V respectively. The driver has, via R_{18}, a connection to the VOX circuit Fig. 4, its output via C_{28} leads to the power amplifier Fig. 5.

AUDIO PHASE
SHIFT NETWORK

SWITCH S2
POSITIONS

VOX
ON ○ ○ ○ ON
OFF ○← ●→ OFF
UPPER   LOWER
SIDEBAND   SIDEBAND
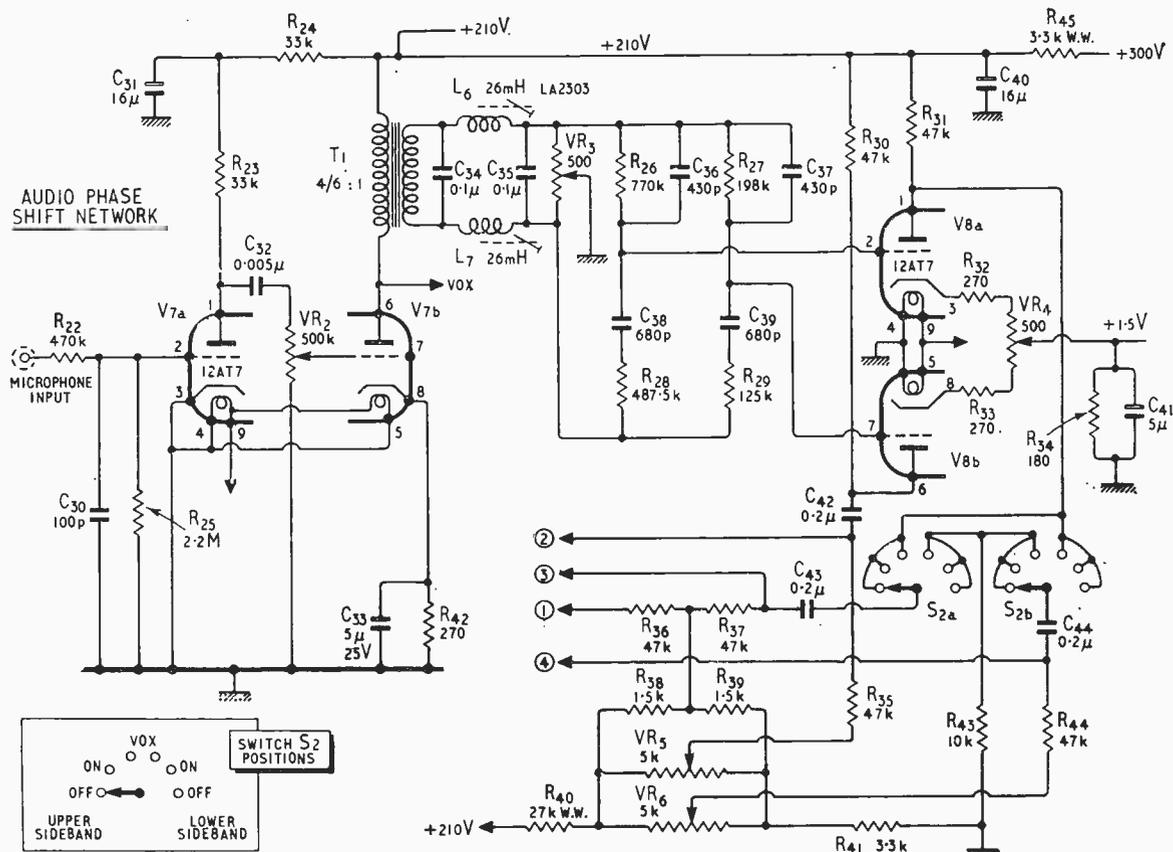
Fig. 3. Audio phase shift network contains microphone pre-amplifier with volume control. This has a 210V power supply requirement which is obtained via the smoothing circuit R_{45}, C_{40} from a 300V power supply. From $VR_4 + 1.5V$ is taken to Fig. 4 the voice control circuit.

VOICE CONTROL

L.S., 600Ω
ANTI-VOX

Rx a.g.c.

AERIAL
RELAY
G   H

NET SWITCH
WITH AUDIO
CONTROL VR2

V.F.O.
RELAY

FROM R_{18}
V6

FROM PIN 6
V7b
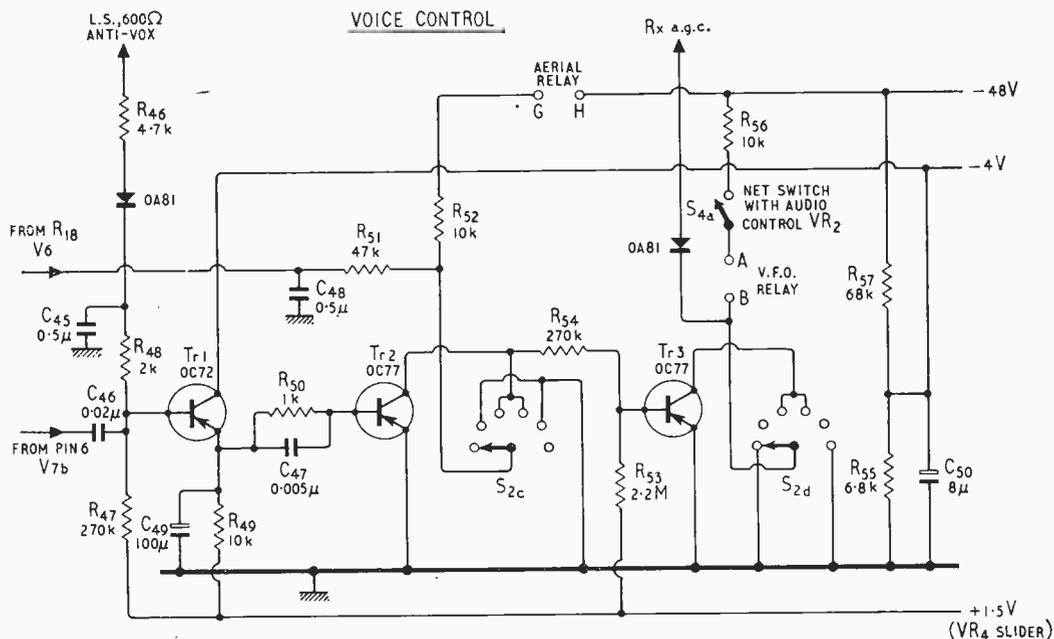
Fig. 4. Voice control circuit involves both the aerial changeover and v.f.o. cut-out relay coils. The anti-vox facility is connected to a receiver's loudspeaker or headphone output. Another connection to be made is that to a receiver's a.g.c. (at one time known as a.v.c.)

transmitted frequency by the coil L^2, the inductive link x y which is wound at the earthy end of the coil being taken to the r.f. phase shift network. (If difficulty is experienced in obtaining a 6870, a 5763 would most likely be suitable.)

R.F. phase shift network and balanced modulator (Fig. 2)—This starts with a capacitor-resistor network for each band. 100-ohm carbon resistors are used in two arms of the bridge and capacitors of good power factor with an impedance of 100 ohms at the operating frequency in the others. In the next issue values will be given and it will be noticed that a mid-point in each frequency band is chosen in order that displacement is unnoticeable at the extremes of each band. A value of approximately 10-15 pF is required to allow for strays. The output from this network is fed to the grids of the 7360s to form a balanced modulator.

The deflection plates 8 and 9 are fed with a.f. signals from the audio phase shift network (Fig. 3). The anode circuits of the 7360s balance and produce a single-sideband signal at the required frequency. A small capacitor C_{31} (4.7 pF) is used to compensate for the take-off capacitor C_{30} which provides the feed to the grid of V6. A ferrite bead was found to be advantageous on the grid lead of the 5763 and the power amplifier. The anode circuit of V6 has slug-tuned coils which are shunted by carbon resistors R_{19} (tables in next issue). This has the effect of broad banding the coil and also prevents instability. Although this does reduce the drive to the p.a. there is plenty of power available, so no loss is noticed.

Audio phase shift network (Fig. 3)—This starts with V7 (12AT7) as an audio pre-amplifier fed from the crystal microphone. Pin 6, the anode of the second triode, is connected to the voice control and also to a step-down transformer which feeds the audio filter (confining the spectrum to 300-3,000 c/s) and the resistor-capacitor network producing two outputs 90° out of phase from the anodes of V8. These outputs from V8 are fed to switches S_{2a} and S_{2b} for selection of upper or lower sideband as required. Capacitors and resistors in the audio phase shift network must be adjusted to within 1% of the stated values by using series or parallel combinations. Failure to do so will lead to an out-of-balance condition in the audio spectrum. Good quality (low power factor) silver mica capacitors are essential.
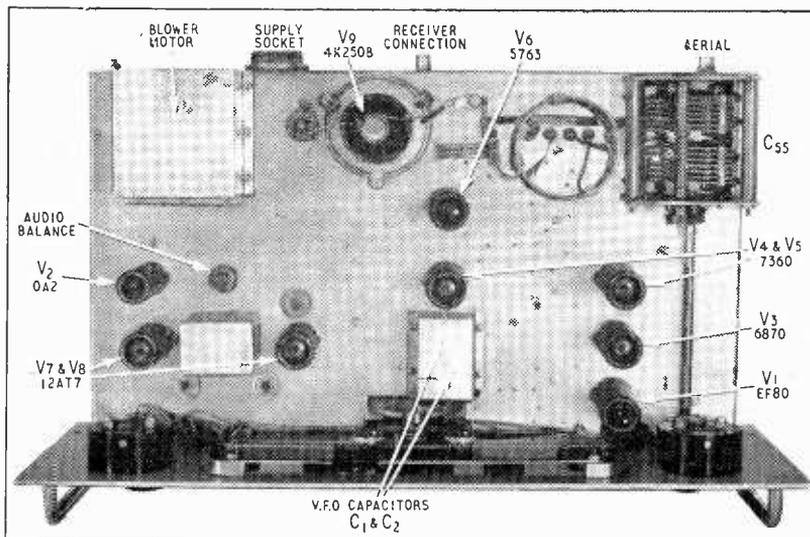
Layout above chassis showing the 3-turn 10-metre coil at right-angles to main inductor. Below is the under chassis view.
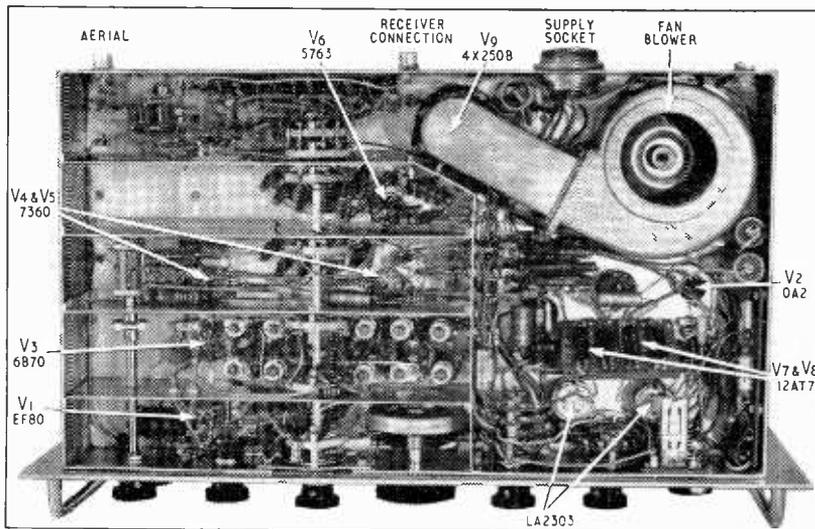
Voice control (Fig. 4).—With the switch S_{9c} and S_{9d} in the VOX position this control circuit acts as follows: Audio from the anode of V7b (Fig. 3) is fed to the base of transistor Tr1, and this has the effect of producing a negative potential at its emitter. As the emitter is connected via the delay circuit C_{47}, C_{49}, R_{50} to the base of transistor Tr2, the result is to overcome the $1\frac{1}{2}$ V positive bias applied and cause Tr2 to conduct, thereby putting the collector of Tr2 virtually at earth potential. This in turn causes current to flow from the -48 V supply via the $10\,k\Omega$ resistor R_{52} and the aerial change-over relay coil connected at GH. This connects the aerial for the "transmit" condition. At

the same time the base of transistor Tr3 becomes positive from the $1\frac{1}{2}$-volt supply, putting it in a non-conducting state; therefore the collector assumes a potential of -48 volts from the supply. As a result the receiver is muted as the potential is applied to the a.g.c. line—the diode OA81 being used to prevent any feedback from the receiver's a.g.c. line when in operation. As no current now flows in the collector circuit of Tr3 the v.f.o. relay connected across AB is released, thus closing the contacts and bringing the v.f.o. into operation.

The delay circuit (C_{47}, C_{49}, R_{50}) is incorporated so that as soon as the microphone is actuated the system responds instantly and is held in the
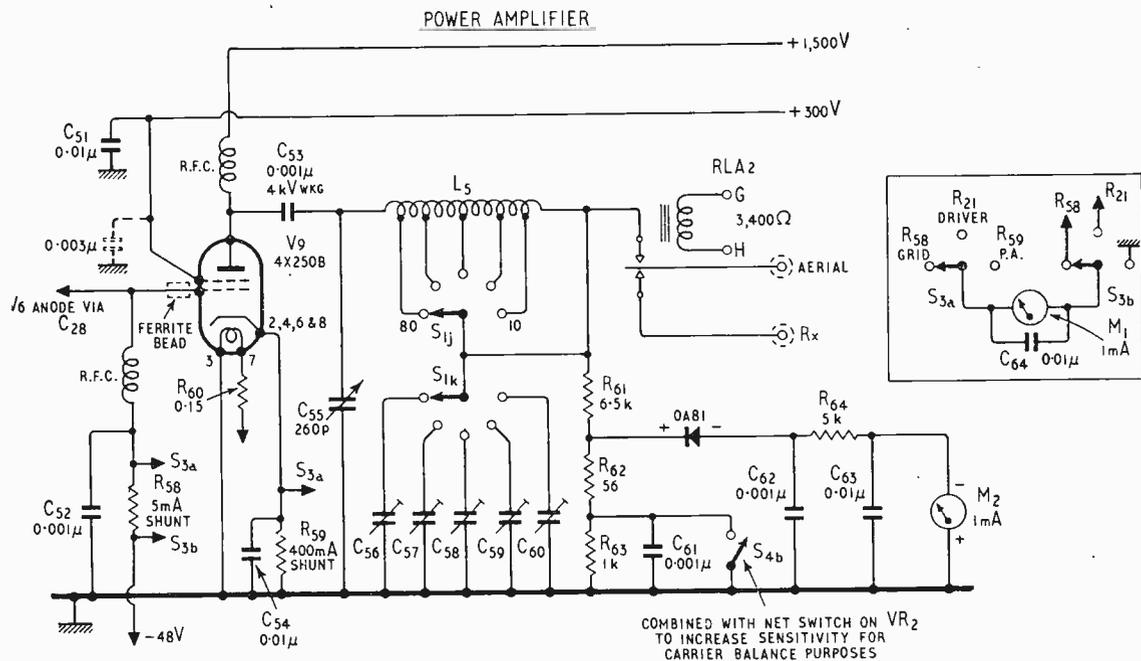
Fig. 5. *The power amplifier circuit includes the metering circuits. Note that the dotted capacitor (under C_{51}) is included in a special valve base.*

activated condition for several milliseconds by the charge on C_{19}. This delay in returning to the "receive" condition is necessary as otherwise the transmitter would switch on and off with every sentence spoken and every breath taken. With the switch S_{2c} and S_{2d} still in the VOX position and no audio applied, Tr2 becomes non-conducting and in so doing applies a potential of −48 volts to the grid of V6 (Fig. 2) thus cutting off this valve and the power amplifier. Also, as no current is flowing through R_{52} the aerial change-over relay is returned to the "receive" or rest condition. In this condition the base of Tr3 becomes negative, being connected via R_{51} to the collector of Tr2, causing Tr3 to conduct so that the collector is virtually at earth potential. This removes the −48 volts from the a.g.c. line of the receiver allowing it to operate. Simultaneously, current flows though the v.f.o. relay AB, causing the contacts to be opened, thus switching off the v.f.o. to avoid beat frequency oscillation with the receiver.

Anti-VOX (Fig. 4).—When the receiver is being tuned, audio from the speaker will actuate the microphone and cause the transmitter to be operative if it were not for the anti-VOX circuit C_{45}, R_{16}, R_{15}, and the diode OA81 which is fed from the speaker output, or audio output, at approx.

600 ohms. This output is rectified by the diode and produces a positive potential at the base of Tr1 which over-rides the negative potential produced from the audio fed from the anode of V7b (Fig. 3), thereby keeping the transmitter in the "receive" condition. Manual operation can be effected by switch S2, and this also switches the receiver and aerial to the appropriate condition, i.e., when the transmitter is on, the receiver will be muted and aerial switched to the transmitter, and vice-versa.

Power amplifier (Fig. 5).—This comprises a 4X250B valve which is supplied with an anode voltage of 1,500 V. It is driven by V6 in Fig. 2. The meter (1 mA movement) can be switched by S_{3a} and S_{3b} to read grid drive current at 5 mA maximum. This drive should be kept to a minimum in order to avoid distortion.

Cathode current is measured in preference to anode current since in the anode circuit the terminals of the meter and switch contacts would have a potential of 1,500 V to earth and therefore would be highly dangerous if touched during adjustment of controls. It must be remembered therefore that both screen (30 mA approx.) and anode current are measured together, and the heavy 400 mA shunt applies heavy damping to the meter. R_{60} is a dropping resistor

as the filament of the 4X250B operates at 6 V, 2.6 A. The dotted-line capacitor 0.003 μF is in fact incorporated in the valveholder, but this screen by-pass is increased by the addition of C_{51} for use at the lower frequencies. The 70 Ω output is tuned by the pre-set capacitors C_{56}–C_{60}. Instead of the usual aerial ammeter, a voltmeter is used, the d.c. for the 1 mA movement being rectified by the diode OA81. A radio frequency signal is taken from the resistor chain R_{61} R_{62} R_{63}. The switch S_{4b} is open-circuited when VR_2 is turned anti-clockwise and in so doing provides greater sensitivity for balancing the carrier. It will be noted than as VR_2 is in the minimum position when this takes place no audio can get through to operate the transmitter, as this would be disastrous to the meter. The 4X250B valve can be operated at higher voltages if required to give up to 1 kW peak power.*

* U.K. limit is 400W peak envelope power—ED.

TROJAN RELAYS

A METHOD FOR RADIO COMMUNICATION ACROSS THE SOLAR SYSTEM

By JAMES STRONG, B.Sc. (Eng.), A.C.G.I.,

IF the currently debated proposal to survey the Solar System with the aid of interplanetary probes is shown to be feasible, some awkward problems in two-way radio communication will have to be faced. For although the successful Mariner flights to Mars and Venus might suggest that a straightforward improvement in radio range is all that is needed to cope with more distant probes, the problem is now seen to be more fundamental.

Primarily the difficulty stems from the orbital motion of the Earth, which each year bears it to a region behind the Sun, relative to any probe, where it can no longer " see " the radio aerials of the spacecraft. In such circumstances direct, line-of-sight communication becomes impossible and there is nothing the radio engineer can do about it. Nor is it merely a question of waiting a day or so until the occulted probe reappears in view; weeks may elapse before attenuated signals can penetrate the background noise due to the solar corona.

It could be argued, of course, and with some justification possibly, that by choosing another launch "window" the crucial moment of encounter with a distant world could be put off to a more convenient date. This may be true enough in some instances, but it is expediency pure and simple, and, with the hoped for expansion in future space activity, can we afford to accept a hiatus in communication every time the Earth finds itself in conjunction with a transmitting source? If planetary orbiters are to do their work efficiently, year in, year out; if solar probes are to travel within 0.1 astronomical unit* of the other side of the Sun; if comets have to be intercepted anywhere in space at rapid notice, talk of convenient launch dates becomes meaningless. And with the possible establishment of manned bases on other worlds, including trip times of 400-500 days, continuous communication, with no reservations, becomes imperative.

Communications for Mariner

However, before proposing a possible solution to the difficulty, it is worth studying the communication techniques used for each of the Mariner interplanetary flights. This will then reveal why similar methods cannot be applied to, say, a "flyby" mission to Jupiter, one of the survey projects now being studied.

The essence of long-range radio communication lies in concentrating whatever radiated power is available into as narrow an aerial beam as possible. It follows that the second essential must be precision alignment of the beam with the target tracking system, i.e. the Earth. Mariner II on its journey to Venus used an Earth sensor, a photomultiplier boresighted to its high gain aerial, which served to lock the aerial beam on to the Earth's disc. Even so, there was a risk that the sensor would mistakenly come to rest on the Moon when it searched initially, and provision was made for ground signals to

* 1 astronomical unit is the mean distance of the Earth from the Sun

James G. Strong is a design study engineer working on advanced projects in the Air Weapons Division of Hawker Siddeley Dynamics Ltd. Previously he had worked on Blue Streak and as a senior stress analyst with De Havilland Aircraft. Well known as a writer on spaceflight for aeronautical journals, he has published a book "Flight to the Stars" inquiring into the feasibility of interstellar flight

override the spacecraft's internal circuits, causing it to break the lock and search again if the signal strength proved less than expected.

In the case of the Mariner IV flight to Mars this method could not be adopted as the Earth moved in orbit inside Mariner IV's flight trajectory, and in trying to follow the Earth's disc the sensor would almost certainly be "blinded" by the Sun. Instead, and because the trajectory was opportune, it was found possible to fix the axis of the high gain aerial with respect to the flight path and still cover the Earth adequately within the aerial beam for most of the 228-day journey.

To bring the aerial to bear in the right direction, now it was fixed, quite a sophisticated attitude control manoeuvre had first to be executed. Shortly after being launched on course, and having freed itself from its Agena boost stage, Mariner IV spread its solar panels, searched for the Sun and locked on to it. It could then draw power and dispense with its internal batteries. Because a second reference axis was also needed the spacecraft then slowly rolled about its solar-pointing axis until its star-tracker had acquired Canopus, a large-magnitude star conveniently close to the south ecliptic pole. Once these two reference axes were secured, mutually at right angles, the vehicle's attitude was fixed in space and its aerial system automatically pointed directly towards Earth. Apart from some concern early on, when the star-tracker repeatedly lost lock and came to rest on another star, the system performed with merit once the trouble had been identified and effectively isolated.

Turning now to the requirements for a probe surveillance of Jupiter, whose orbit lies beyond Mars, some 400 million miles away, neither of the two Mariner methods of aerial pointing are of any use. Calculations show that even when propelled by the powerful Saturn boosters soon to become available, an interplanetary probe will still take $2\frac{1}{2}$ years to reach Jupiter. Consequently the Mariner IV fixed aerial principle would be unable to cope with a situation in which the Earth twice circled the Sun during the trip time, while Earth sensing is plainly confined to trajectories that lie inside the Earth's orbit where the sensor looks away from the Sun.

No doubt a steerable aerial, programmed to follow a year-long, simple harmonic sweep would fit the bill, provided enough fuel for the continuous operation of
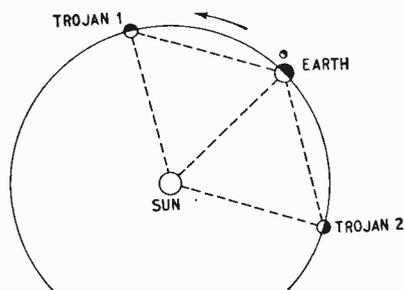
Fig. 1. Satellites that travel along the Earth's orbital path at the same speed as the earth remain in stable equilibrium if they are stationed at the Earth's "equilaterals" as shown.

small thrust jets could be carried. Alternatively, the aerial could be locked on to the Sun, but we should then have to resign ourselves to communicating with the probe only when the Earth passed through the aerial beam. This is not as bad as it sounds, for contact would be made during the critical period up to four months after the launch date, when course corrections might be necessary. Thereafter contact would take place during the 17th and 30th months after launch, the latter period coinciding with an encounter with Jupiter.

During the somewhat prolonged intervals of silence between these dates, environmental data accumulated en route would have to be stored and played back when the opportunity presented itself. Either way, whichever scheme were adopted, all contact would still be lost when the Earth was in conjunction on the other side of the Sun. On the face of it there seems only one way to circumvent this dilemma, but it is a concept that calls for as much courage and imagination as it does careful thought.

Earth equilateral

One of the lesser known theorems of celestial mechanics is the three-body problem, first published as an essay by the French mathematician, Lagrange, in 1772. In it he showed that if a planet, such as the Earth, revolved in a circular or elliptical orbit around a massive second body, such as the Sun, there were two positions in space where, if a third body were introduced, this body would remain in dynamic equilibrium. Both positions lie along the planet's orbital path, one leading and the other lagging behind the planet by 60° respectively. They are known as "planet equilaterals" for they form, together with the Sun and (in our case) the Earth, the apices of two giant equilateral triangles whose sides are 93 million miles long (see Fig. 1).

The gravitational and centrifugal forces that hold an Earth equilateral body in space require, as a prime condition of equilibrium, that the body should be moving at the same speed and direction as the Earth and along its orbital path. With these conditions fulfilled the body will then remain in its relative position indefinitely, and only force can dislodge it.

Remarkable proof of the three-body problem has been found in the so-called Trojans of Jupiter, two groups of small asteroids (named after heroes of the Trojan War—Hector, Achilles, Troilus, etc.) that are unmistakably travelling along Jupiter's path, ahead and behind the planet. Once wandering asteroids, they must have been captured in the remote past and are now prisoners for all time at Jupiter's equilaterals, perhaps better known as the Trojan Positions.

From this it follows that if we deliberately station satellites at the equilaterals of the Earth they also will be subject to the same natural laws, and there may be other benefits to be had. First, the satellites will possess an inherent, self-compensating ability to remain "on

station," and we can forget the need to correct any tendency to drift, as we do in the case of satellites in synchronous orbit above the Earth. Secondly, and equally important, since they flank the Earth they enable us to " see " around the Sun where it blocks our radio view. In effect they would act as radio periscopes, relaying incoming signals we should otherwise never receive, and relaying outgoing instructions in the same manner. Because of their unique position, they could be called Trojan relays.

It might be asked whether the dynamic equilibrium of a Trojan relay would be disturbed by the gravitational pull of planets passing in adjacent orbits. Undoubtedly it would be perturbed to some extent, for every planet exerts *some* influence on every other body in the solar system, but with Venus never closer than 25 million miles, and Mars rarely less than 40 million miles away, their influence would be negligible. In these circumstances it is doubtful whether the orbital shift they might induce would be observable in much less than a century, and certainly there seems little need for qualms on his score.

Design of relays

Though Trojan relays will help to solve the difficulty of solar occulation, it is only fair to admit they are bound to bring other problems in their train. These may be grouped under the headings of reliability, attitude control, power supplies and long life. Placing the Trojans in position is the least of our worries, a matter of propulsive effort and navigational accuracy that is well within the capability of existing space equipment.

Until spaceflight becomes commonplace, and orbiting satellites are serviced periodically like Trinity House navigational buoys, a long and durable life, coupled with absolute reliability is essential. This would be especially pertinent to a Trojan relay for, at a distance from the Earth equal to the Sun itself, inspections would be most infrequent. It would probably be more economic to launch a replacement than go to the trouble of refurbishing one that has ceased to function for any reason. Consequently circuit redundancy, duplicate sub-systems, long-life power supplies and maximum protection from meteorite and radiation hazards must take priority in the design.
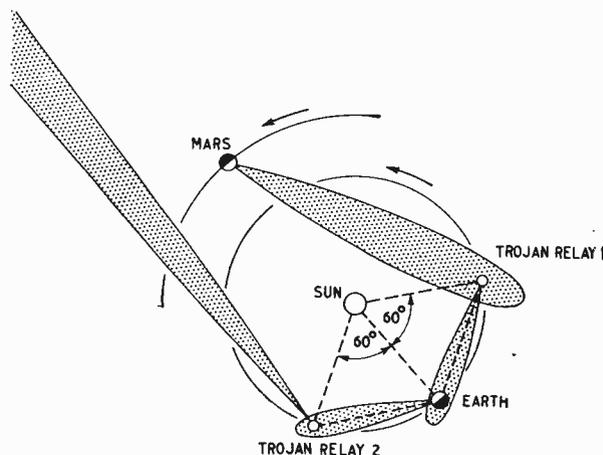

Fig. 2. Trojan relay stations would prevent all radio contact with spacecraft being cut off for several weeks, due to the solar corona, while Earth was in conjunction. The figure shows both incoming and outgoing messages being relayed "around the Sun".

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Ideally, of course, all electrical power should be drawn from the Sun, but it may be some while before solar cells are efficient enough to satisfy all needs completely. Meanwhile, contacting interplanetary probes launched in the next decade or so, with the prospect of reaching Saturn or even Uranus, 2,000 million miles from the Sun, will demand prodigious amounts of power. To meet this requirement large and improved nuclear-powered generators would have to be developed, even though their reliability in space is still an unknown quantity.

Attitude control, so vital to accurate aerial-pointing, will present the toughest problem of all, for any form of orientation by means of small thrust jets sets a limit on the life of the relay when the fuel is exhausted. The alternative seems to lie in the progressive development of gravity-gradient stabilization, using the Sun's gravitational field to exert erecting forces on the relay via four long, slender booms at the ends of which are fluid dampers. Initially the relay might have to be oriented by jets, but once a series of star-trackers had locked on to specific sources they could control the vehicle electrically, counteracting small oscillations by lengthening or shortening appropriate booms. Any forces or torques generated in the system as a result of swinging the aerial about an axis would naturally have to be balanced by moving counterweights.

Stabilizing the relay by deliberately spinning it, as in the Intelsat satellites, is possible but perhaps not useful because of aerial-beam orientation problems. It is probably better to provide the relay with enough nitrogen fuel to stabilize itself with the aid of small gas jets. Without too great a weight penalty enough fuel could be carried to last five years, and by then everyone will be anxious to replace the relay with something better anyway. Equipped with duplicate Canopus sensors, Earth sensors and Sun sensors, the relay should have no difficulty in orienting itself in space with sufficient accuracy to direct its aerials precisely when commanded to.

On the question of radio range it is now known that communication between such a relay station and Earth is feasible. This can be seen from the fact that Mariner IV's 10-watt travelling-wave-tube transmitter supplied adequate signal strength over a distance of 134 million miles, and subsequently was detectable at 191 million miles, more than twice the distance from Earth to a Lagrangian "point" on the Earth's orbit.

However, it is conceivable that an interplanetary probe will have reached the vicinity of Uranus by the late 1980s, and if a Trojan relay is in position and operational by then it will be expected to reach out to a distance of some 2,000 million miles. All things being equal, on applying the inverse-square law to the basic transmission formula it will be found that r.f. power of some $2-2\frac{1}{2}$ kW will have to be radiated. While future developments can perhaps be expected to reduce this figure, refinement of detail, as in other aspects of spaceflight, usually turns out to be less important than accepting the inevitable and learning how to generate copious amounts of energy.

Lastly, if so large and heavy a satellite is to be placed where it becomes the focal point for other, improved versions that may wish to occupy the same space one day, it must be possible to destroy the station completely so as not to constitute a hazard to its replacement. Admittedly space is large, and there is little risk of physical contact, but a few ounces of high explosive and a radio frequency combination lock will put an end to any chance interference or future embarrassment.

This leaves only the problem of launching and positioning the relays along the Earth's orbit. Perhaps con-
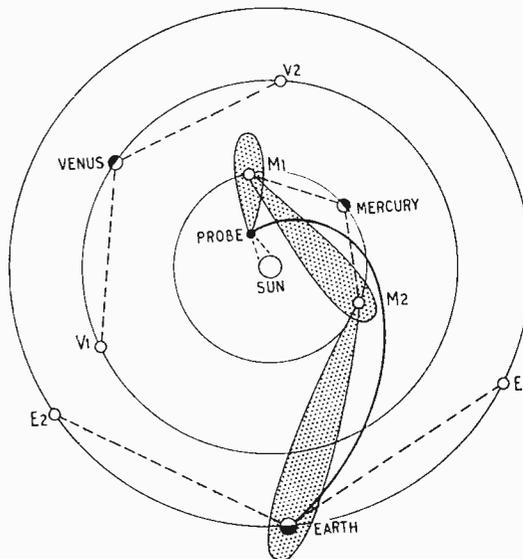
Fig. 3. A network of Trojan relays stationed at the equilaterals of the inner planets, Mercury and Venus, would provide complete coverage for space activities inside the Earth's orbit. The diagram shows how data from a solar probe on the other side of the Sun would be relayed to Earth.

trary to expectation, both relays would be launched in a *forward* direction, relative to the Earth's motion, one swinging outwards along an arc that returned to intersect the orbital path, the other inwards to enter a perihelion orbit round the Sun before coming up behind the Earth. On reaching their stations, both relays would be slowed by retro-rockets to the same speed as the Earth. Their final position would not be important to within a degree or so, but the resultant velocity vector should be substantially correct.

Completing the network

The safe deployment of Trojan relays on either side of the Earth still leaves unresolved the question of how an interplanetary probe will recognize in which direction to aim its aerials. Circumstances will vary, and the only safe decision is to provide it with a steerable aerial and a set of reference axes. Direction co-ordinates would be transmitted from Earth when the time came, via a Trojan relay possibly, but now with sure knowledge that an answer should come back wherever Earth was (Fig. 2).

Nevertheless, even with two Trojans operational, there still would be blind areas that could not be viewed, especially the region between the orbit of Mercury and the Sun. However, if Trojans can be set up at the Earth equilaterals they can be stationed just as easily at the equilaterals of the inner planets, Venus and Mercury. Being closer to the Sun, they would orbit more rapidly: Venus equilateral in 225 days and Mercury equilateral in 88 days. One or other of the six Trojans then in motion should ensure that solar system coverage was complete (Fig. 3).

No doubt many aspects of this Trojan relay scheme are debatable, and some people may well regard the whole idea as outrageous. But, equally, there may be other unsuspected advantages in the scheme that only the future can disclose. Possibly not until these have been realized will someone have the courage to propose we put the Trojans to work.

Design of Schmitt Trigger Circuits

FOR DEFINED THRESHOLD APPLICATIONS

By A. E. CRUMP

Much of the design work involved in the calculation of a Schmitt trigger circuit tends to be empirical, and the purpose of this article is to present a step-by-step design method so that the necessary resistor values may be obtained merely by substituting the required parameters in a set of equations. The article is concerned with circuit design from the viewpoint of trip points. Here the author deals with the normal Schmitt circuit and later will be concerned with the case of an additional emitter resistor— often neglected in the literature.

SCHMITT trigger circuits are frequently used in voltage monitoring applications. In many cases, the design requirement is for a circuit to give a certain value of "backlash" voltage, whereas in others a certain output condition is to be presented at a precisely determined magnitude of input voltage.

This article is intended to deal with these two requirements only, and the design methods described apply to the basic circuit shown in Fig. 1. Although there are variants to the basic Schmitt trigger, and it is acknowledged that they have advantages in certain applications, the circuit of Fig. 1 is highly suitable for general purpose applications where a set of design formulae may be standardised.

Two approaches to design are described, one for the simpler, general purpose applications where stability of threshold conditions is not very critical (and medium to high values of backlash are required), and the other for precise work, where stability of threshold voltages must be guaranteed to close tolerances at small values of backlash.

BACKLASH

The circuit of Fig. 1 has two states. One state is with Tr1 on and Tr2 off, and the other with Tr1 off and Tr2 on.

Fig. 2 shows the ideal curve of collector current (I_{C2}) of Tr2 plotted against input voltage (V_{IN}) to trigger. It can be seen that when V_{IN} is zero, I_{C2} is a maximum and that when V_{IN} is increased, a point is reached where I_{C2} suddenly drops to zero. This voltage will be referred to as the "restore" voltage, i.e. the voltage at which Tr1 conduction is restored. It is also noted from Fig. 2 that reversion to the condition where Tr2 is conducting only occurs when V_{IN} is reduced to a value below the restore voltage (V_R). This lower voltage will be referred to as the "trip" voltage (V_T).

The difference between V_T and V_R is referred to as the backlash or hysteresis of the circuit.

The design problems involved in designing a precise circuit to have a certain ($V_R - V_T$) value are considerably less than those involved in producing an absolute value of V_R and/or V_T. This is because in the former case V_R and V_T values may be selected so that they are high compared to the base-emitter voltage drop (V_{BE}) of the transistors, thus easing the temperature stability problems.

In the latter case, the V_T and V_R values are design parameters, and so their proximity to V_{BE} values is predetermined, and suitable temperature corrections must be made.

LOOP GAIN

The transition from one state to the other at V_R and V_T is caused by a regenerative, or a positive feedback effect.

Let us consider that at V_T and V_R both Tr1 and Tr2 momentarily conduct i.e. during the transition region. The a.c. equivalent circuit of the trigger is shown in Fig. 3, and it is apparent that there is a closed loop of positive feedback as shown by the arrows. This means that providing the loop gain, γ_o, $\geqslant 1$, the circuit will oscillate. Now the condition where Tr1 and Tr2 are both conducting is a very unstable one, as their base voltages have to be of comparable magnitude and polarity. As soon as oscillatory conditions are set up, the first transient of oscillation disrupts this delicate condition, and the circuit rapidly assumes one of the two states where only one transistor is conducting.

Now if the loop gain is less than unity, oscillation will not take place and so there will not be a rapid transition of state; instead the circuit will slowly change state and can be stopped between the two states, with both transistors conducting.

A source of error during computation of loop gain is failure to calculate it at low values of collector current. As a regeneration condition is approached, one transistor

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s biased off. Now at the instant when it starts to turn on, its collector current will be low and so its current amplification value (β) will be much lower than the value at full conduction, see Fig. 4. Thus the loop gain will vary as the transistor turns on. Now if the full conduction value of loop gain is close to unity, then the circuit will initially have a loop gain less than unity, and regeneration will not take place until loop gain reaches unity. This results in an uncertainty of the value of V_R and V_T because the low-current loop gain will be ill-defined, and part of the switching characteristic will be sluggish.

For these reasons, it is advisable to design the circuit for loop gain far greater than unity in the full conduction region, thus reducing the uncertainty of V_R and V_T. If the low-current parameters of the transistors are known, these should be used in γ_o calculation.

The higher the loop gain, the lower the uncertainty. This is demonstrated in Fig. 5. The loop gain is therefore a very important design parameter. (An expression for loop gain of the trigger is derived in Appendix 1.)

It is noteworthy that it is more difficult to achieve high loop gain with low backlash, than with high backlash. There is a relationship between backlash and loop gain, but it is not intended to investigate this aspect within the scope of this particular article.

The equation derived in Appendix 1 indicates that the γ_o value is more dependent on β_2 than on β_1, as the function of β_1 present is α_1. Now, $\alpha_1 = \beta_1/(1+\beta_1)$ and $d\alpha_1/d\beta_1 = -1/(1+\beta_1)^2$, hence changes in β_1 have a very small effect on α_1 and so a small effect on γ_o.

It is apparent therefore that the starting value of γ_o will be higher when Tr2 is turning off and Tr1 turning on, than in the reverse condition, i.e. γ_o will be higher at V_R than at V_T. This effect is more noticeable at low values of backlash.

BASIC TRIGGER (Fig. 1)

Consider the design procedure for predetermined V_R and V_T. The equivalent circuit with Tr1 conducting and Tr2 off is shown in Fig. 6. The circuit is analysed in Appendix 2, and an expression for V_T obtained. For non-precision applications and especially where silicon transistors are used the leakage currents may be neglected, and the expression can be modified to:—

$$V_T = \frac{V_{CC} + \alpha_1 \, V_{BE1} \dfrac{R_L}{R_E}}{1 + \dfrac{R_1 + R_L}{R_2} + \alpha_1 \dfrac{R_L}{R_E}} + V_{BE1} - V'_{BE2} \quad \cdots \quad \cdots \quad (1)$$

The equivalent circuit with Tr2 conducting and Tr1 off, is shown in Fig. 7. The circuit is analysed in Appendix 3 and an expression for V_R obtained.

Modifying the equation derived in Appendix 3 to neglect leakage currents:—

$$V_R = \frac{V_{CC} + V_{BE2}\left(\dfrac{R_1 + R_L}{(1+\beta_2)\,R_E}\right)}{1 + R_1 + R_L\left(\dfrac{1}{R_2} + \dfrac{1}{(1+\beta_2)R_E}\right)} + V'_{BE1} - V_{BE2} \quad (2)$$

(V'_{BE} is the value of V_{BE} at which conduction commences, as opposed to the full conduction value, see Fig. 8.)

To present a step-by-step design sequence it is necessary to manipulate expressions (1) and (2) and to evaluate some of their terms. The unknown circuit constants are R_1, R_2, R_L, and R_E. The transistor parameters will be
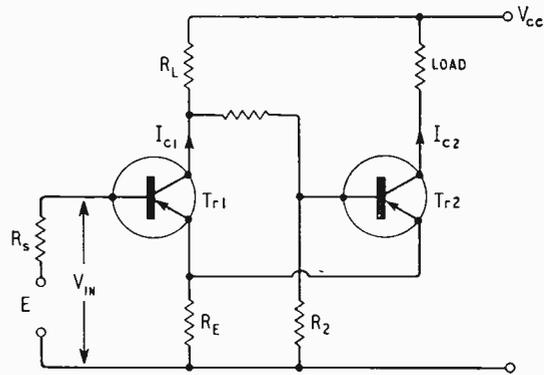
Fig. 1. Basic Schmitt trigger circuit.


Fig. 2. Ideal V_{IN}-I_{C2} characteristic.
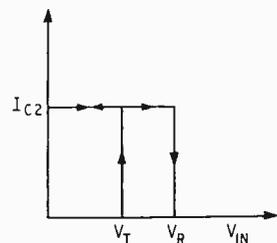
Below: Fig. 3. Small-signal open-loop equivalent circuit.
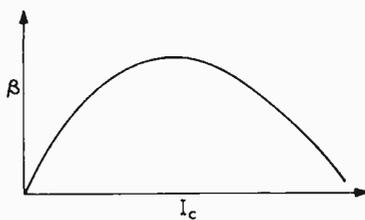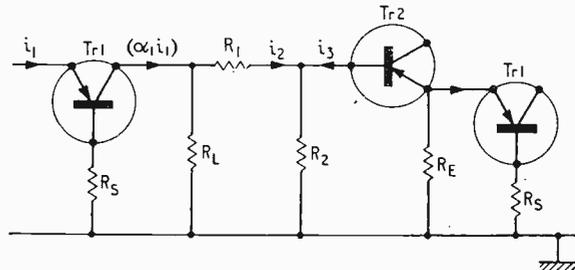
Fig. 4. Variation of β vs collector current.

Fig. 5. Effect of γ_o on V_{IN}-I_{C2} characteristic.
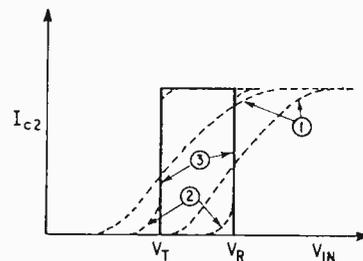
① STARTING AND MAXIMUM γ_0 VALUES <1
② STARTING γ_0 <1, MAXIMUM γ_0 VALUES >1
③ STARTING AND MAXIMUM γ_0 VALUES >1

known from the data sheets of the transistors used. V_R and V_T are design parameters.

If two of the unknown constants could be evaluated by other means, then (1) and (2) could be solved simultaneously to find the other two.

R_E Calculation. R_E can be calculated from V_R and I_{C2}. This presets the desired output conditions from Tr2 as a design parameter.

$$R_E = \frac{(V_{R(min)} - V_{BE2})\,\alpha_{2(min)}}{I_{C2}} \qquad .. \qquad .. \qquad .. \qquad (3)$$

(This equation is derived by inspection of Fig. 7.)

Calculation of R_2 from stability considerations
It is apparent from (1) and (2) that V_T is less affected by transistor β than is V_R, as the significant coefficient in (1) is α, which is relatively insensitive to β variations, whereas the significant coefficients in (2) are directly dependent on β. The condition is analysed in Appendix 4, where the problem is the shunting of R_2 by the input resistance (R) of Tr2 stage. In the manner shown, R_2 can be calculated from the required tolerance on V_R and the β spread of Tr2.

The β_{2max} and β_{2min} figures used in Appendix 4 may be expressed as:—
(a) Selection tolerance of β_2.
(b) Selection tolerance plus temperature effect tolerance.
(c) Temperature effect tolerance only.

In case (c) the β selection tolerance would be overcome by selection of R_2 to give the required V_R on each trigger manufactured; but on the other hand higher loop gain would be achievable than in cases (a) and (b) due to the reduced β spread. The more convenient approach is to use case (b) and calculate the overall temperature effect from (6) and putting $\delta\beta_2/\delta T = 0$.

DESIGN SEQUENCE

The design sequence is summarized in the panel. Although the expressions appear cumbersome, they are quite simple to use as their practical application merely involves substitution followed by simple arithmetic. An example showing the design procedure is given at the end of this article. Various checks should be made to the resistor design values derived from the equations suggested in the panel, such as those given below.

Loop Gain Check. The calculated resistor values

$V'_T = V_T + V_{BE1} - V'_{BE2}$
$(V'_T = V_{B1})$

Fig. 6. D.C. equivalent circuit at V_T threshold.

$V'_R = V_R - V_{BE2} + V'_{BE1}$
$(V'_R = V_{B2})$
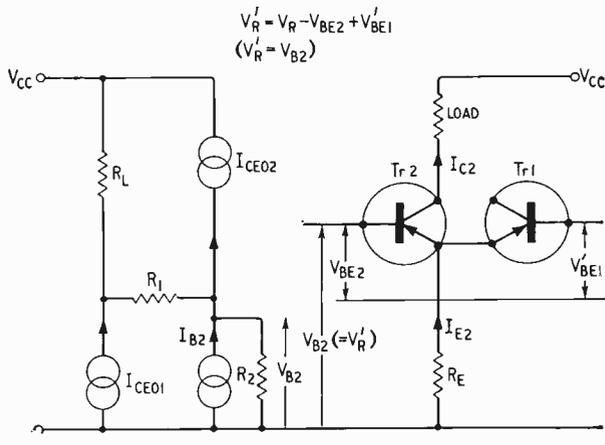
Fig. 7. D.C. equivalent circuit at V_R threshold.

should be inserted in the equation for γ_o (Appendix 1) to check the loop gain, bearing in mind previous discussion regarding the low-current value of β_2. If the calculated value of γ_o is less than unity, there are various steps that can be taken to improve it, the choice depending on the application.

(a) Either increase V_{CC} or return R_L to a higher voltage rail, recalculating resistor values.
(b) Reduce R_S.
(c) Widen the V_R tolerance.
(d) Use higher gain transistors.
(e) Return R_E to a more positive supply.

These various remedies can be tried by substitution in the γ_o expression (Appendix 1) until the required result is obtained. Generally, the γ_o value will be greater than unity, but in cases of low backlash and/or high V_R accuracy, some of these remedies may be necessary.

SUMMARY OF DESIGN PROCEDURE

(1) Calculate R_E from (3).
(2) Calculate R_2 from Appendix 4.
(3) Calculate R_L and R_1 by solving (1) and (2), yielding:—

$$R_L = \frac{V_{CC}}{V'_T} - \frac{V_{CC} - V_R - V_{BE2} + V'_{BE1}}{\left[(V_R - V'_{BE1})\left(\dfrac{1}{R_2} + \dfrac{1}{(1+\beta_2)R_E} \right) + \dfrac{V_{BE2}}{R_2} \right] R_2 \left(1 + \dfrac{V_{BE1}}{V'_T} \right) \alpha_1} \cdot \frac{R_E}{} \quad ...(7)$$

and

$$R_1 = \left[\frac{V_{CC}}{V'_T} + \alpha_1 \cdot \frac{R_L}{R_E} \left(\frac{V_{BE1}}{V'_T} - 1 \right) \right] R_2 - R_L \quad .. \quad .. \quad .. \quad ..(8)$$

where $V'_T = V_T - V_{BE1} + V'_{BE2}$

Saturation. It occasionally happens that a trigger designed as described saturates while the input voltage is increasing from V_T to V_R. In the trigger to be described in Part 2, this condition can be designed-out, but with the basic trigger there are not enough circuit variables to pre-determine the saturation point. After completing the design sequence, therefore, it is advisable to substitute in expression (4) to find the input saturation voltage. If saturation is encountered, the circuit must be redesigned using:—

   (a) Lower loop gain, or
   (b) Lower V_{CC}.

$$V_{IN(sat)} = \frac{V_{CC} - V_{CE1(sat)}\left(1 + \frac{R_L}{R_1 + R_2}\right)}{1 + \frac{R_L}{R_1 + R_2} + \frac{R_L}{R_E}} + V_{BE1(sat)} \cdots \quad (4)$$

Negative resistor values. If a resistor has a calculated negative value, this is an indication that the parameters required of the trigger are not compatible with the components and supplies used.

The more usual remedies are:—
   (a) Increase V_{CC}
   (b) Widen V_R tolerance
   (c) Use higher-β transistors.

The choice of (a), (b) and (c) depends, as with the other remedies, on the specific trigger considered, and can be determined by experimental substitution of values.

Temperature dependence of V_T. Referring to the expression obtained in Appendix 2, it is clear that the temperature dependent terms are V_{BE1}, I_{CEO1}, I_{CEO2} and α_1. The change in V_T per unit temperature can then be expressed as in the expression (5) below:—

$$\frac{\partial V_T}{\partial T} = \frac{1}{D}\left[D + \alpha_1 \frac{R_L}{R_E}\left(\frac{\partial V_{BE1}}{\partial T}\right) - R_L\left(\frac{\partial I_{CEO1}}{\partial T}\right) + R_1 + R_L\left(\frac{\partial I_{CEO2}}{\partial T}\right)\right] - \frac{\partial V'_{BE2}}{\partial T} \quad \cdots \quad (5)$$

where $D = 1 + \frac{R_1 + R_L}{R_2} + \alpha_1\left(\frac{R_L}{R_E}\right)$

The effect of $\partial\alpha/\partial T$ is neglected, as this is very much a second-order effect.

Temperature dependence of V_R. This is calculated in a similar manner to that used for V_T, by partial differentiation of the expression derived in Appendix 3. The temperature dependent terms are V_{BE2}, V_{BE1}, β_2, I_{CEO1} and I_{CEO2}.

$$\frac{\partial V_R}{\partial V_T} = -\frac{1}{A}\left[\left(\frac{R_1 + R_L}{(1 + \beta_2)R_E} - 1\right)\frac{\partial V_{BE2}}{\partial T} - R_L \frac{\partial I_{CEO1}}{\partial T} + (R_1 + R_L)\frac{\partial I_{CEO2}}{\partial T}\right] + \left(\frac{V_{CC} - A.V_{BE2}(R_1 + R_L)}{A^2\beta_2^2 R_E}\right)\frac{\partial\beta_2}{\partial T} + \frac{\partial V'_{BE1}}{\partial T} \quad \cdots \quad (6)$$

where $A = 1 + R_1 + R_L\left(\frac{1}{R_2} + \frac{1}{(1 + \beta_2)R_E}\right)$

Note: The value of β_2 to be substituted in (5) should be β_{2min} to ensure worst-case design. If the temperature coefficient of β_2 has already been allowed for in the calculation of R_2, then $\partial\beta_2/\partial T$ can be put to zero in (5).

Dependence of V_T and V_R on power supply stability. This is found by differentiating the equations derived in Appendices 2 and 3 (or equations 1 and 2)

Fig. 8. Typical $V_{BE} - I_C$ characteristic, showing knee voltage, V'_{BE}.
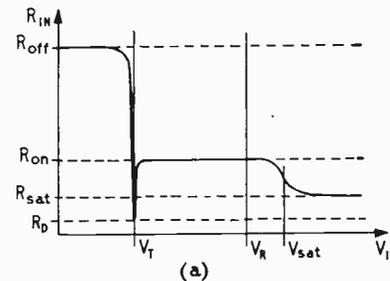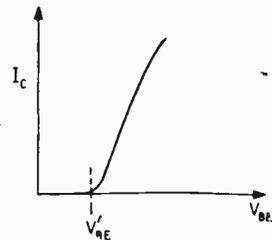
Fig. 9(a). Variation of input resistance with input voltage (V_{IN} increasing).

   (a)
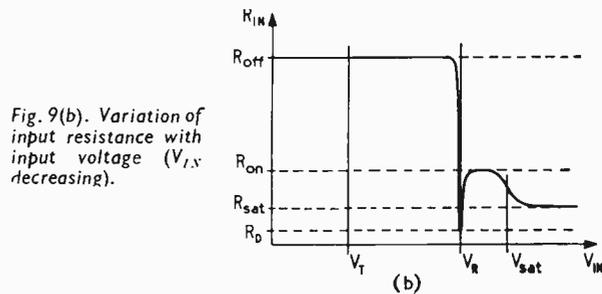
Fig. 9(b). Variation of input resistance with input voltage (V_{IN} decreasing).

   (b)

with respect to V_{CC}: $\partial V_T / \partial V_{CC} = 1/D$ and $\partial V_R / \partial V_{CC} = 1/A$ (D and A are defined above.)

Input resistance. This depends on the input voltage magnitude and whether it is increasing or decreasing. The characteristics are shown in Fig. 9, and the input resistance is seen to have four main values:

R_{off}: input resistance with Tr1 non-conducting.
R_{on}:   ,,   ,,   ,,   ,, conducting.
R_D: ,,   ,,   during regeneration.
R_{sat}:   ,,   ,,   with Tr1 saturated.

R_D is derived from the equivalent circuit of Fig. 3, and may be expressed by the combination:—

$$R_D = (G \| R_E + r_{E1})(1 + \beta_1) + r'_{bb1}$$

where $G = r_{E2} + \frac{(R_1 + R_L) \| R_2 + r'_{bb2}}{1 + \beta_2}$

This equation is useful in computing the loading effect of the trigger on the source.

EXAMPLE

A trigger is to be designed to the following specification:—

$V_T = 10\,V \pm 120\,mV$ at 25°C (drift from +25°C to be within $\pm50\,mV$)

$V_R = 11.25\,V \pm 250\,mV$ over same temperature range.

$V_{CC} = 24\,V$

$I_{C2} = 5\,mA$

Source resistance $= 200\,\Omega$

Transistor parameters:—

$V'_{BE} = 0.5$ V $\qquad V_{CE(sat)} = 0.2$ V

$V_{BE} = 0.7$ V (at 5 mA) $I_{CEO} = 0.1\ \mu$A (125°C)

$V_{BE(sat)} = 0.9$ V $\qquad r_e = 27/5\ \Omega$

$\beta = 45\text{-}221$ including selection and temperature spread

Substituting in equation
$\left\{\begin{array}{l}(3)\\(B)\\(7)\\(8)\end{array}\right.$
gives $R_E = 2.2$ kΩ (2.2 kΩ)
,, $R_2 = 11.1$ kΩ (12 kΩ)
,, $R_L = 1.186$ kΩ (1.2 kΩ)
,, $R_1 = 9.5$ kΩ (10 kΩ).

Substituting in (A), $\gamma_o = 1.4$ for worst-case conditions of β. Substituting in (4), $V_{IN(sat)} = 14.9$ V which is greater than V_{Rmax} and therefore acceptable.

Test results.

$V_T = 10.00$ V at $+25$°C and 9.97 V at $+125$°C. Change in $V_T = 30$ mV.

$V_R = 11.53$ V at $+25$°C and 11.42 V at $+125$°C. Change in $V_R = 110$ mV.

V_R value at 25°C is slightly outside the specification since preferred value resistors were used rather than calculated values.

Verification of drift calculation. The V_T temperature effect may be calculated from equation (4). Ignoring the leakage currents as their effect is negligible in this case; $\partial V_T / \partial T = 48$ mV/100 deg. C (assuming $\partial V_{BE} / \partial T = 2$ mV per deg C). Thus the calculated change is 48 mV and the measured change is 30 mV.

(To be concluded.)

APPENDIX 1

Refer to equivalent circuit (Fig. 3)

Loop gain $\gamma_o = \dfrac{i_4}{i_1}\alpha_1 = \dfrac{i_4}{i_3} \cdot \dfrac{i_3}{i_2} \cdot \dfrac{i_2}{i_1} \cdot \alpha_1$

$\therefore \gamma_o = \dfrac{R_L}{(R_L + R_1 + R_2 \| Z_2)} \cdot \dfrac{R_2}{R_2 + Z_2} \cdot \dfrac{(1+\beta_2).R_E}{(R_E + Z_1)} \cdot \alpha_1$

i.e. $\gamma_o = \dfrac{\alpha_1 R_L (1+\beta_2)}{\left[(R_1+R_L)\left(\dfrac{Z_2}{R_2}+1\right)+Z_2\right]\left(1+\dfrac{Z_1}{R_E}\right)}$ ......(A)

where $Z_1 = r_{e1} + \dfrac{(r'_{bb1} + R_s)}{(1+\beta_1)}$,

and $Z_2 = (1+\beta_2)\left\{r_{e2} + \dfrac{R_E Z_1}{(R_E + Z_1)}\right\} + r'_{bb2}$
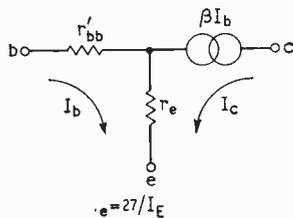
t-equivalent circuit for transistor used in the analysis:-

$r_e = 27/I_E$

APPENDIX 2

Applying the superposition theorem to Fig. 6, to obtain an expression for V_{B1}:—

Suppressing I_{C1} and I_{CEO2}:—

current in $R_2 = \dfrac{V_{CC}}{(R_1 + R_2 + R_L)}$

<table>
<tr><td colspan="2" align="center">**SYMBOLS**</td></tr>
<tr><td>V_{CC}</td><td>Supply voltage</td></tr>
<tr><td>V_{Bsat}</td><td>and V_{IN}. Input voltage which just causes trigger to saturate</td></tr>
<tr><td>V_T</td><td>Lower trip voltage</td></tr>
<tr><td>V_R</td><td>Upper trip or restore voltage</td></tr>
<tr><td>R_S</td><td>Source resistance</td></tr>
<tr><td>β</td><td>Current amplification factor★</td></tr>
<tr><td>r'_{bb}</td><td>Internal base resistance</td></tr>
<tr><td>r_e</td><td>Internal emitter resistance</td></tr>
<tr><td>V_{BE}</td><td>Base-emitter voltage</td></tr>
<tr><td>V'_{BE}</td><td>Knee of I_B-V_B curve</td></tr>
<tr><td>V_{CEsat}</td><td>Collector emitter saturation voltage</td></tr>
<tr><td>V_{BEsat}</td><td>Base-emitter saturation voltage</td></tr>
<tr><td>I_{CEO}</td><td>Collector-emitter leakage current</td></tr>
<tr><td>S</td><td>Current stability Factor ($\approx 1 + R_S/R_E$)</td></tr>
<tr><td>★</td><td>In γ calculations put $\beta = h_{fe}$. In all other calculations put $\beta = h_{FE}$, if known.</td></tr>
</table>

Common-emitter T-equivalent circuit (bracketing β, r'$_{bb}$, r$_e$)

Suppressing I_{CEO2} and V_{CC}:—

current in $R_2 = \dfrac{-R_L \cdot I_{C1}}{(R_1 + R_2 + R_L)}$

Suppressing I_{C1} and V_{CC}:—

current in $R_2 = \dfrac{I_{CEO2}(R_1 + R_L)}{(R_1 + R_2 + R_L)}$

Adding currents algebraically and multiplying by R_2:—

$V_{B1} = \dfrac{\{V_{CC} - I_{C1}(R_L) + I_{CEO2}(R_1 + R_L)\}}{(R_1 + R_2 + R_L)} R_2$ .. (a)

At V_T threshold, $V_T = V_{B1} + (V_{BE1} - V'_{BE2})$

From Fig. 6, $I_{C1} = S\, I_{CEO1} + \dfrac{\alpha_1(V_T - V_{BE1})}{R_E}$ .. (b)

Combining (a) and (b) and transposing for V_T:—

$V_T = \dfrac{V_{CC} + \alpha_1 V_{BE1}\left(\dfrac{R_L}{R_E}\right) + I_{CEO2}(R_1 + R_L) - S \cdot I_{CEO1}R_L}{\left(1 + \dfrac{R_1 + R_L}{R_2} + \dfrac{\alpha_1 R_L}{R_E}\right) + V_{BE1} - V'_{BE2}}$

APPENDIX 3

Applying the superposition theorem to Fig. 7 in a similar manner to that used for Fig. 6 in Appendix 2, we can obtain an expression for V_{B2}:—

$\dfrac{R_2\left[V_{CC} + V_{BE2}\left(\dfrac{R_1 + R_L}{(1+\beta_2)R_E}\right) - I_{CEO1}\beta_1 R_L + I_{CEO2}(R_1+R_L)\right]}{R_1 + R_2 + R_L + \dfrac{(R_1 + R_L)R_2}{(1+\beta_2)R_E}}$

At V_R threshold, $V_{B2} = V_R - V'_{BE1} + V_{BE2}$,

$\therefore V_R = \dfrac{V_{CC} + V_{BE2}\left(\dfrac{R_1 + R_L}{(1+\beta_2)R_E}\right) - I_{CEO1}\beta_1 R_L + I_{CEO2}(R_1 + R_L) - V_{BE2} + V'_{BE1}}{1 + R_1 + R_L\left(\dfrac{1}{R_2} + \dfrac{1}{(1+\beta_2)R_E}\right)}$

Consider Tr1 off and let input resistance to Tr2 be R. Let voltage at base of Tr2 be at the restore point (i.e. V_R).

Now $V_R = V_{CC}\left(\dfrac{d}{a+d}\right)$ where $d = R_2 \| R$ and $a = R_1 + R_L$, see Fig.

So $V_{Rmax} = \dfrac{V_{CC}}{1 + \dfrac{a}{d_{max}}}$ and $V_{Rmin} = \dfrac{V_{CC}}{1 + \dfrac{t}{d_{min}}}$

giving $\dfrac{d_{min}}{d_{max}} = \dfrac{\left(\dfrac{V_{CC}}{V_{Rmax}} - 1\right)}{\left(\dfrac{V_{CC}}{V_{Rmin}} - 1\right)} = F$, say.

As $R_2 \| R$ and $R = r'_{bb2} + (1 + \beta_2)(r_{e2} + R_E)$

then $F = \dfrac{R_2 R_{min}}{R_2 + R_{min}} \cdot \dfrac{R_2 + R_{max}}{R_2 R_{max}}$

(R is given max. and min. values according as β takes max. and min. values). Transposing:—

$R_2 = \dfrac{1 - F}{\dfrac{F}{R_{min}} - \dfrac{1}{R_{max}}} \cdots$ (B), where $F = \dfrac{V_{CC}/V_{Rmax} - 1}{V_{CC}/V_{Rmin} - 1}$.

By inspection of the Fig.:—

$$V_{CC} = I_{sat}R_L + V_{CE1\,sat} + V_{B\,sat} - V_{BE1\,sat}$$

where

$$I_{sat} = (V_{B\,sat} - V_{B1\,sat})\left(\dfrac{1}{R_E} + \dfrac{1}{R_1 + R_2}\right) + \dfrac{V_{CE1\,sat}}{R_1 + R_2}.$$

By substituting for I_{sat} and transposing for $V_{B\,sat}$, we have:—

$$V_{B\,sat} = \dfrac{V_{CC} - V_{CE1\,sat}\left(1 + \dfrac{R_L}{R_1 + R_2}\right)}{1 + R_L\left(\dfrac{1}{R_E} + \dfrac{1}{R_1 + R_2}\right)} + V_{BE1\,sat}.$$

Above: Notation used in Appendix 4.

Right: Showing symbols for Appendix 5.

H. F. PREDICTIONS — MARCH

MEDIAN STANDARD M U F
OPTIMUM TRAFFIC FREQUENCY
LOWEST USABLE H F
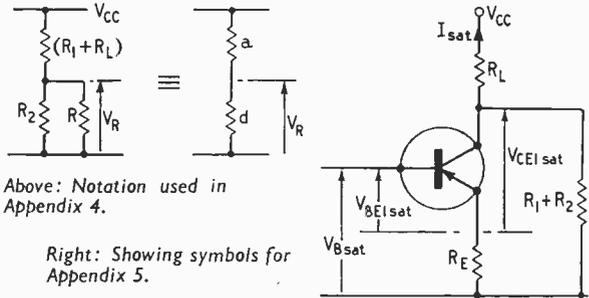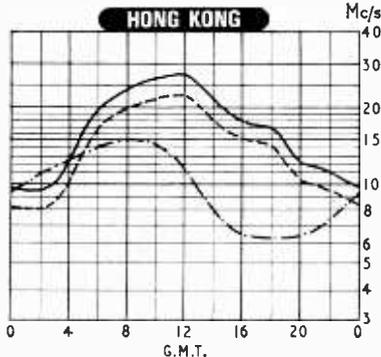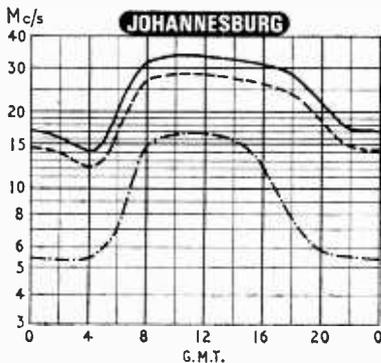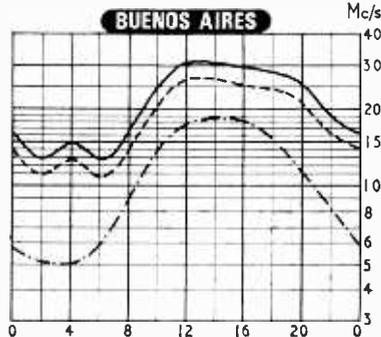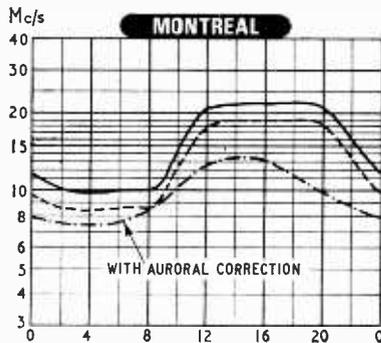
The prediction charts, which are prepared three months in advance by Cable and Wireless Ltd., show the median standard MUF, optimum traffic frequency (FOT) and the lowest usable frequency (LUF) for reception in this country from the areas indicated.

MUFs are some 20% higher than for March 1966, and curves for routes in the northern hemisphere are smoother than recent months. The FOT, or optimum working frequency (OWF), is the highest frequency usable for 90% of the month. LUFs are dependent on type of service, equipment, and local noise levels, hence, unlike MUFs, they differ for each direction of the route. Those shown are for commercial telegraphy using powers of several kilowatts and rhombic type aerials. For reception of high-power broadcasting stations LUFs would be similar, but for amateur telephony would be a few megacycles higher.

PERSONALITIES

W. A. S. Butement, C.B.E., B.Sc., D.Sc.(Adelaide), who was a member of Sir Robert Watson-Watt's original radar team and has been chief scientist in the Australian Department of Supply since 1949, has left the Department and has joined Plessey Pacific Pty Ltd., Melbourne, as director of research. When he was appointed chief scientist, at the age of 45, he was also given executive charge of the Australian Defence Scientific Service which includes the Woomera Rocket Range. Incidentally, Woomera's main square is named after him. Dr. Butement, who during the latter part of the war was assistant director of scientific research in the U.K. Ministry of Supply, received £1,200 from the Royal Commission on Awards to Inventors for "his contribution to the development of radar installations" which included the "split" method of d.f. and a fire control system using echoes from shell splashes.

It is announced by the Board of Trade, Telecommunications Division, which is responsible for the provision and operation of radar, communications, navigational aids and other electronic facilities for civil aviation and air traffic control, that **W. H. Garnett,** O.B.E., F.I.E.E., is appointed director of telecommunications in the National Air Traffic Control Services. Mr. Garnett,


W. H. Garnett

who is 50, served his apprenticeship and the early part of his career in the G.P.O. Engineering Department. During the war he served in the R.A.F., attaining the rank of wing commander. He joined the Ministry of Civil Aviation in 1946 and has since served in a number of posts concerned with the development, installation and operation of radio navigational aids, radar, and communications equipment for civil aviation. He was at one time assistant director of electronics research and development (civil aviation) and latterly deputy director of telecommunications.

The 45th award of the I.E.E. Faraday Medal has been made to **Professor H. E. M. Barlow,** Ph.D., B.Sc.(Eng.), F.R.S., "for his pioneering work in microwave engineering, embracing the development of absolute measurements of microwave power, the investigation of a particular type of low-loss wave guide and its application to long-distance transmission, and detailed studies of surface waves." Professor Barlow, who is 67, became a member of the academic staff in the Faculty of Engineering at University College, London, in 1925. In 1939 he joined the Telecommunications Research Establishment of the Air Ministry, to work on radar development, and later became superintendent of the radio department, Royal Aircraft Establishment, Farnborough. Professor Barlow was recently appointed chairman for six years of the British National Committee for the International Scientific Radio Union (U.R.S.I.). He is a member of the newly formed Ministry of Technology Council for Measurement and Calibration Services, is chairman of its High Frequency Committee and has been a member of the B.B.C. Scientific Advisory Committee since 1953. Since 1963 he has been a director of Marconi Instruments Ltd.

S. E. Clarke, who has been with the Marconi Company since 1946, principally in the Radar Division, and latterly in the International Division of which he was appointed overseas manager in 1963, has now become manager of the division. After war

S. E. Clarke
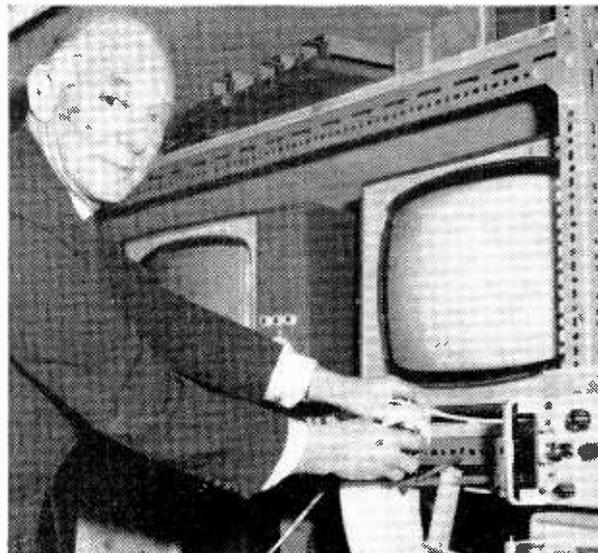
Professor H. E. M. Barlow at work in the laboratory.

service as a radar officer in the Royal Navy Mr. Clarke, who is 46, joined the Marconi Company and played a significant part in the initial formation of the Company's Radar Division. Following the installation of a radar set on the cruiser *La Argentina* during her voyage to South America, he set up a radar training school in Argentina which he ran for four years. In 1951 he returned to England to become a project engineer in the Radar Division in Chelmsford. Two years later he was appointed sales manager in the naval section of the Division.

Miss Rose Winslade, president of the Women's Engineering Society, has been appointed to the staff of the Council of Engineering Institutions. She spent several years on the engineering staff of the Plessey Organization and for the past fifteen years or so in a technical/commercial capacity with Philips Industries. Latterly Miss Winslade was joint manager of the Electronics Division at Research and Control Instruments Ltd., now amalgamated with M.E.L. Ltd.

Dr. Denis Taylor, M.Sc., F.I.E.E., since 1963 head of the UNESCO Mission in the Faculty of Engineering at University College, Nairobi, has been appointed to the new chair of electronic science and telecommunications in the School of Electrical Engineering, University of Strathclyde, Glasgow. He is a graduate of University College, Hull, where he obtained his Ph.D. in radio engineering in 1934 and was a lecturer until 1939 when he joined the staff of the Bawdsey Radar Research Station. During the war he was concerned with the development of radar and for his work on G.C.I. (ground controlled interception) equipment he received an award of £2,400 from the Royal Commission on Awards to Inventors. He

continued in the Government Scientific Service, latterly as head of the Electronics and Instrumentation Division of the Atomic Energy Research Establishment, until 1957 when he joined Plessey Nucleonics Ltd. as director and general manager. In 1962 he was appointed co-ordinator of research and development for the Plessey Group.

Brigadier, E. Holland, B.Sc.(Eng.), M.I.E.E., R.E.M.E., has been appointed director of guided weapons (military) in the Ministry of Aviation in succession to **Brigadier F. W. Grant** who is retiring from the Army. Brigadier Holland, who is 51 and a graduate of Manchester University, joined the Army in 1940. From 1963 to 1965 he was assistant director of electrical and mechanical engineering in the Ministry of Defence and for the past two years has been director of electrical inspection in the Ministry of Aviation.

Jack Bostock, M.I.E.E., director and general manager (operations) of the Sperry Gyroscope Company since 1962, has succeeded **Lionel Jofeh,** O.B.E., F.I.E.E., as chairman and managing director of the company. Mr. Jofeh who joined Sperry in 1947 as an equipment engineer on naval gunfire control is leaving the company. Mr.

J. Bostock

Bostock joined the company in 1948 as a design engineer (also on naval gunfire control), he became superintendent computer projects in 1955 and in 1958 was appointed engineering manager of the Bracknell, Berks, factory. In 1961 he became group manager responsible for stable platforms and inertial navigation systems and for the past four years has been general manager (operations).

C. F. Machin, B.Sc., F.Inst.P., has been appointed a director of Mullard Ltd., which he joined in 1962. He continues as head of the Mullard Industrial Markets Division, but relinquishes his directorship of Associated Semiconductor Manufacturers Ltd., the joint Mullard-G.E.C. semiconductor development and manufacturing company. Mr. Machin, who is 52, joined the G.E.C.

C. F. Machin   *J. A. Jenkins*   *J. C. Akerman*

Research Laboratories in 1931. In 1956 he was made chief engineer of the company's semiconductor department, and two years later he was appointed manager of its semiconductor plant at Stockport, Cheshire.

J. A. Jenkins, M.A., A.Inst.P., at present a director and general manager of Associated Semiconductor Manufacturers Ltd., becomes managing director, and **J. C. Akerman** becomes a director. Mr. Jenkins (47) joined Mullard Research Laboratories in 1947, where he subsequently took charge of the photoelectronics division. He left the laboratories in 1955 to establish the Mullard semiconductor manufacturing division and to head the first of Mullard's specialist transistor factories, at Southampton. When Mullard and G.E.C. merged their semiconductor businesses in 1962 to form Associated Semiconductor Manufacturers Ltd. he was appointed to the board and became its general manager. Mr. Akerman (49) is commercial product manager for all semiconductor devices, including microcircuits, within the Entertainment Markets Division of Mullard.

Two senior appointments have been made in the Radio Division of Standard Telephones and Cables Ltd. at New Southgate, North London. **E. H. Bruce-Clayton,** who joined the company in 1965 as aviation marketing manager, is appointed aviation planning manager. Succeeding him as aviation marketing manager is **R. D. Stirk,** who recently joined S.T.C. from Rank-Bush Murphy Electronics Ltd., where he was the overseas sales manager. Previously he was with G.E.C. Electronics Ltd.

W. C. Morgan, B.A., F.I.E.E., has been appointed a vice-president of the Andrew Corporation, of Chicago, manufacturers of microwave aerials and associated equipment. He will be responsible for developing the company's operations in Europe, based at a new factory at Lochgelly in Fife. A graduate of Oxford University, Mr. Morgan joined the Royal Signals on the outbreak of war and left in 1953, with

the rank of Lieut.-Colonel, to become a director of E.M.I. Electronics Ltd. In 1963 he joined Elliott Automation Continental S.A.

G. H. Stone, who joined Cannon Electric (G.B.) Ltd. as sales manager in 1957 and has been sales director for the past two years, has become managing director. He succeeds **J. H. Powell** who has resigned but continued as consultant for three months.

J. W. M. Child, B.Sc.(Eng.), a graduate of King's College, London, has been appointed sales manager of G. A. Stanley Palmer Ltd. in addition to being general sales manager of Elmbridge Instruments Ltd., an associate company. Both companies are now located at West Molesey Trading Estate, Surrey.

OBITUARY

J. E. (Dick) Goodwin, B.A., group service manager with British Relay Ltd., died on January 8th aged 61. He joined the company in 1946 (after war service as a Lieutenant Commander in the R.N.V.R.) as service manager of the newly formed p.a. department which later became the Special Services Division. When the company entered the television field he was appointed manager of the Television and Rental Department. In addition to being group service manager he was also a director of a subsidiary company Gem Electrical & Radio Services. Mr. Goodwin had been a member of the council of the Radar & Electronics Association for some years.

Colin H. Gardner, who was with the Mullard Company for 32 years until his retirement in 1961, died on December 27th at the age of seventy. He entered the radio industry in 1921. For many years he handled technical/commercial liaison work with dealers. For the last eight years of his service he managed the Mullard Films & Lectures Organization. Mr. Gardner was a past-president of the Incorporated Practitioners in Radio & Electronics and was an amateur transmitter from 1910 until 1939.

NEWS FROM INDUSTRY

£1M Communications Systems for NATO

TWO transportable communications systems for NATO are being supplied by the Marconi Co. Ltd. and are expected to be fully operational by the 1st April, seven months after the order was placed. Each of these systems will consist of a transmitting station, with a number of transmitters from the MST (Marconi Self Tuning) range, and a receiving station equipped with dual diversity receivers. Frequency changes can be achieved in seconds, by the operation of decade dials, and tuning is automatic. The two stations within each system will be connected to each other by multichannel microwave links. Operating within the area of Allied Command Europe, these systems will provide h.f. communication for SHAPE in Belgium, and the headquarters of AFCENT (Air Forces Central) in Holland. Altogether 18 transmitters and 15 receivers will be employed and each system has been designed to fit into a transportable container complete with microwave links, telephone and telegraphy channelling equipment, teleprinters and control apparatus. Aerials and high-power cable networks with power supplies are also to be supplied by Marconi.

Microwave equipment for "Starrnet," the 15-station radio relay system which will enable the telecommunications network of the British Army of the Rhine "to be rationalized and to provide facilities to meet the increased demands imposed by sophisticated equipment in the Army," is to be supplied by Marconi. Initially, the system, which will cost some £500,000, will cater for 120 speech channels over a single radio path but could be expanded to 300 channels. Provision will be made for it to handle telephone, telegraph and data transmission.

Flight trials of a new air defence system developed by British Aircraft Corp. in conjunction with Decca Radar Ltd., are now in progress. Decca is completing the development of a target detection radar and a command transmitter for this ET316 system, which will be known as "Rapier." It is believed to be the world's most advanced **low-level air defence system** capable of detecting aircraft and helicopters flying at heights from tree-top level to several thousand metres. The target detection radar is fully automatic, and unskilled personnel can be quickly trained to operate the system in the field. The equipment is housed within a mobile launcher which carries a rotatable platform for four missiles.

Standard Telephones and Cables **radio altimeter** type STR70-P is to be fitted in place of American equipment in the Phantom F-4Ks and F-4Ms to be supplied by the McDonnell Aircraft Corp. to the Royal Navy and R.A.F. This solid-state radio altimeter, which was wholly developed by S.T.C. in the U.K., is frequency modulated, is designed for low level operation and can be used for automatic landing. The order is worth approximately £210,000.

The **fully-automatic landing system,** jointly developed by British Aircraft Corporation and Elliott-Automation, is to be fitted in all B.O.A.C's Super VC10s. This was announced after over a year's experimental use of the system on a specially equipped VC10 during which it had made over 560 fully automatic landings.

Doppler Navigators are to be fitted to the nine Boeing 707s in the service of Air India, through an order placed with the Marconi Co. Ltd. This order, worth nearly £250,000, includes test equipment, spare components and sub-units. It is expected that by mid-1967, each of these international jets will have a single Doppler sensor and track guide computer installed to provide the crew with accurate basic navigational information, independent of ground-based aids.

A symbol-writing waveform-generator is to be developed by Specto Avionics Ltd. in co-operation with the Royal Aircraft Establishment, Farnborough. This instrument will be used in the development of electronic displays for aircraft cockpits with particular emphasis on head-up displays. In its present experimental form the generator allows the operator to "write" as many as ten symbols for simultaneous display. Some of the symbols which can be formed are alpha-numeric, linear, ramps, triangles, thermometer scales, and circles, all of which may be modified, or erased and re-written as required.

Empressa Nacional de Telecomunicaciones (TELECOMS), the Colombian telecommunications authority, has given an order worth over £250,000 to S.T.C. Ltd., for the supply and installation of h.f. radio communication equipment. An S.T.C. "Stanfast" system, to be installed by the autumn of 1968, will give TELECOMS **remote controlled operation for its international telephone and telegraph services.** At El Rosal— on the Bogota plateau—a station will be equipped with five 30 kW and five 3 kW auto-tune transmitters, drive units, log periodic aerials for horizontal and vertical polarization, and an automatic

system for coaxial switching of transmitter and aerials. The San Juan receiver station (east of Bogota) will be equipped with five "Stanfast" autotune receivers with extended control facilities, and will operate with log periodic aerials designed for the service. Transmitting and receiving stations will each be manned by one operator.

Transitron acquire Lemco.—An agreement between the London Electrical Manufacturing Co. Ltd. (Lemco), and Transitron Electronic Corporation, Wakefield, Mass., U.S.A., permits Transitron to acquire all the assets of the British company for Transitron stock. This agreement includes an additional facility in Northern Ireland, 50% of which is owned by Lemco. The company, which recently closed its factory in S.W. London and is now concentrated at Beavor Lane, London, W.6, will operate as a wholly owned subsidiary of Transitron under its present management.

Aveley Electric Limited, South Ockendon, Essex, have signed an agreement with **Metronex, of Poland,** for the exclusive selling rights in the U.K. of five electronic instruments made by Unipan, a subsidiary of the Polish Academy of Science.

Den Norske Hoyttalerfabrikk, the Norwegian manufacturers of **D.N.H. loudspeakers,** are to be represented in the U.K., and their products marketed by, Highgate Acoustics, 71-73 Great Portland Street, London, W.1.

Hivac Limited, of South Ruislip, Middx., a wholly owned subsidiary of the Plessey Company, will no longer trade under its present full corporate title. It will, in future, be known as the **Hivac Division** of the Components Group of the Plessey Company.

Nand-Nor Electronics Ltd. has been formed by Charles Corner, formerly plant manager for SGS-Fairchild. The company, with headquarters at 43 Chantry Way, Billericay, Essex, is developing digital instruments and will undertake the engineering and development of instruments and controls to specifications.

Lisle Instrument Systems Ltd., of Toronto, are to manufacture under licence and sell throughout Canada the **Elremco** range of industrial timing and remote control equipment of Electrical Remote Control Company of Harlow, Essex.

Erratum.—It is regretted that because of a printer's error, the opening sentence of the third paragraph in the right-hand column, on page 88, of the February issue, did not make sense. It should have read "A teleprinter with a print-out speed of 3,000 words per minute. . ."

TRAVELLING-FIELD FUNCTION GENERATORS

ANALOGUE/DIGITAL CONVERTER IN SINGLE PELLET OF BULK SEMICONDUCTOR

A NEW class of semiconductor devices in which functions of time can be generated by electric-field domains travelling through bulk semiconductor material is being developed by Standard Telephone Laboratories. Experimental analogue-to-digital converters have been devised using the technique—known as "domain originated functional integrated circuits" (DOFIC)—and the company say they foresee further extensive application possibilities "including perhaps entirely integrated television camera and display systems."

The electric-field domains are launched in the bulk material when a d.c. bias voltage applied across it exceeds a certain threshold value, and they travel through the crystal, which is typically a few hundredths of an inch long, at velocities up to 10^7 cm/s. The conduction path through the material is shaped, however, by doping or alterations in cross-sectional area, to give a variation of conductivity along its length. Thus, as a travelling domain encounters these regions of different conductivity, the current through the device varies correspondingly and it is this varying current which forms the output waveform.

Although the "conductivity profile" built into the device constitutes a static characteristic, the normal output current waveform can be modified by dynamic control (i.e., while a domain is in motion) by varying the instantaneous bias. Thus, a domain can be arrested at any point along the conduction path. Furthermore, the point along the path at which the domain is removed can be made, for example, proportional to the applied bias, by introducing an overall slope or taper into the profile.
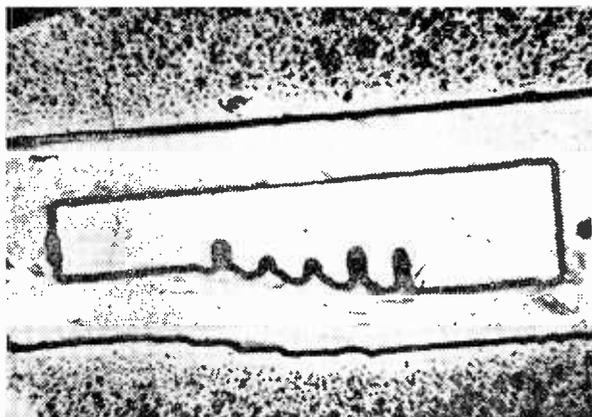
The picture shows the epitaxial construction of a four-level analogue-to-digital converter. In this the number of output current pulses obtained is proportional to the applied bias. The "digital" profile which produces the pulses and the overall slope can be seen. S.T.L. say that a 64-level, 6-digit converter using a 2-mm long drift path in gallium arsenide seems quite feasible.

A drawback in the S.T.L. devices using the present method of domain formation (inter-valley transfer of hot electrons from lower to higher effective mass states) is

that bit rates, determined by the domain velocity of 10^7 cm/s, are at microwave frequencies. However, by using other types of domain formation (e.g., electron-phonon coupling) these can be reduced, it is stated, by a factor of 100 or more.

In addition to obtaining the output waveform from the current through the device it is possible to make use of the high electric fields due to the domains: these can be readily picked up by electrodes placed sufficiently near to the surface of the semiconductor. Thus, it is possible to have a completely separate electrode system bearing any additional code profile, etc., electrostatically coupled to the domain. The sweeping domain will then produce output potentials as it moves past the electrode, which can be shaped to produce any desired time spacing of the output pulses.

It is also possible to obtain optical read-out by detecting light excited by the domain as it passes through the crystal. This raises the prospect of completely different types of display device that might well be applied to television engineering.

Bio-Engineering Show

MEDEA—67, the International Medical Engineering and Automation Exhibition sponsored by the Electronic Engineering Association and the Scientific Instrument Manufacturers' Association, will be held at Earls Court, London, from March 13th to 17th. In association with the exhibition there will also be the second European Symposium on Medical Electronics at which some forty papers will be presented; many of them from overseas.

The exhibition will be open from 1000 to 1800 (except on the 16th when it will close at 2100), and admission will cost 3s or by invitation card obtainable free from exhibitors; a list is given below.

A.B. Optimus Anchorverken	Lan Electronics
Alvar Electronic	Lexington Instruments Corp.
B & K Instruments	Lucas
Barr & Stroud	Medicor
Beckman Instruments	Medtronic Inc.
Bell & Howell	Metrimpex
(Consolidated Electrodynamics)	Morgan, P. K.
Boers, Jan	Nicholas Products
Bosch Elektronik	Nuclear-Chicago Europa N.V.
Cardiac Recorders	Nuclear Data Inc.
Compagnie des Compteurs	Officene Toscane Elettromeccaniche
Corbin-Farnsworth Inc.	Pergamon Press
Data Laboratories	Picker International Corp.
Devices Sales	Pitman, D. A.
Disa Electronic	Polaron Equipment
Disc Instruments	Precision Instrument
E.M.I. Electronics	Quartz & Silice
Electronic Associates	Rimbach Publications
Electronic & X-ray Applications	Röntgen, Emisa
Elliott Medical Automation	S.E. Laboratories
Epyslon Industries	Shackman, D., & Sons
Esterline Angus Instrument Co.	Shandon Scientific Co.
Flaig, W. G., & Sons	Sierex
Fox, C. J., & Sons	Sonasales
Hewlett Packard	Spembly Technical Products
Honeywell Controls	Statham Instruments
How, James, & Co.	T.E.M. Sales
Ingenjorsfirman Besam A.B.	Technical Measurement Corp.
Instrumentarium	Telco S.A.
Joyce, Loebl & Co.	U.K. Atomic Energy Authority
Kent, George	Vickers
Kent Industrial Instruments	W.T.W.
Kimal Scientific Products	Wireless World and Industrial
Laboratory Equipment Digest	Electronics .

Tracking Russian Satellites

NEW DOPPLER METHOD TAKING ADVANTAGE OF COSMOS SATELLITE F.S.K. TRANSMISSIONS

By G. E. PERRY,* B.Sc., A.Inst.P.

Kettering Grammar School came in for a good deal of publicity recently when it was revealed that a group of boys and their science masters had tracked a number of Russian Cosmos satellites and located their launching sites. The observation techniques were devised by the school's senior physics master, who describes them in this article.

METHODS of receiving radio signals from artificial satellites and using the Doppler effect to determine the time of closest approach (hereafter referred to as c.a.) were described shortly after the first Sputniks were launched.[1,2,3] A typical Doppler curve is shown in Fig. 1. Because of the motion of the satellite, the signal, when first received, appears to have an increased frequency as the satellite approaches the receiving station. This gradually falls to the true frequency when the satellite is at c.a., at which instant the rate of change of frequency is most rapid, and goes on falling as the satellite travels away.

The transmissions on 19.995 Mc/s from the Russian Cosmos satellites (which are recovered after eight days in orbit) are not on a single frequency as were those from the earlier Sputniks. Frequency-shift keying, with a repeating pattern similar to that shown in Fig. 2, is employed, the difference between the two radio frequencies being approximately 900 c/s. This makes analysis by the normal method[1] difficult, and a further difficulty arises from the fact that the transmissions are not continuous, but are commanded from ground stations within the Soviet Union. This means that the satellite must be above the horizon of the command station to allow it to be switched on, and at this switching on time it is well above the horizon of our receiving station at Kettering, Northants. Consequently it is not possible to obtain the complete Doppler curve at Kettering—indeed it often happens that the satellite is beyond c.a. when the signals start.

It will be seen that the amount of frequency-shift and the Doppler shift on 20Mc/s are approximately equal. Use is made of this fact to obtain the time of c.a. easily. Fig. 3 shows the Doppler curves of both frequencies and also the setting of the receiver local oscillator at the true frequency of the higher one. This setting is made by adjusting the local oscillator, while the satellite is still approaching, until the two audible beat-frequency tones (heard as pulses of tone) are in unison—the f.s.k./Doppler-shift equality automatically ensuring that the local oscillation is sited at the true signal frequency, as indicated in Fig. 3. Although at first sight this may

seem a crude technique, the human ear is a good detector of small frequency differences and the setting can be made quickly and with some accuracy.

Now consider what is heard as the satellite transit proceeds. The a.f. notes produced are the difference frequencies between the received signals (with their associated Doppler shifts) and the stable frequency generated by the local oscillator. The difference between the higher signal frequency and the local oscillator decreases as the satellite approaches and the pitch of the audible note falls correspondingly, the rate of fall increasing as the satellite nears c.a. When the difference drops below 30 c/s the note becomes inaudible and passes into "zero-beat." The received frequency continues falling as the satellite goes away and when the difference again reaches 30 c/s, a rising note appears out of "zero-beat" and goes on rising. The lower of the two frequencies is already below the local oscillator frequency at the start and, as it drops still further, the difference increases and a rising note is heard for the whole time. This is shown diagrammatically in Fig. 4.

With a near-overhead transit and its associated rapid Doppler effect, the two unison notes initially diverge; one rises continuously while the other falls, passes through "zero-beat," being inaudible for up to 40 seconds, and then reappears and rises also. By taking the mid-time of "zero-beat" as c.a. an error of less than ±30 seconds is introduced.

These particular Cosmos satellites are commanded to transmit only on orbits which take them eventually over Russian territory. Thus they transmit only on northbound transits across the U.K. which take place in daylight, and not on the later southbound transits. This knowledge, together with the inclination of the orbit to the equator, which is given in the Tass announcement of the launch, is sufficient to locate the position of the satellite.
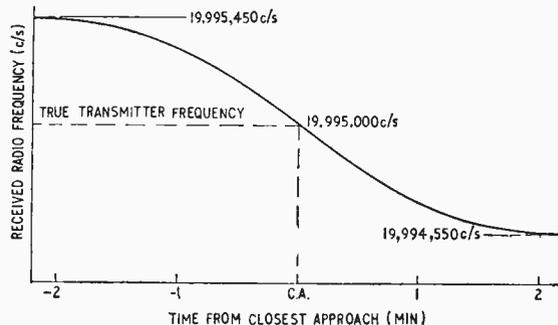

Fig. 1. *Normal Doppler curve for satellite with single-frequency transmission. The true frequency is received at the time when the spacecraft is closest to the receiving station, as indicated by the broken lines.*

* Senior Physics Master, Kettering Grammar School.

Fig. 2. Typical sequence of frequency shifting of signal from 8-day Cosmos satellite. The sequence repeats after a burst of approx. 20 short pulses (Based on transmissions from Cosmos 126). ▶

APPROX 900 c/s

TIME (SEC)
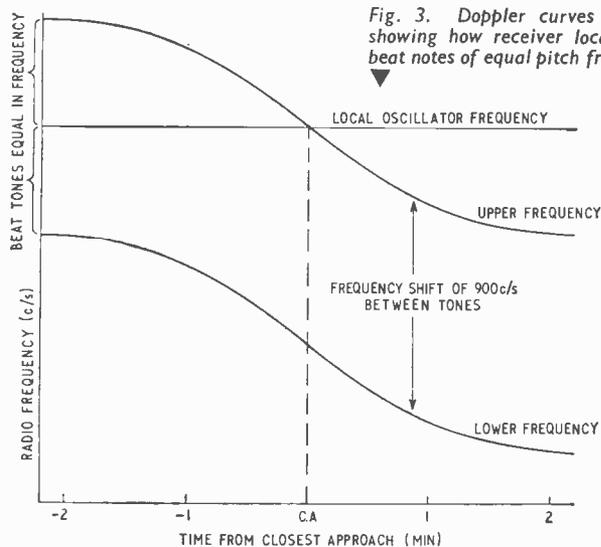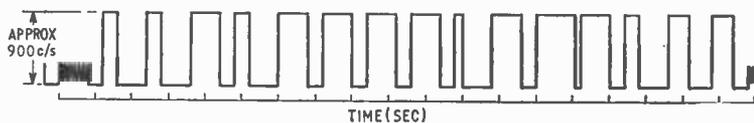
Fig. 3. Doppler curves of frequency-shift satellite transmission showing how receiver local oscillator frequency is set to give a.f. beat notes of equal pitch from the upper and lower radio frequencies. ▼

BEAT TONES EQUAL IN FREQUENCY

RADIO FREQUENCY (c/s)

LOCAL OSCILLATOR FREQUENCY

UPPER FREQUENCY

FREQUENCY SHIFT OF 900c/s BETWEEN TONES

LOWER FREQUENCY

TIME FROM CLOSEST APPROACH (MIN)

Fig. 4. Variation of a.f. difference frequencies. Note period of inaudibility of one tone as upper r.f. passes through value giving zero beat. ▼

AUDIO FREQUENCY (c/s)

1,350

LOWER FREQUENCY

UPPER FREQUENCY

450

50
0

TIME FROM CLOSEST APPROACH (MIN)
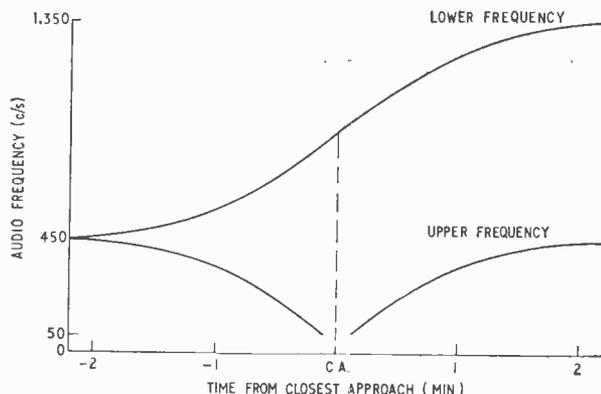
The difference between c.as on successive days, divided by sixteen, gives the orbital period to within ±0.1 minute. This enables the track separation (angle through which the earth rotates between successive transits) to be calculated, due allowance being made for the rotation of the orbital plane about the earth's axis under the influence of the equatorial bulge.

For orbits inclined at 65° to the equator, it can be shown that a transit passing over Kettering will have its northern apex at 52°E. Working back from the time of c.a. (plus eight minutes to reach apex) and this assumed longitude, the period and separation are repeatedly subtracted until the launch day is reached. At this point another assumption is called for; with a launch from the usual Aral Sea complex, the initial northern apex occurs at 125°E. When a longitude lying between 113.5° and 136.5°E on the launch date is reached, it is known that this is the initial orbit. The longitude is then set to 125°E and calculations are made forward from this by repeatedly adding on the period and track separation until the 128th revolution is reached on the eighth day—the usual recovery time. For this work a manually operated desk calculator is available but an Algol computer programme has been devised and, on occasions, used on a local digital computer.

It was the output from the computer which revealed that Cosmos 129, launched on 14th October 1966, had obviously not come from the Aral Sea. The revolution numbers obtained differed by three from those given by American predictions. Since longitudes and times agreed, it was clear that the source of error lay in the programme itself and that the 125°E should, in this case, have been nearer 60°E. This implied that the satellite had either been launched from a more northerly Russian site or from central France! On 21st April 1966 I had suggested in a letter to Flight International (an associate journal of Wireless World) that the 72° satellites, Cosmos 112 and Cosmos 114, had been launched from a new site

The tracking station at Kettering Grammar School.

near the Arctic Circle. I was now able to plot the initial orbits of these satellites and Cosmos 129 on the same map and see where they intersected. This occurred at 63°N, 41°E, a point south of Arkhangelsk—even so, a possible inaccuracy of ±1 must be allowed in both latitude and longitude. The co-ordinates were announced at the Autumn Meeting of The British Interplanetary Society and in Flight International.

REFERENCES

1. Osborne, J. M. Short Wave Mag., 15, Nov. 1957, p. 459.
2. Osborne, J. M. School Science Review, 39, Mar. 1958, pp. 244-253.
3. Perry, G. E. and Slater, J. D. Spaceflight, 4, Nov. 1962, pp. 198-200.
4. Perry, G. E. Spaceflight, 8, Sept. 1966, p. 336.

BOOKS RECEIVED

An Anthology of Philips Research, edited by H. B. G. Casimir and S. Gradstein. Compiled to celebrate the 75th anniversary of the Philips company, this volume consists of a collection of papers on a very wide range of subjects in which Philips have interests. It is essentially for browsing rather than for serious cover-to-cover reading. The majority of the papers are written on developments since 1950 and many of these will be of interest to readers of *Wireless World*. The first part of the book provides historical background from 1891 to 1951 and includes descriptions of research into the gas filled lamp, physics and solid state chemistry. The second part consists of 17 representative papers covering such subjects as delta modulation, Ferroxdure II and III, stereo, reverberation, the gyrator, projection of colour television pictures, orthocyclic coil winding, the alloy-diffusion technique for transistors, and Plumbicon camera tubes. The third and final part, entitled "miscellaneous contributions", contains 20 papers on electronic, chemical and associated subjects ranging from the evolution of permanent magnets to a description of a gas laser. This well illustrated book is printed on good quality paper; page size 9in × 11in. Pp. 469. Price 37s. Centrex Publishing Company, N.V. Uitgeversmaatschappij Centrex, P.O. Box 76, Eindhoven, The Netherlands.

Marine Radio Manual, by G. L. Danielson and F. C. Mayoh. Although this book is primarily intended for those preparing for the P.M.G. 1st and 2nd Class certificates with the aim of becoming ships radio officers, it should also prove suitable for anyone who wishes to make a study of radio starting from first principles. The first twenty-four chapters are devoted to basic theory including a.c. & d.c. principles—machines—valves—transistors—power supplies—oscillators—a.f. & r.f. amplification—frequency modulation—c.r.ts. and propagation. Final chapters describe marine Auto Alarm—Lifeboat—direction finding—and transmitting and receiving equipment. An appendix includes useful mathematical information and a number of typical questions taken from P.M.G. Certificate examination papers. Pp. 621. Price 80s. George Newnes Ltd., Tower House, Southampton Street, London, W.C.2.

Electronic Sensing Devices, by A. F. Giles. A non-mathematical treatise on the various physical-electronic and chemical-electronic methods of sensing temperature, pressure, flow and other parameters associated with industrial control engineering. Presented under the following headings, solid-state, electrolytic, gaseous ion, capacitive, and magnetic sensors; electronic sensors for physical quantities; and electronic sensors for chemistry; this book ends with a list of manufacturers in the field. Pp. 158. Price 45s. George Newnes, Tower House, Southampton Street, London, W.C.2.

Transistor Bias Tables, by E. Wolfendale. These computer compiled tables should be of great use to the designer and experimenter who wishes to arrive at near optimum values for the three bias resistors used in a conventional transistor amplifier. These resistor values are derived from tables which take into account a large number of combinations of supply voltage, collector current, junction temperature, transistor gain, etc. Pp. 71. Price 21s. Iliffe Books Ltd., Dorset House, Stamford Street, London, S.E.1.

Fluctuations of Stationary and Non-Stationary Electron Currents, by C. S. Bull. The early part of this book is devoted to a discussion that assumes that the electric field is discontinuous and examines the consequences of this assumption. This is followed by an explanation of the various types of electrical fluctuations and the necessary mathematics. In the final six of the 13 chapters subjects such as Heisenberg's uncertainty principle, the effect of assumptions in fluctuation theory and the characteristics of a planar diode are examined in detail. Pp. 217. Price 68s. Butterworth & Co. Ltd., 88, Kingsway, London, W.C.2.

Semiconductors, Vol. 1, Physics and Electronics, by E. J. Cassignol (from the Philips Technical Library). Starting with a study of the physical properties of semiconductors, this book goes on to consider the transistor as an active device. H.F. and l.f. equivalent circuits, and bias networks are discussed in some detail as is the use of the transistor as a switch. Pp. 310. Price 72s. Cleaver Hume Press Ltd., Little Essex Street, London, W.C.2.

AUDIO FAIR TICKETS

THIS year's International Audio Festival and Fair will again be held in the Hotel Russell, London, W.C.2, from March 30th to April 2nd. There will be a record number of 88 exhibitors, most of whom will have demonstration rooms as well as stands. The first day from 1100 to 1600 is reserved as a trade preview. Admission later that day and on the other days (1100-2100; Sunday 1100-2000) is by ticket (admitting two) which can be obtained from exhibitors or from this office. Requests for tickets must be accompanied by a stamped-addressed envelope.

MARCH
CONFERENCES & EXHIBITIONS

Further details can be obtained from the addresses in parentheses.

LONDON

Mar. 13-17   Savoy Place
Air Traffic Control Systems Engineering
(I.E.E., Savoy Pl., W.C.2)

Mar. 13-17   Earls Court
Medical Engineering & Automation Exhibition (Medea)
(Electronic Engineering Assoc., 11 Green St., W.1)

Mar. 14-16   King's Head, Harrow
Public Address Exhibition
(A.P.A.E., 394 Northolt Rd., South Harrow, Middx.)

Mar. 30-Apr. 2   Hotel Russell
Audio Festival and Fair
(C. Rex-Hassan, 42 Manchester St., W.1)

CANTERBURY

Mar. 30-31   The University of Kent
Transport Properties of Superconductors
(Inst. P. & Phys. Soc., 47 Belgrave Sq., London, S.W.1)

OVERSEAS

Mar. 1-3   Washington
Particle Accelerator Conference
(I.E.E.E., 345 E. 47th St., New York, N.Y. 10017)

Mar. 5-14   Leipzig
Spring Fair
(Leipziger Messeamf, Post Box 329, Leipzig)

Mar. 9-14   Paris
Festival du Son
(S.I.E.R.E., 16 due de Presles, Paris 15e)

Mar. 20-24   New York
I.E.E.E. International Convention & Exhibition
(I.E.E.E., 345 E. 47th St., New York, N.Y. 10017)

Mar. 22-24   New York
Symposium on Modern Optics
(Polytechnic Inst. of Brooklyn, 333 Jay St., Brooklyn, N.Y. 11201)

Point-to-Point Review, 1966

By **DAVID WILKINSON,*** B.Sc., M.I.E.E.

THE improvement in h.f. conditions noted in 1965 was maintained during 1966 and was largely due to the increase in values of sunspot number and ionosphere index (IF2). The predicted value of the latter for December 1966 was 66, compared with 26 for the same month in 1965. However, the rate of increase in solar activity was much slower than at the same phase of the previous sunspot cycle and, during the second half of the year, the provisional sunspot number showed very little change from month to month.

Professor Waldemeir, of Zurich, forecasts that the next maximum is likely to occur in the autumn of 1968 with a sunspot number in the region of 100, which is considerably lower than the 1957/58 value. The Greenwich provisional monthly mean sunspot number for 1966 was 50.4 compared with 15.3 for 1965.

Twenty-one sunspot groups of area equal to, or greater than, 500 millionths (approximately 585 million square miles) of the visible solar hemisphere were reported. Of these, five were of area 1,000 millionths or greater, the largest reaching 1,500 millionths during its passage across the sun's disc, December 5th-17th.

Forty-six sudden ionosphere disturbances (Dellinger fades) were reported during 1966. Many were of a minor nature and had little effect on h.f. circuit operation. March, July and September were the months during which most of this activity occurred, with 7, 9 and 11 fades respectively. There was a slight increase in the level of magnetic activity in 1966, the monthly mean Hartland "C" value† for the year being 0.57 compared with 0.49 for 1965. Increased activity during the second half of the year was largely responsible for this, several more prolonged disturbances occurring during this period. The effect of these disturbances were generally masked, however, by the use of suitably lower frequencies at critical times and h.f. communication was usually not seriously affected.

The increase in sunspot activity and values of IF2 (well shown by the smoothed values in the graph below) resulted in higher MUFs and the influence of sporadic E on circuit operation was less marked.

As was to be expected, most h.f. circuits showed an increase in efficiency compared with 1965 and the monthly average percentage efficiency of four representative circuits using ARQ (automatic error detection and correction) and received in this country was 92.9 as against 91.0 for 1965. This implies an unprotected efficiency of over 99% (as the ARQ equipment uses up eight characters to correct each mutilated character).

The Early Bird satellite continued in use, and exceeded its expected life of 18 months in October. In October the first Intelsat II satellite was launched but, due to a failure of the apogee motor, did not reach the intended synchronous orbit. The electronics equipment, however, operated satisfactorily and enabled useful tests to be carried out.

Earth stations were completed on Ascension Island, Grand Canary Island and at Andover, Maine, to make use of the Atlantic Intelsat II satellite and at Carnarvon (Western Australia), Paumalu (Hawaii) and Brewster Flats (Washington) to use the Pacific Ocean Intelsat II satellite. These stations were primarily built to carry channels for the NASA Apollo project.

Many other earth station proposals were announced. 1967 should see a large increase in this number.
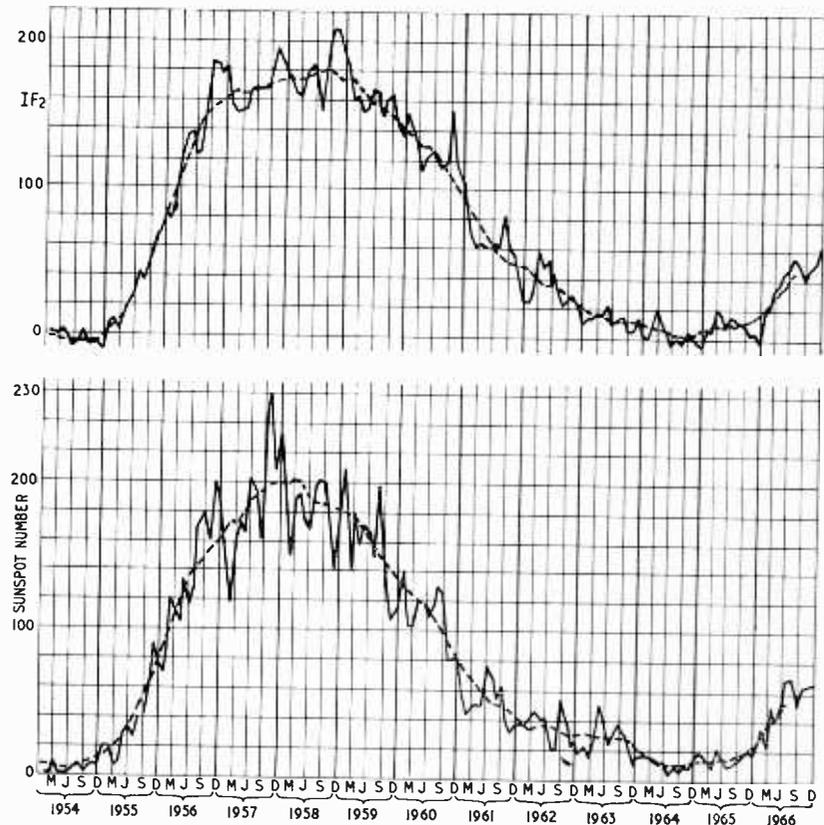
The monthly figures and smoothed values of the IF2 (upper graph) and the sunspot number for the past thirteen years.

Common-Frequency Radio Relaying

EXPERIMENTS WITH "SYNCHRONOUS STABLE RELAYING" DEMONSTRATE METHOD
OF EXTENDING THE RANGE OF FIXED AND MOBILE COMMUNICATION SYSTEMS

By J. R. BRINKLEY, M.I.E.R.E.

SINCE the earliest days of radio communication engineers have faced a serious obstacle when the range of communication required exceeds the "natural" range of a single station. In point-to-point systems the problem is normally solved by relaying the original transmission on a second frequency. This solution is quite satisfactory for such systems, provided the extra frequencies required are available.

It would, of course, be preferable to relay without changing to a new frequency but attempts to do this in the past have run into two serious difficulties. First, if direct radio pick-up is attempted, it is difficult to prevent the relay transmitter from feeding back to its pick-up receiver. Feedback of this kind causes the relay station to go into self oscillation. Secondly if the relay station is connected by telephone line it is difficult to synchronize the stations perfectly. In this case a further difficulty may occur due to heterodynes and interaction distortion between the two stations.

In mobile systems, additional difficulties occur when the range required is beyond the capability of a single station. In this case the use of further frequencies for relaying gives rise to need for multichannel "switchable" mobile equipment. This adds considerably to the cost and complexity of manufacturing and servicing the mobile equipments.

Worse than this, however, a serious operational confusion arises. As mobiles pass from the coverage area of one station to another, their operators have to remember to change to the appropriate channel. This is far from easy for the operator. The coverage pattern for the different stations particularly at higher frequencies is diffused, especially in hilly and built-up areas, and much confusion can arise as a result. The task of the central station operator is also rendered more difficult. He has no certain way of knowing the channel disposi-

tion of the various mobiles in the total area and does not readily know which station to activate in order to contact a particular mobile.

In view of these difficulties the advantages of a system which could relay on the same frequency without going into oscillation would be outstanding and may be summarised as follows:—

(1) It would enable the range of a single-frequency transmission to be extended almost indefinitely by relay after relay.

(2) It would enable a substantial economy of frequency allocation to be achieved.

(3) It would avoid the unrewarding approach of using very high power in single station schemes to strain coverage to the limit.

(4) It would enable system engineers for the first time to "tailor" the coverage to the social and geographical needs of the system.

(5) It would simplify mobile equipment and its operation by avoiding the need for multichannel mobile equipment.

The recent development of reliable solid-state u.h.f. equipment operating in the 450 Mc/s band led to a re-examination of these problems, for three reasons. First, highly stable relaying equipment has as a result become a much more practical proposition. Secondly, directional aerials are much more effective and manageable than at lower frequencies.

The third reason for re-examination has been that the relaying problem previously described has recurred in a rather acute form in some of the many u.h.f. pocket radio telephone systems now being established for the police services and for other purposes. In these systems a single station scheme has a typical range of several miles. If coverage at greater distances is required then one is faced with the age-old problem of how to extend the range. The new form of the problem is acute because of the obvious disadvantages of a multichannel pocket equipment and the particular kind of operational confusion arising in the overlap areas between stations in such systems in confined and built-up areas. It was as a result of these problems that it was decided to evolve and test the new system known as "synchronous stable relaying" or s.s.r.

The basic idea was to pick up the original signal, to amplify it in a relatively high-gain amplifier without overall change of frequency and to re-radiate in such a manner as to minimize back coupling. The equipment arrangement is shown in Fig. 1. It comprises a completely solid-state equipment arranged to heterodyne the received signal down to an intermediate frequency. This is passed through a crystal filter, amplified and stepped up again to the precise original frequency, which is in turn amplified. A relay equipment of this kind can, it is found, have a stable gain of as much as 140 dB with-

J. R. Brinkley, who has been managing director of Pye Telecommunications Ltd. since 1956, received his early training at the Post Office Research Station. During the war he was seconded to the Home Office where he was responsible for the development of many of the first mobile radio systems. He joined Pye Telecommunications Ltd., in 1948 and was appointed technical director the following year. Mr. Brinkley is a member of the P.M.G.'s Frequency Advisory Committee.

out presenting practical difficulties in itself. It can also be designed to meet British Post Office and American F.C.C. specifications in full; an important consideration.

In order that the station shall be effective as a relay it is, in addition, necessary to ensure that the radiated output is isolated from the pick-up aerial by a loss of 100 dB or more. This is achieved by four techniques. First, a directional pick-up aerial of fairly conventional design is used. Secondly, the "retransmit" aerial is arranged to have low backward radiation in the direction of the pick-up aerial. Thirdly, polarization is changed through 90°. This last feature calls for a mobile aerial sensitive to vertical and horizontal polarization, but this is not difficult to arrange at u.h.f. Lastly, a reasonable space factor is inserted between the two aerials in the form of a horizontal spacing typically of the order of 50 to 150 feet.

The success of such an arrangement can only be verified in practical field conditions. In particular, without practical field trial it might be expected to be vulnerable to oscillation via unwanted feedback due to multiple site reflections. A series of tests of relays on "bad" sites, that is in built-up areas in Cambridge and London, has shown that this consideration does not in practice cause difficulty. To date a variety of relaying sites have been tried. No special or critical aerial adjustments have proved necessary and the test systems have been set up at each new site, tested in a few hours and without any instability troubles arising. (See Fig. 2.) Working gains of 120 dB have been typical.

In operation the retransmitted signal is found to be indistinguishable except in increased strength from the original. The signal input to the pick-up receiver is high and thus the signal-to-noise ratio at the output is also high. A large number of such stations in series over a long route would, therefore, appear to be eminently practical.

Surprisingly, interaction and distortion effects in the equi-signal overlap areas are absent. Calculation shows, however, that path length differences between the original and relayed transmission are small. Interaction distortion is not in fact to be expected and is not in the event experienced. Rather more surprisingly, however, the two fields seem to be additive in nearly every situation and, indeed, employing both listening and measurement tests, it has been very difficult to detect any locations at which positive addition of the two signals does not take place. This result must be due to the diffuse nature of u.h.f. propagation, especially in built-up areas, and to some extent to the change in polarization on retransmission. Further investigation into this interesting discovery is obviously desirable but tests so far conducted indicate the interaction problem has at last been overcome.

In the systems tested the originating transmitter had a power of 5 watts. The relay power has been in the region of 0.5 watt. Relay stations of 5 watts are under construction and the systems have adequate margin of
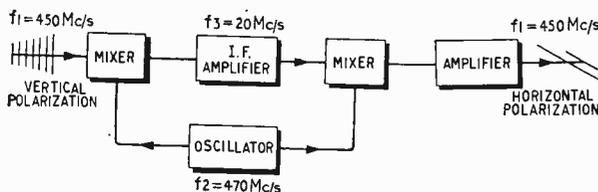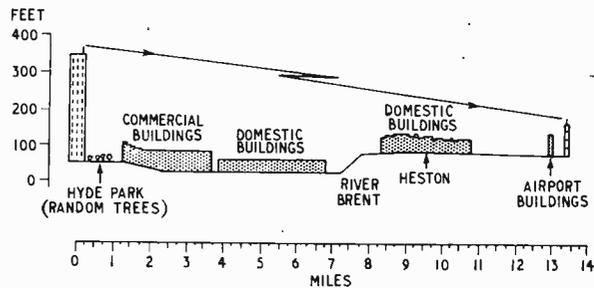
Fig. 2. Contour of an s.s.r. relay path 13½ miles long between London's Hilton Hotel and London Airport. The repeater gain was 130 dB and the relay was completely stable. London Airport was selected as a test site partly to investigate the possibility of instability occurring as a result of aircraft reflections. No instability due to this or any other cause was experienced.

stability to accept this higher power level. It is also clearly possible to scale up both the original transmitter power and the retransmission power in any desired ratio.

These is scope for a good deal of further work on the best forms of aerials to be used for various relay station applications but the aerials used in the field tests to date have been simple and conventional. Indeed aerial simplicity and ease of setting up have in themselves provided convincing evidence of the practicability of the s.s.r. system.

Not only does the system avoid the need for additional frequencies for relaying purposes but it also avoids the need for separate frequencies or telephone lines for linkage purposes. In applications where a substantial number of stations is required to cover a large area this is a very real practical advantage. In long route systems for trunk roads or railways the need for elaborate line or radio interconnection links can be avoided. In this case, since the relay operates at a high signal-to-noise ratio it is possible to envisage as many as 100 stations at 20-mile spacings in a 2,000-mile mobile system for trans-continental communication. In the first place, however, it is expected that the system will find its widest application in extended area coverage systems of all kinds.

Relaying on the same frequency has so many obvious advantages and so many potential applications that it is interesting to consider why its practicability should have gone unnoticed until now. The probable reasons may be listed as follows:—

1. Although a few attempts have been made in the past to perfect this kind of relay, such attempts have been made at v.h.f. as opposed to u.h.f. Equivalent aerials at v.h.f. are, of course, much larger and less manageable.

2. Solid-state techniques make a stable high-gain "same frequency" amplifier much more practical than was previously the case with valve amplifiers.

3. A mobile aerial sensitive to two polarizations is more practical at u.h.f. and probably has not been previously considered.

4. Only practical tests would confirm the high attenuation readily achieved between the relay transmitter aerial and its pick-up receiver aerial. Tests using all the features described have not previously been carried out so far as the writer is aware.

The equipment development and field trials of s.s.r. have been under the supervision of Mr. Brian Armstrong of Pye Telecommunications Ltd.

Fig. 1. Schematic of a synchronous stable relay station.

LETTERS TO THE EDITOR

Symbols: a rejoinder from I.E.C. and further comments

I SHOULD like to be allowed to comment on the Editorial in the January issue, as I believe that it may give rise to a misunderstanding with respect to the objects and function of the International Electrotechnical Commission.

In the first place, the decision of the C.C.I.R. to use the "hertz" as the unit of frequency follows from the I.E.C. recommendation, that, incidentally, dates back to 1935. The use of the term "hertz" has received consistent support from the International Conference on Weights and Measures indicating that this is not merely a question of the "Continentals" imposing their will. The argument that the use of the "hertz" is undesirable because it does not indicate the property of frequency can also be applied to a number of other widely used units.

In the second place, I fear that the end of the article may tend to give the impression that I.E.C. Procedures are not adequate to ensure that its "formal decisions . . . on technical matters . . . represent as nearly as possible an international concensus of opinions on the subject dealt with." I think that anyone who has taken part in I.E.C. activities would agree that the I.E.C.'s Procedures do give the maximum guarantee that all opinions are duly made known and taken into account.

Incidentally, the zig-zag symbol for a resistance still appears in I.E.C. Publication 117, as a form internationally recognized. In judging the advisability or otherwise of showing the rectangular form on the "preferred" symbol, it is necessary to take into consideration the widespread use of the zig-zag to represent a winding. Not only does the I.E.C. Publication 117 attempt to reconcile differing national practices, but it also seeks to reconcile both "heavy" and "light" current drawing practices.

L. RUPPERT,
(General Secretary)
International Electrotechnical Commission,
Geneva, Switzerland.

WE would like to comment on your remarks in your January Editorial regarding symbols. As a company we are rather perturbed at what appears to be the sudden change in approach to these problems by the B.S.I. and, in particular, by the way in which new graphic symbols have been introduced into BS3939 with very little consultation. This could be the result of a too compliant attitude on the part of B.S.I. as you infer.

This company believes in following British Standards unless there are very strong reasons for not doing so. The situation which is emerging as a result of these recent changes may produce such a reason.

We fully support your view on the new "objective symbol" for resistors. The selection of this symbol is the more surprising in view of the fact that the rectangular outline is far from being generally used even on the Continent. It is difficult to see, therefore, the reasons for over-riding the sound principles that you enunciate.

It is not only in conventional electronics that the situation appears unsatisfactory. Even greater difficulties are likely to arise if some of the proposals now under discussion for logic diagrams are accepted. While the present B.S. proposals for logic diagrams leave much to be desired (and discussions are taking place to improve them) nevertheless the present series of logic symbols have the merit that they clearly indicate the function being performed. One of the new proposals of the I.E.C. now under discussion by B.S.I. is for the use of a uniform square or rectangular box with wording inside to indicate the function. We understand that the reason for this proposal is that diagrams can be drawn by computer using this method. This may be so, but it would appear that the advantage of the "means" is causing the protagonists of this arrangement to overlook the shortcomings (perhaps even the unusability) of the "ends". (Samples of the new arrangements circulated by the I.E.C. for consideration were in fact illegible.)

We regard the wish of the B.S.I. to follow I.E.C. Standards as most commendable, but it is questionable whether this should be at the expense of adequacy. Perhaps the answer is for British industry, through B.S.I., to play a more formative part in I.E.C. Standards.

A. J. WHEELDON,
(Manager Technical Information Dept.)
Marconi Company,
Chelmsford, Essex.

THE Editorial in the January issue was, to say the least, timely. It has served a double purpose, viz., to present a problem (which has been intensively discussed by the profession for some months past) not only in clear perspective, but also in terms of its background and implications. Thus the problem—the acceptance of the proposed I.E.C. changes—is exemplified by the c/s versus Hz issue, at first sight almost irrelevant, but, on closer examination, underlining the advantages of symbols possessing inherent meaning.

Both professional engineers and students are greatly concerned to acquire new information with the maximum accuracy and (usually) the maximum speed. This means that intelligence should be taken from the printed page without "interpretative discontinuity," however momentary. Such discontinuities increase the possibility of misunderstanding.

On the c/s and Hz question, it does seem a pity to abandon a piece of nomenclature which instantly defines the specific parameter physically and without ambiguity. Furthermore, the c/s is the only electrical unit which is established in terms of "natural" quantities, as distinct from the arbitrary basis of the remainder; so that one feels that it could well be distinguished from them by its "meaningful" name, as opposed to the surnames carried by the man-made units.

The main point of contention which has appeared is, however, the proposed changes in circuit diagram symbols, and in the resistor in particular. Apart from the fact that the rectangle lacks the pictorial communication power of the zig-zag, it also must be condemned

in this context because of its association with another sphere. The rectangle is (and presumably it is intended that it should remain) the stuff from which block diagrams are made. Block diagrams have a major function to fulfil, especially for much logic diagram work; let them be restricted to this duty, and do not introduce even an element of uncertainty or confusion by what amounts to ambiguous use if they are employed in two entirely separate kinds of diagram.

It may well be that draughtsmen find the rectangle much easier to draw than the zig-zag (assuming that they carry out their task the hard—traditional—way). However important this is in terms of time and money, it must be weighed against all that is achieved by clarity of expression. Perhaps it is not inappropriate to regard this as one facet of a principle laid down by a former Editor (Mr. F. L. Devereux) who had no doubts as to the duty of a writer to his readers. His basic quotation, from Moore's "Life of Sheridan," was that "easy writing's curst hard reading."

It is in connection with this over-riding requirement for clarity in pictorial communication that a final tribute must be paid, and a lost-cause period recalled, to W.W. The former is a matter of history, going back to the 1930s, when the British radio circuit diagram was a model of clarity as compared with its American counterpart. This could be largely attributed to the British method of showing the thermionic valve as an entity within an envelope, whereas the American symbol consisted solely of the electrodes without enclosure.

It must be stressed that clarity is not entirely a matter of the way in which a key symbol is shown. Relative layout can often make all the difference, and it is in this area that the writer has felt that the *Wireless World* has been consistently in the lead. The period of the lost-cause therefore developed when *W.W.* adopted "that" transistor symbol.

"PATENTEE"

WHY not accept the hertz? It is brief, apt and widely used already. The name of a unit need not contain its definition. For example, one does not use the newton metre per ampere second (joule per coulomb) as being more meaningful than the volt.

Not that we are alone in such matters: I have German equipment in which charge is marked in As. Perhaps in the interest of international language the Germans will recognise M. Coulomb if we pay homage to Herr Hertz.

In the same vein, do I understand that we are about to adopt the tesla for the cumbersome weber per square metre? The sooner obsolete c.g.s. magnetic units are replaced by appropriately named m.k.s. units, the better for those we teach.

J. M. OSBORNE
Westminster School,
S.W.1.

I BELIEVE the hertz will eventually oust the cycle per second, also that its ally the tesla will supplant the weber per square metre, but not until its proponents have fought a vigorous beach-head action. It is true that the older terms are more suggestive of the definitions of the quantities involved, but we have already learnt to use the ampere instead of the coulomb per second; the watt is more familiar than the joule per second, and so on. The new units remove two more of the cumbersome "something per something" type of term, but we still have the metre per second. Possibly this is because the concept of velocity has been with us for so long that it is difficult to find any one worker to whom the honour of having a unit named after him could be assigned. Meanwhile, what of the ampere-turn per metre (magnetic field strength), the volt per metre (electric field strength) and the coulomb per square metre (electric flux density)?

R. BAYFIELD
Hove, Sussex.

Gyrators: their use in tuning and other circuits

IT would appear that Mr. Butler's gyrator can be used to solve the problem of getting a 10:1 frequency range using an ordinary tuning capacitor. Since the gyrator simulation of a tuned circuit turns one capacitance into an inductance while leaving the other as a capacitance, the use of a two-gang tuning capacitor with one section at the input and one at the output will produce the equivalent of simultaneously variable L and C. Since the frequency of tuning is proportional to $1/C$ instead of $1/\sqrt{C}$ as in an ordinary tuned circuit, a 10:1 frequency range will be obtained if the ratio of maximum to minimum capacitance is also 10. Range switching could be accomplished in theory by changing the gyration resistance, though I cannot see how to do this in practice without upsetting the d.c. circuit conditions.

If the gyrator were perfect, then the Q of the simulated inductance would presumably be very high. It would be interesting to know what can be achieved in practice with a simple gyrator. Even if the Q were not high, all would not be lost. If the dynamic resistance of the simulated tuned circuit were constant over the tuning range Q could easily be improved by positive feedback.

Another useful trick would be to gyrate a distributed constant RC transmission line (which can be made from a high stability resistor and a bit of silver paper) into a distributed-constant RL transmission line (which for practical purposes cannot be made at all). Since one of these has a phase angle of impedance of $+45°$ at all fre-

quencies and the other a phase angle of $-45°$ at all frequencies, it should be possible to obtain a frequency-independent differential phase shift of 90°. This would have uses in single-sideband generation, phase-sensitive detection, etc.

Incidentally, the individual amplifier circuits of the "simple gyrator" look as if they would be useful as tape recording amplifiers, along the lines of those described in *Wireless World* for August 1965, p. 403, and March 1966, p. 144. Now that planar transistors can be had for less than the cost of electrolytic capacitors, the addition of a couple of transistors to the original circuits is no great penalty. Another possible application of these high-output-impedance amplifiers is to drive a rectifier meter and so provide a wide-frequency-range voltmeter of good linearity.

G. W. SHORT
Croydon, Surrey.

The author replies:
MR. SHORT'S first suggestion is perfectly feasible, at least in principle. With a 2-gang capacitor, 500pF maximum per section, and assuming a gyration resistance of 1,667 ohms, the frequency range would be 200-2,000 kc/s. At frequencies in the middle of the audio range, gyrators may be used to stimulate inductors with Q-factors around 500 or so, but the performance deteriorates even at low radio frequencies. Nevertheless, rough checks with a

(a)   (b)

gyrator built with commonplace h.f. transistors show that operation up to 300 kc/s is possible with Q-factors of about 40. These figures are suspect because it is thought that some regeneration must have been present to account for the relatively high Q.

Checks made at lower frequencies with decade capacitor boxes are strictly in accord with theory. It is more than likely that phase shifts round the gyrator loop could cause some instability, and a little design effort might be required to reduce this effect.

The second suggestion, to gyrate a distributed-constant RC transmission line into its RL counterpart is an extremely interesting one, well worth testing. Although conventional wide-band 90° phase-shift networks can be made to give a good performance, the best types are lossy, complex, and require close-tolerance components of awkward values.

As regards the use of the individual amplifiers of a gyrator for other purposes, there are many such applications. Mr. Short's two suggestions are excellent examples. I have used these amplifiers as rectifier meter drivers of extreme linearity, wide-band phase-splitters (an inverting amplifier in one channel, non-inverting in the other), constant-current sources for integrators and time-base generators, as substitutes for the conventional cascode circuit, as the maintenance amplifier of current-fed Wien bridge oscillators, as RC tuned amplifiers and as drivers for complementary push-pull output stages, where they reduce cross-over distortion under zero bias conditions.

As regards methods for controlling or varying the gyration resistance, this is admittedly a problem when d.c. coupling is used. The circuit, Fig. (a), shows one way of varying the resistance without upsetting the d.c. conditions. Essentially we have a differential amplifier pair with separate emitter load resistors and with a variable resistor coupling the upper ends. When R is zero the transistors form a long-tailed pair; as R is increased towards infinity, the gain progressively falls to zero, causing the gyration resistance to rise to some high value. If a.c. coupling is admissible in the gyrator, gain control is much simplified and almost any of the standard methods may be used. Such a scheme would be perfectly satisfactory for the purposes envisaged by Mr. Short. Feedback is more easily applied to increase the amplifier output impedance and, to raise the input impedance, field-effect transistors could be used, whereas, due to the peculiar biasing requirements, some ingenuity is required to incorporate them in d.c. amplifiers.

Since my article was written, E. W. Shallow and P. J.

Baxandall have described a new constant-current circuit.* This, with minor modifications, seems to be suitable for use as the output stage of a high-grade gyrator. A suggested arrangement is shown in Fig. (b). It would be worth trying this with the input and driver stages of my original Fig. 5.

F. BUTLER

Cheltenham,
Glos.

* See, Letters to the Editor, *Wireless World*, December 1966, p. 609.

MR. BUTLER gave a very clear explanation of the operation of gyrators in the February issue, and his circuits look most useful. Perhaps some enterprising integrated circuit manufacturer will offer cheap and compact versions of them before too long.

In the meantime, however, useful results can be obtained with very much simpler circuits. Possibly the simplest of all is shown in Fig. 1. In this case the transistor acts as the phase inverting amplifier and the resistor, R_1, as the non-inverting "amplifier." If a capacitor is connected between the base and emitter the collector-emitter terminals will have the characteristics of an inductor. The reverse is also true of course.

We actually use a version of this circuit in the Sinclair PZ-3 power supply shown in Fig. 2. In this case the components in the dotted box replace, and are directly equivalent to, the choke which might be used in this position in a conventional circuit. Tr1 and Tr2 form a Darlington pair and Tr1 has to be a small power type. The voltage dropped across the simulated inductor is small and the ripple on the output of the power supply is only 50 mV for a drain of 1 A. As the current in the transistor circuit can vary so can the equivalent inductance, thus the circuit resembles a swinging choke with an inductance given by the formula $L = CRr_e$ where C is the base-emitter capacitor, R is the collector-base resistor and r_e is the intrinsic emitter resistance of the compound transistor. This last term is a function of current and the equation gives an inductance value of about 1 H at 100 mA. The circuit is very much smaller than its passive equivalent and is also less expensive.

The very simple circuit of Fig. 1 can also be used in filters and tuned circuits and it should be particularly useful where large values of inductance are required in a small space.

C. M. SINCLAIR

Sinclair Radionics Ltd.
Cambridge.
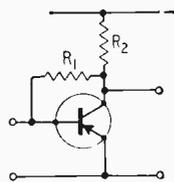
Fig. 1. Simple gyrator circuit

Fig. 2. (Below) PZ-3 power supply using gyrator circuit
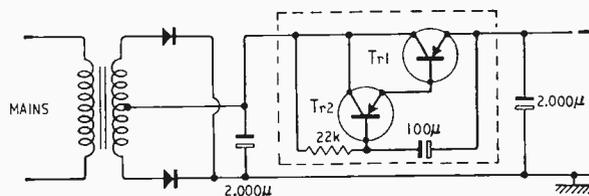
The Future of Electronics

WHILE I share "Vector's" disappointment with the report of the Electronics E.D.C. (*Wireless World*, January 1967, p. 54) I was perhaps less hopeful than he was. It should first be pointed out, however, that his picture is a little too black since there is an area in which the British electronics industry has strength (in the sense of being at least as far ahead of the rest of the world as it is behind U.S.A.), namely, in capital goods such as computers and marine radar. Consumer goods and components are the less vigorous areas.

My lack of expectation of any startling pronouncement was based on the knowledge that the E.D.C. was not a group of supermen, but of representatives of the industry as it is plus some economists. On a rough classification of the membership listed in the Report, the E.D.C. consisted of eight managers, five trade-union representatives, three Government economists, three representatives of ministries capable of subsidizing the industry and one independent economist who is distinguished for his work on economic forecasting. Since much of British industry is unfortunately an arena for the fight between management and unions, the presence of these two groups may inhibit the frank and impartial discussion of the facts. Then if there are problems, who is to solve them? If a company had a solution to a major problem, it would not want its representative on the E.D.C. to pass on the advantage to everyone else; but the more probable situation is that no company has found a solution and therefore the E.D.C. has not one. This, of course, leaves out of account the Ministry of Technology and the Aviation section of the Board of Trade and the N.R.D.C.; do these ministries contain enough supermen to solve the problems which commercial managements have failed to solve?

Neither does it surprise me that the E.D.C. said no more than *Wireless World* said eighteen months earlier. I doubt whether any member of the E.D.C. would personally have given so much attention to microelectronics as technical journalists will have done; and the E.D.C. would have neither the time nor the resources to carry out a more detailed investigation.

What, then, is the use of an E.D.C.? I am inclined to think it is worth while forcing all parties concerned (management, unions and government departments) to face the problems, and that some mutual sharpening of wits may result. But the "crow-bar effect" is a very real danger and the crowning success of any private enterprise would be to give a lead where the E.D.C. fails to do so.

"AMATEUR ECONOMIST"

Television Receiver Sound Quality

I WAS interested to read Mr. Butler's letter in the February issue regarding television receiver sound quality.

Although not living on licence payers' money myself I feel I must point out that no other organization has done more to support good engineering standards than the B.B.C. despite a domestic receiver industry which in the main seems disinterested in matching those standards. In fact at the present time the domestic receiver industry and the audio engineering industry seem to be entirely separate spheres of activity. It was not always so; the 1936 "Radiolympia" used as its main selling feature the quality of reproduction of its receivers. I am interested to learn that the manufacturers do make receivers with

"a considerably wider acoustic frequency response," but I must say these are not very evident in the dealers' shops or in advertisements.

Of course, a superior device will cost more. A car with heater, windscreen washers, tuned-up engine will cost more than the basic model, but many people are prepared to pay the extra. A demand for any product has to be created by explaining to the public the advantages that the extra outlay will bring. I cannot recall any television receiver being launched in a National advertising campaign which claimed as one of its main features a superior quality of sound reproduction.

In conclusion, I must admit that on reflection I may live partly on licence payers' money as my employers are one of the major equipment suppliers to the B.B.C.

D. A. PAYNTER

Billericay,
Essex.

Listening Through Headphones

MR. CAWKELL'S remarks (*W.W.*, April 1966) draw attention, once again, to the difference of subjective experience resulting from wearing headphones rather than listening to sounds produced by a loudspeaker. The special effects that he mentions, produced by modifying the presentation of the sounds objectively, must necessarily be related to certain subjective reactions that I reported some years ago (Ref. 1).

In my investigation—albeit in a different world of subjective experience, namely the reaction of my subjects to the distortion of pure tones—a dramatic reduction was reported in the subjective "rating" of distorted sounds when they were observed through high-grade headphones as compared with the rating reported on the same distortion reproduced by high-grade loudspeakers. That the difference in reaction was in some way related to the delays in *arrival-time* of the harmonic terms of the distorted sounds as compared with the fundamental term, was demonstrated unequivocally by tests made (Ref. 2) in which the fundamental term was successively delayed with reference to the harmonics, or *vice versa*.

In the investigation cited this finding seemed to fit in very well with the other facts deduced about the peculiar way in which distortion was subjectively judged.

I do not suggest that Mr. Cawkell's work was influenced by distortion unwittingly introduced into the sounds listened to, but rather that room reverberation could well be a factor that could alter the subjective response to the sounds produced by loudspeakers. To check whether this is so tests should be repeated in an anechoic room or the open air. Has this been done?

This may well be a suitable occasion to point out that the effects reported in Ref. 1, which to me were quite astonishing, have apparently had no influence whatever upon acousticians in general for so far no one has either supported or rebutted them.

E. RAMSAY WIGAN

Portsmouth, Hants.

1. *Electronic Technology*, April & May 1961.
2. Final appendix to the above.

Voltage-controlled Ignition Unit

YOUR readers may be interested in the following small modification to the electric ignition system of a gas cooker. The system fitted to the oven and high level

grill of the cooker worked from a 1.5 V low capacity battery. Due to cell voltage drop on load·and,across exposed switch contacts, the original system required frequent battery changes and switch clearing.

The system described has a 4.5 V battery as energy source and a 1.5 V battery as voltage reference.

The circuit is a typical series transistor voltage regulator. Tr3 is the series regulating transistor and its Darlington connection with Tr2 is used to reduce the base drive requirements. The base drive for the series regulating element is set by the collector current drawn by Tr1. The collector current of Tr1 is determined by its base potential with respect to its emitter voltage of -1.5 V. The two diodes D1 and D2 prevent both elements being energized by the closing of one switch. Due to voltage drop across the blocking diode and the emitter base diode of Tr1 the output voltage is approximately 0.4 V greater than the potential of the reference cell. Resistor R2 is adjusted on test to give 1.4 V across the ignition element, and will have a value between 0.2 and 1 ohm. The series regulating action maintains 1.9 V across the igniter and R2 for battery voltage drop or switch voltage drop of approximately 2.0 volts.

The series transistor emitter current is between 0.5 and 1 A and the emitter current of Tr2 is approximately 20 mA. Under normal operating conditions the collector current of Tr1 is 5 mA, but rises to approximately 100 mA if the switch is closed on to an open circuit (due to a displaced or burnt out element). This is caused by Tr1 being bottomed and no base current being required by the super alpha pair. The battery drain with neither switch closed is 2 μA for the 4.5 V battery and 0.25 μA for the 1.5 V reference battery at a temperature of 16°C.

J. S. TAYLOR

Dumfries, Scotland.
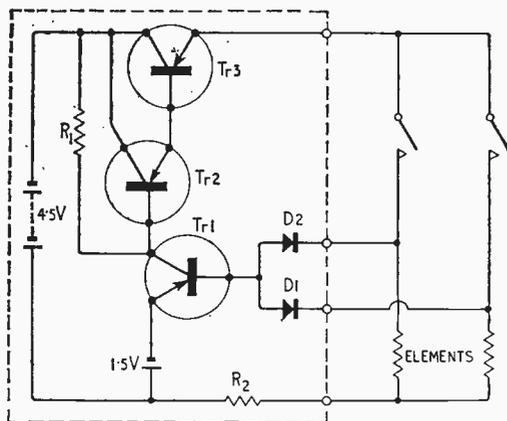
Voltage-controlled ignition unit power supply described by Mr. Taylor with (below) the components used.

	Component used	Min. ratings for alternative types
Tr1	OC 72	I$_C$ 100mA; V$_{CE}$ 6V; P$_{TOT}$ 100mW
Tr2	OC 72	I$_C$ 30mA; V$_{CE}$ 6V; P$_{TOT}$ 20mW
Tr3	OC 35	I$_C$ 1A; V$_{CE}$ 6V; P$_{TOT}$ 2W
R1	33Ω 1W	0.4W
D1 & D2	OA 81	I$_F$ 10mA; p.i.v. 10V
R2	Short length of resistance wire.	Rating approx. 1W.

Tape Track Selector Switch

THE circuit shown is intended to act as a track selector switch for tape-head signals from a two-channel magnetic recorder. It is suggested that it could be used, for instance, with Dr. Bailey's recent stereo amplifier circuit. It is necessary in the case of tape playback systems to provide a mono-stereo switch, mono being selected from
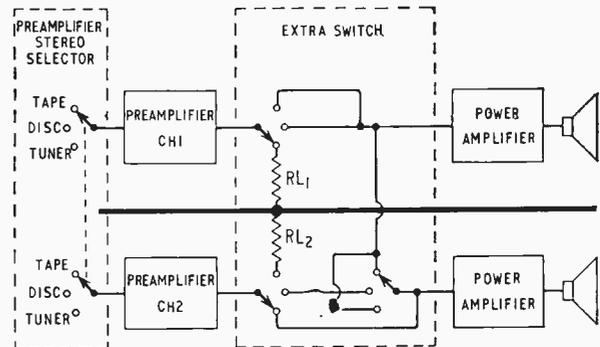
any available track of four tracks and the upper track of a two-track head. The normal stereo-mono shorting switch is unsuitable as the two unrelated tracks would be mixed together. Tape head equalization and amplification sometimes has its problems with transistor noise.. It is for this reason the switching circuit is placed after the pre-amplifier and not before (switching very low voltage signals could be a very noisy business indeed). There is another advantage in this positioning of the circuit— the redundant pre-amplifier may be used for other purposes. Programmed slide-projector cues, recorded on the unused track, could be amplified by this pre-amplifier and directed via an extra output socket to an automatic slide projector. A further possibility, in view of the fact that the majority of radio broadcasts are at present mono, is that the switch would be useful for those who wish to operate another mono input, for example, from an a.m. tuner. The only other foreseeable problem is that of cross talk. To combat this it is suggested that care should be taken in constructing both the switching circuit and the pre-amplifier circuit.

A. D. HODGE

London, S.W.1.

The author replies:
I WAS very interested in Mr. Hodge's letter as I have been confronted with the same problem just recently. My answer was to use shorting switches across the two head channels so that either or both could be selected. I can see, however, that for some purposes there are definite advantages to be gained in having a spare pre-amplifier. In addition the duplication of mono input channels could be very useful. The only drawback that I can see is that it is an additional control for the front panel and it might cause confusion in unskilled hands. This might be too pessimistic a view, however; a lot depends upon the correct and simple labelling of controls.

In short, therefore, I feel that if tape is the only problem, then a channel selector switch on the deck itself is the simplest solution. If additional inputs or systems such as automatic slide changing are envisaged, then the system outlined would definitely be the best way of doing it.

ARTHUR R. BAILEY

Bradford.

www.americanradiohistory.com

Battery Eliminator for Transistor Receivers

CIRCUIT USING AUTOMATIC BATTERY-MAINS SWITCHING

By R. F. COOK

THE essential requisites for a mains driven power unit to operate transistor equipment are reliability (particularly in the sense that the voltage applied to a radio receiver for example should never be too high nor of reverse polarity), ease of use (i.e. ease of changing from mains to battery operation and vice-versa), low cost and require no modifications to the equipment it will supply.

Circuit.—The unit consists of a (rough) d.c. power supply derived from the a.c. mains in any conventional way and a regulator which uses this supply to produce a constant voltage for the receiver. The voltage reference for the regulator is the receiver battery, while the regulator (consisting only of a transistor, a capacitor and an optional resistor) is contained within the set. The regulator transistor (in Fig. 1) when active, functions in the common collector mode, i.e. as an emitter follower. The voltage applied to the receiver is that of the battery less the base-emitter voltage drop (about 0.2 V). The current drawn from the battery is only about $1/\beta$ of the current required by the receiver (where β is the current gain of the transistor), typically 1 or 2%, the bulk of the current coming from the rough supply. When the supply is disconnected, or switched off, the receiver operates by drawing its full current from the battery through the base-emitter diode. The presence of the diode causes an increased supply impedance, which is offset by the capacitor Q, and a slightly reduced voltage. This capacitor is also useful in reducing the surge current that occurs when the receiver is switched on, since it remains charged almost to the full battery voltage all the time.

The collector resistor R limits the transistor dissipation at high load current, by reducing the applied collector voltage. It also serves to define the upper limit of the load current (when the transistor bottoms) and to increase adaptability to various rough supply voltages. It could be omitted altogether if the supply is low and constant

enough, but its presence is necessary if the supply should fail catastrophically to the extent that reverse voltage is applied to the regulator. In this situation the transistor acts as two diodes in the forward bias condition with a common electrode (the base), supplied from the battery. The transistor will function like this, without receiver damage, while the battery can maintain the current back into the supply or the base-emitter junction of the transistor remains good against the resultant reverse voltage when the battery becomes exhausted.

Construction.—In practice it is not necessary to tamper with the set in any way since there is often an aperture or grid at the back of the receiver through which the supply wires can be passed. It is possible to mount the two or three regulator components on the back of the polarised connecting plugs from an old battery, with short leads to similar plugs which will plug into the battery. The leads from the receiver then connect to the plugs carrying the regulator components. The two leads carrying the external supply can be permanently connected to the regulator (see Fig. 1). Similar plugs could be used to disconnect the suppy when the receiver is used as a portable, but the author preferred to use a four-way connector and used the spare two pins to provide a shorting link which controlled the application of a.c. to the power supply. The supply unit consisted of a bell transformer with a bridge rectifier and 250 μF reservoir capacitor. This gave about 18 V open circuit.

In the following analysis the author's values are shown.

V open circuit voltage of power supply			18 V
v battery voltage			8.5 V
I maximum current required			25 mA
C reservoir capacitor			250 μF
n rectification factor,	1 for full wave, or bridge		
	2 for half wave		

The required collector resistance is given by:—

$$R = (V-v)/I - 10n/C \text{ kilohms, or approx. } 0.34 \ (340\,\Omega)$$

I can be measured using a sensitive voltmeter across a 10 Ω resistor inserted in series with the transistor equipment, at maximum volume. The maximum dissipation required of the transistor is then given approximately by:—

$$P = (V-v)^2/4(R+5n/C) \text{ milliwatts} \quad \quad 65 \text{ m W}$$

The transistor can be chosen knowing the following maximum requirements:—

Collector-base voltage	9.5 V
Collector current	25 mA
Base-emitter current	25 mA
Power dissipation	65 mW
Reverse base-emitter voltage, $v+2$ say, for fault conditions	10.5 V

The value of R is fairly critical; if it is too large there will be a sudden onset of mains hum at high volume level, and if it is too small the power dissipated in the transistor will be unnecessarily high at medium to high volume.
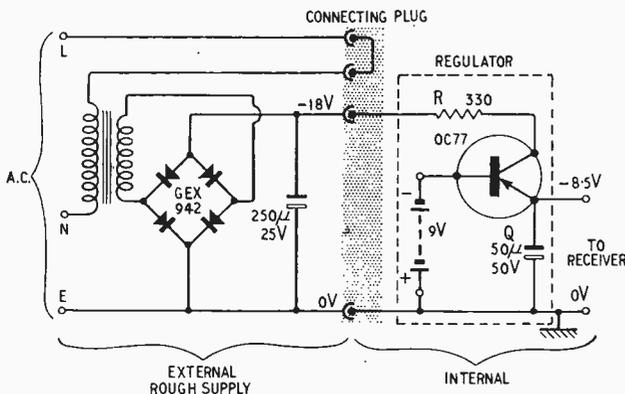

Fig. 1. Battery eliminator and voltage regulator circuit for transistor receivers.

NEW PRODUCTS

equipment   systems   components

Improved Crystal Pickup

THE Walton M1 crystal pickup cartridge has been designed to provide a competitively priced mono pickup that will track stereo records satisfactorily, without damaging them, and at the same time give an output high enough for the average radiogram. It uses a "decoupled stylus tip" technique* which gives the high compliance in all directions required by stereo records (actually, lateral compliance 4×10^{-6} cm/dyne, vertical compliance 2.5×10^{-6} cm/dyne) and also the low stylus mass needed to reduce distortion in the high frequency region (total effective stylus mass 1.5 mgm). Tracking weight is 3 to 5 gm—the greater weight being needed for loud records—and the output is 1.25 volts/5cm/sec. Frequency response is 30 c/s to 14 kc/s, ± 3dB. A load impedance of 1MΩ or over is required. The cartridge has the usual turn-over arrangement for l.p. and 78 r.p.m. records and uses sapphire styli, but

* British Patents 979856/60.
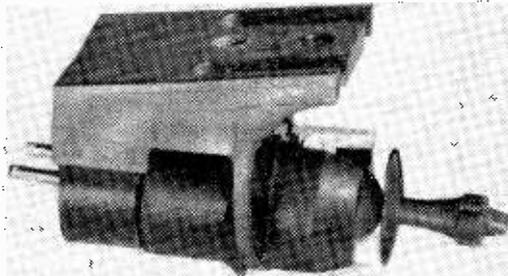
diamond styli will become available later.

When tried in a medium-quality record player the pickup gave agreeable and clean reproduction from both mono and stereo records, and on some loud and complex orchestral passages was noticeably better than the well-known cartridge supplied with the player. Retail price is £1 15s 4d. The makers, Rainer-Walton Enterprises Ltd., 19 New End, Hampstead, London, N.W.3, say that a stereo model will be available later.

WW 301 for further details

P-N-P Silicon Devices

MULLARD announce the addition of seven p-n-p types to their range of silicon planar transistors. Five have power ratings of 600 mW and two have power ratings of 350 mW. Because of their linear gain/current characteristics all the new types are suitable for both switching and linear applications. Their p-n-p characteristic permits complementary operation in conjunction with Mullard n-p-n types. The two 350 mW devices are BCY70 and BCY72. The former has a high V_{CEO} of 40 V and a low saturation voltage. It is primarily intended for medium-speed switching applications. General purpose transistor BCY72 is suitable for use in switching and amplifying applications with less stringent requirements. Both types are in TO-18 encapsulation with the col-

lector connected to the can. A low leakage current, low saturation voltage and a high cut-off frequency generally in excess of 200 Mc/s are features of the new 600-mW transistors (which meet JEDEC specifications). Four of the JEDEC types also have a high emitter/base breakdown voltage of 5 V. Applications for the 600 mW group of devices are similar to those recommended for the lower rated devices although the high power rating also makes them suitable for use in driver and output stages. All devices in this group are in TO-5 encapsulation with the collector connected to the can. Mullard Ltd., Mullard House, Torrington Place, London, W.C.1.

WW 302 for further details

Tunnel Diode

LOW cost tunnel diodes in the TD700 line are produced through a combination of planar and thin film fabrication techniques. Priced at less than 10 shillings in quantities, they are available from the General Electric Company, U.S.A. The TD700, and the TD700H (high temperature germanium tunnel diodes) are available with peak currents of 0.5, 1.0, 2.2, 4.7, and 10 mA. International General Electric Company of New York Ltd., Lincoln House, 296 High Holborn, London, W.C.1.

WW 303 for further details

PAL Pattern Generator

THE Philips television pattern generator PM 5507 is a service instrument for installation, repair and aligning of colour receivers. Although developed for the PAL system, it can also be used for the N.T.S.C. system. The generator provides a PAL signal on 625 lines, 50 c/s field frequency, over a tunable range of 480 to 850 Mc/s vision carrier (continuously adjustable with vernier drive), and it will supply black/white convergence as well as colour patterns. The video signals available for the test pattern are (a) 12 horizontal lines, (b) 12 vertical lines, (c) cross hatch made by (a) and (b), (d) dots, (e) colour bar, (f) rainbow patterns. In positions (e) and (f) the colour signal (luminance and chrominance) can be externally adjusted from zero to maximum, and in the maximum position, $Y = 50\%$ and chroma = 35% of total video amplitude. The colour synchronizing burst (subcarrier frequency) has a width of 12 cycles, and it starts 5.3 μs after the line sync pulse leading edge. The subcarrier frequency is 4.43361875 Mc/s. The keying frequency is 187.5 kc/s which is equal to 12 times the line frequency. The instrument operates from 110/220 V 50 c/s mains and the price is 9 in × 7 in × 8 in. The price is £227 10s. M.E.L. Equipment Co. Ltd., Manor Royal, Crawley, Sussex.

WW 304 for further details
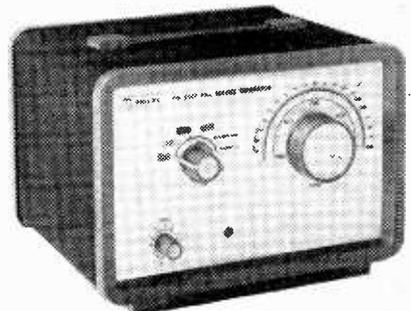
F.E.Ts

SILICON diffused n-channel field effect transistors encapsulated in TO-18 packages produced in two ranges SI.211N and SI.221NA series are available from Jermyn Industries, Sevenoaks, Kent. The SI.211N single gate devices and the SI.221NA double gate devices combine high transconductance (spreading from 200 to 7,000) with high input impedance and low pinch off voltages. The SI.221NA series are low-noise devices subdivided into three noise groups—A, B and C (the B version has a noise figure of 1 to 2 dB with a source resistance of 1 MΩ). The series SI.221NA have maximum quoted gate leakage currents of 2nA and the SI.211N series 10nA. This Akers Electronics, Norway, range is also available in matched pairs or encapsulated pairs in a 6-lead TO-18 package with transconductance ratio greater than 0·9.

WW 305 for further details

System Analyser

PLOTTING a system's phase and amplitude response at various frequencies is possible with the single instrument known as the 1995 Servomatic analyser, manufactured by the Servo Corporation of America. The instrument is a combination of multiple function generator, calibrated phase shifter, and precision amplitude control. Sine, square, and triangular waveforms are all available. A reference signal is provided, which is phase synchronized with respect to the output signal. Internal modulation provides a " bow tie " image on an oscilloscope for zero phase shift indication, and system phase shift can be measured from this form of display by the Lissajous method. The frequency range is 0.005 c/s to 1 kc/s, continuously variable over five ranges for all waveforms. Frequency calibration accuracy is ±2 % max. of dial setting. There is an 0 to 360° direct reading phase dial
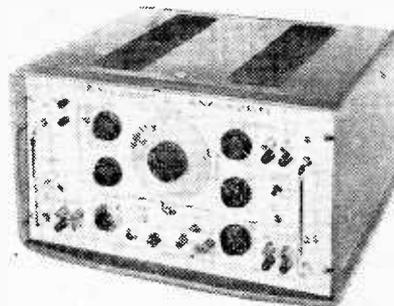
with 0° and 90° reference points. Carrier acceptance is 50 c/s to 10 kc/s (external). The applications for which this analyser is intended include : transfer function of open and closed loops, phase angle measurements, amplitude measurements, transfer function of damping and filter networks, frequency response of parts of systems, response of servo amplifiers, servomotor time constants, and response of magnetic amplifiers. Microwave Systems Ltd., 32 Hunting Gate, Hitchin, Herts.

WW 308 for further details

Strain Gauge Bridge

THE portable strain gauge bridge Type 5580 has been designed for the " on site " measurement of strain and stress in all types of structures and machines, using Tinsley resistance strain gauges in the range 50 Ω to 2 kΩ. This solid-state instrument weighs only 12 lb, and is suitable for single-gauge, 2-gauge and 4-gauge bridges. The bridge supply is obtained from a self-contained 1 kc/s square-wave oscillator operating at approximately 3 V. The output from the bridge is amplified in a 3-stage amplifier, and a manual balance obtained on a centre zero pointer type detector. Supplies for the oscillator and amplifier are obtained from an internal battery which can be charged in situ when not

in use. Two ranges are provided: × 1 measuring ±10,000 units of microstrain in steps of 10 units and × 0.1 measuring ±1,000 units of microstrain in steps of 1 unit. The gauge factor dial covers from 1.8 to 4.5 in steps of 0.01. The limit of error of the bridge is ±0.5 % of reading or 5 units whichever is the greater. Where it is necessary to obtain measurements from a number of gauge positions, a balancing unit and selector switch Type 5580B must be used. This unit contains a 10-way switch and 10 apex units for balancing the individual circuits. H. Tinsley & Co. Ltd., Werndee Hall, South Norwood, London, S.E.25.

WW 306 for further details

Digital Clock

INTENDED for general time keeping applications on the 12 or 24 hour system, the Six-Seventy digital electronic clock in the Digicron range has an in-line neon tube display. The hours and minutes digits are 30 mm high, and the seconds digits are 15 mm high, and it is stated that these characters can be read at over 40 ft away, even under high ambient light levels. The time source is normally derived from the 50 c/s mains supply, although a crystal time source can be fitted at extra cost. A single control is used to set the time, and one switch sets the clock for either the 12 or 24 hour system. Should the mains supply be interrupted, the clock will only start when it has been correctly reset. A 60 c/s version is also available. The front panel is coloured light buff to BS.2660. Case colours available are mid-grey, dark green, mid-blue, mushroom. Darang Electronics Ltd., Restmor Way, Hackbridge Road, Hackbridge, Surrey.

WW 309 for further details

Transistorized Multimeter.—We erroneously attributed a recorder output to the multimeter type 130S by Comark described in the January 1967 issue, p. 49). This is a feature of a d.c. millivoltmeter (type 120S) by the same manufacturer.

Electronic Timer

THE circuit of the ET timer is based on trigger tubes, one of which drives a relay having a single pole changeover output contact which is rated at 4 A, 415 V a.c. Normal operation is from a supply of 200 to 240 V 50 c/s, and includes voltage stabilization. Repetition accuracy of a timing cycle is ±2 % for an input variation of ±10 %. Power consumption of the unit is 3 VA, and it will operate satisfactorily over a temperature range of −20°C to +50°C. Timing of both pause and impulse periods is set by two independent control knobs and associated scales, and

each scale may be selected from one of five ranges which cover from 0.1 second to 120 seconds. Remote potentiometers, scales, and knobs can be supplied separately where the mounting position of the ET makes this feature necessary. The timer is intended for any system, mechanism, or process where separate control of " on " and " off " conditions are essential. Manufactured by SBIK of West Germany and marketed by Elremco Sales Ltd., P.O. Box 10, The Fairway, Bush Fair, Harlow, Essex.

WW 307 for further details

Digital Voltmeter

COST considerations are said to have influenced the design of the Type 500 integrating digital voltmeter by Weir Electronics Ltd. This instrument employs ring counter circuitry with n-p-n, p-n-p transistor pairs for switching the neon tubes, rather than the conventional binary counter with matrix decoder. It measures 1 mV to 1 kV d.c. in four ranges with a sensitivity ranging from 1 mV to 1 V, and it has an accuracy of ±0.1% of full scale reading. The input impedance is greater

than 1 MΩ on the 1 V range. The internal calibration voltage is derived from a low temperature coefficient zener diode having a stability of ±0.001% per year at normal temperatures, the operating temperature range being +10°C to 35°C. Common mode rejection is 30 dB at d.c., 50 c/s, and 100 c/s. The input overload limit is 1,000 V d.c., which will not damage the instrument irrespective of the range in use. Polarity may be reversed by a push button switch which also operates the positive terminal neon indicator lamp. The instrument has no chassis, and circuit boards are firmly held between the covers by alignment of tongued projections and p.v.c. foam compression strips. Interconnections between the seven circuit board modules are made by gold plated multiple connectors, thus eliminating the need for cable forms. Weir Electronics Ltd., Durban Road, Bognor Regis, Sussex.

WW 310 for further details

S.S.B. Transceiver

KW2000 CA (working range of over 1,000 miles) is a single sideband commercial transceiver with a frequency coverage of 3 to 19 Mc/s and a frequency stability of 1 part in 10^6 over the temperature range −10°C to +70°C. Transmission and reception modes are A3J (single sideband, suppressed carrier), A3H (compatible amplitude modulation), and A1 (cw. telegraphy). Transmitter power in the s.s.b. mode is 180 W p.e.p. input; c.w. 75 W output; and a.m. 25 W output. The receiver output is 2 W max. with 8% overall distortion in 3 Ω. For "fixed" or mobile opera-

tion it can be powered by a mains supply of 105/125 V or 200/250 V at 45 to 65 c/s; alternatively, a 12 V d.c. transistor power pack will drive the set, with either negative or positive chassis. Weight of transmitter, receiver and power supply unit is 47.5 lb. Battery consumption on transmit is 20 A, and on receive it is 10 A. Also available are aerials for mobile and fixed operation, beams, and masts. K.W. Electronics Ltd., Vanguard Works, 1 Heath Street, Dartford, Kent.

WW 311 for further details

Voltage Impulse Meter/Flux Meter

A RANGE of small precision instruments by Siemens and Halske (Germany) distributed in Britain by R. H. Cole Electronics Ltd., 7-15 Lansdowne Road, Croydon, Surrey includes a voltage impulse meter. This meter can measure fields associated with permanent magnets, relays and electrical machines. It can also measure voltage and current pulses and may be used to plot complete hysteresis curves of ferro-magnetic materials for short period measurements (approximately 0.1 ms to several seconds). The meter characteristics include an almost torqueless movement with an extremely small moment of inertia (second moment of area), a rela-

tively low resistance in closed circuit provides strong electromagnetic damping thus permitting a short setting time compared with that of a ballistic galvanometer. The mirror scale is marked linearly into 75 divisions. The reading sensitivity is 1×10^{-4} Wb/div. The fluxmeter's catalogue number is M805-A80, a matching search coil's number is M805-A 800. The dimensions and other specifications common to the range of instruments are 178 × 138 × 78 mm and all have a 100 mm long mirror-scale, knife-edge pointer and screening as a protection against the effects of static electricity and interfering fields.

WW 312 for further details

INTEGRATED CIRCUITS

NEW elements in the Signetics (U.S.A.) range of integrated circuits are now available from the Microelectronics Division of Electrosil Ltd., Colnbrook By-Pass, Slough, Bucks. These include the decade counter/storage register (S1280A) and binary counter/storage register (S1281A). They are multi-function monolithic sub-systems packages in the 14-lead dual in-line configuration, designed to provide both counting and storage functions. The S1280A will divide by 2, 5 or 10, depending on the connections by the user, and provides individual outputs for applications in counting, storage, register and memory. The S1281A provides the facility of dividing by 2, 4, 8 or 16. Both devices have counting rates of 20 Mc/s typical and operate over the range 0°C to 70°C.

WW 313 for further details

TELEMETRY RECEIVER

MODULAR telemetry equipment by Dynatel Ltd., Astronaut House, Hounslow Road, Feltham, Middlesex, now includes the DRT-2 telemetry receiver. The circuits are of solid-state design, and the i.f. and r.f. stages are plug-in units allowing rapid changes in range and operating mode. This receiver is capable of a.m. and f.m. operation. The frequency range is determined by r.f. plug-in units covering 25 Mc/s to 500 Mc/s. Sensitivity for both f.m. and a.m. operation is 5 μV input. The local oscillator stability is ± 0.0003% for crystal with oven, and ± 0.001% for crystal without oven. The i.f. filter bandwidths available are 500, 250, 200, 150, and 100 kc/s. Input impedance 50/75Ω unbalanced. Spurious responses are better than 60 dB down, with spurious emissions of less than 5 milli-μW. A.M. distortion is less than 1% for 65% modulation, and a.m. frequency response is 100 c/s to 50 kc/s.

WW 314 for further details
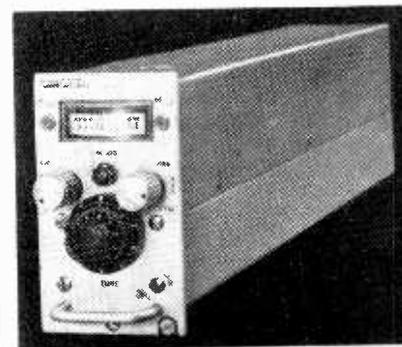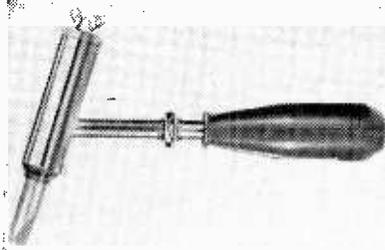
Soldering Tool

OBTAINABLE in any operating voltage from 6 to 250 V the Adcola R900, and R1000 soldering tools are fitted with 0.5 in diameter bits. Their rating is 50 W at 360°C. Total weight is 14½ oz. The bit is held by a wing nut at the back of the tool, providing an easy release of the bit should it seize up in its holder. The handle is made of fibre glass. Adcola Products Ltd., Adcola House, Gauden Road, London, S.W.4.
WW 315 for further details

MINIATURE FILTERS

COMMON electrical specifications of the Denesco EMI range of low pass filters include a temperature range of −55°C to + 125°C without voltage derating, and a d.c. resistance through the filter of 0.01 Ω. Type 05-VB-90 has a guaranteed minimum attenuation of 100 dB from 1,000 to 10,000 Mc/s, and 90 dB from 200 to 1,000 Mc/s. The I-VE-50 has a diameter of 0.080 in and it is 0.280 in long. It will maintain an attenuation of over 50 dB from 200 Mc/s to 10 Gc/s and over. The insulation resistance is a minimum 20,000 MΩ at 25°C, and a minimum of 5,000 MΩ at 125°C. Denesco Inc., 2408 San Mateo Pl., N.E., Albuquerque, New Mexico.
WW 316 for further details

Draughting Aids

TRANSPARENT, self-adhesive labels printed by a heat-transfer process, can be printed with the required designs up to 3 in × 2 in in black. Known as Circuitape Draughting aids, they can be supplied reeled in cardboard dispensers. The range of applications include printed circuit pads and networks, logic symbols, and circuit symbols. There is also a standard range of telecommunication symbols to BS 530. Suitable for dye-line printing and photocopying. Minimum orders are one box of 500 symbols of one sort. B. & T. Designs (Richmond) Ltd., 70, High Street, Tring, Herts.
WW 317 for further details

Automatic Lighting Dimmer

THE Photolite Unit consists of a standard MK switch box containing a s.c.r. dimmer circuit. It is also fitted with a two selection push button and two pin socket. A separate housing contains a photo-electric cell. It is complete with twelve feet of cable and plug for connecting to the dimmer box. The photo-electric unit is mounted on a window looking out at natural daylight and the dimmer box can be mounted in any convenient position and wired in series with the supply and the lighting load. The unit can be operated in either of two ways:—(a) With the selector switch in one position the variable control on the lid of the dimmer unit can be rotated manually to provide variation in the intensity of the artificial lighting from " off " to full intensity. (b) With the selector switch in the other position the variable control can be switched from the " off " to the " on " position and the photo-electric cell will then automatically control the intensity of the artificial lighting from 12½% to full intensity in proportion to the amount of natural daylight falling on to the photocell. Four models are available in the new Photolite range and these are for 250 to 1500 W, costing from £7 16s 0d to £17 0s 0d. Photain Controls Ltd., Randalls Road, Leatherhead, Surrey.
WW 319 for further details

Faster Thyristors

TWO new ranges of British developed silicon controlled rectifiers by International Rectifier, Hurst Green, Oxted, Surrey, are available to meet customer requirements of turn-off times down to less than 3 μs. Designated 8RCU and 10RCU these ranges are rated at 8A and 10A respectively with peak inverse/ peak forward voltages of 50 V to 600 V in seven voltage grades. Under test conditions of a rate of rise of forward current of 5A/μs and rate of rise of reapplied forward blocking voltage of 20 V/μs, the base temperature of the 8RCU is 105°C and that of the 10RCU, 125°C; the forward current prior to turn-off is 8 A for the 8 RCU and 10 A for the 10 RCU. A suffix is used to denote both the voltage rating and the guaranteed turn-off time. Example, with the type 8RCU5(3): 50 V maximum repetitive voltage; 75 V maximum transient voltage (5ms); 50 V maximum forward breakover voltage and a guaranteed turn-off time less than 3 μs.
WW 318 for further details

Avalanche Diode Oscillator

AN avalanche diode oscillator developed by Microwave Associates Ltd., provides a minimum 10 mW of c.w. power in a tunable waveguide mounting. Known as the MA4983X, it operates over the frequency range 9 to 14 Gc/s (using the MA4980X avalanche diode), and mates with either WR90 waveguide for X-band operation, or WR62 waveguide for Ku-band operation. Microwave Associates Ltd., Cradock Road, Luton, Beds.
**WW 320 for further details**

120W Amplifier

A HIGH power silicon transistor power amplifier suitable for use as a vibrator driver has been introduced by Sinclair Radionics of 22 Newmarket Road, Cambridge. The output power into a 4 Ω resistive load is claimed to be 120 W from a full bridge output stage. The output transistors are RCA 2N3055 with 2N3054 drivers. With a 15 Ω resistive load, output power is 30 W. With a 4 Ω load, harmonic distortion is given as 0.5 % (at mid and low frequencies) and for frequencies above 5 kc/s power output and distortion figures are not given. For a 15 Ω load, where output power is limited to 30 W, the amplifier is said to deliver its rated output up to 20 kc/s; for a 8 Ω load, up to 10 kc/s. Power requirements are 40±1 V at 8·2 A peak (5·2 A mean). Input required: 1 V into 5.6 kΩ.
**WW 321 for further details**
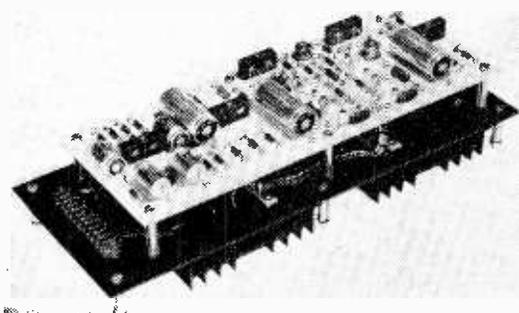
Transistor Holder

SEALECTRO has added a transistor holder to its "Press-Fit" line which will accommodate either TO-5 or TO-18 cans having three leads. Designated the RTC-305, the holder has three brass feed-through lugs which accept the leads of the TO-5 can. On a circumference inside that of the lugs are three holes through the Teflon bushing through which leads of the TO-18 holder are fed and wrapped around the lugs. For installation of the RTC-305 in production there is the Sealectro tool designated B-29-X1. Sealectro Ltd., Walton Road, Farlington, Portsmouth, Hants.

WW 322 for further details
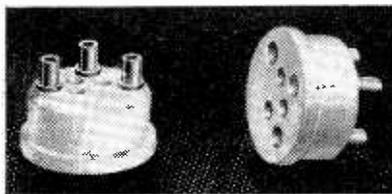
Screwless Terminals

THE "Modena" range of screwless plugs and terminals eliminates screw type connections. Each plug and terminal is fitted with a spring-loaded metal ball. When the stripped end of a wire is pushed into the plug and against the pressure of the spring loaded ball, it slips to one side of the ball, which immediately grips the wire tightly. Any attempt to remove the wire from the plug by pulling will only increase the grip on it. Release of the wire is obtained by pushing the ball down with a pointed instrument. A fully patented device, it is claimed to be free from loss or loosening of screws through vibration, and no tools are required for mounting.
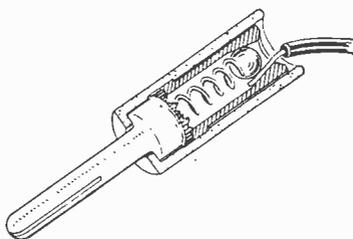
Provided in a comprehensive range including banana plugs, terminal blocks, plugs for television applications and connectors; miniature versions are also available. Techna (Sales) Ltd., 47, Whitehall, London, S.W.1.

WW 323 for further details

Potentiometers

CARBON composition potentiometers rated at 0.5 W and covering a range from 500 Ω to 10 MΩ in linear, log, semilog, anti-log and other laws have been announced by A.B. Metal Products Limited, 119/127 Marylebone Road, London, N.W.1. These potentiometers, given the series number 45, are available with single or double taps, standard bush, plug-in or twist tab mounting, standard lug, printed circuit or wire-wrap terminals; and with dual ganged or concentric controls. Mains switches can be fitted for high surge current conditions usually associated with silicon rectifier power circuits. The manufacturers claim that the Series 45, owing to its mechanical versatility and low cost, will permit appreciable saving in installation and replacement time.

WW 324 for further details

DIE-CAST BOXES
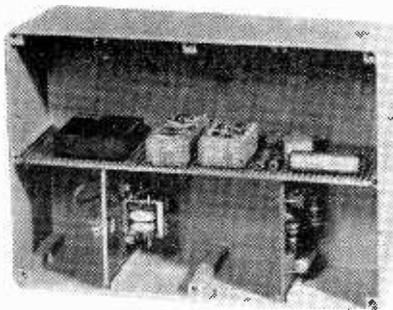
ALUMINIUM die-cast boxes available through STC Electronic Services, Edinburgh Way, Harlow, offer adaptability for equipment construction. The five sizes of this construction system range from $4\frac{3}{4}$in × $3\frac{3}{4}$in × $1\frac{5}{32}$in deep to $10\frac{1}{4}$in × $6\frac{1}{4}$in × $2\frac{5}{32}$in deep. Internal slots for screens and printed circuit boards are provided and specially designed ranges of Veroboard of suitable depth are available. They can be used as rigid chassis for mounting in instrument cases.

WW 325 for further details

Miniature Resistors

A LOW ohmic range of miniature resistors developed for transistor equipment has been introduced by the Resistor Division of the Plessey Components Group. Designated types TW and TP, these resistors are scaled down versions of the Group's present glass fibre cored resistors. They are available with both wire and printed-circuit terminations with a 0.3 in or 0.4 in spacing between pins. Finished in green silicone cement they have an overall resistance range from 0.22 Ω to 6.8 kΩ at a rating of 1 W. They are available in a copper wire wound version where the temperature coefficient characteristics of copper are desired. Cheney Manor, Swindon, Wilts.

WW 326 for further details

I. C. Test Set

FOR testing all present integrated circuit configurations, the 800 IC test set is available from Wessex Electronics Ltd., Bristol 1. It is also intended to accommodate any foreseeable future development in this field. There are facilities for rapid repetitive testing without reprogramming the instrument. The 800 possesses decade load resistors and capacitors, an optional integral pulse generator, and a read-out accuracy of 1% full scale. There is a test facility with a 10 × 20 or 10 × 40 crossbar matrix with provision for up to five external inputs. Provision is made for external d.v.m. or oscilloscope display, and there are integral d.c. supplies, with the option of digital programming.

WW 327 for further details

PUSHBUTTON SWITCH

WITH a diameter of $\frac{3}{4}$ in the Orcon 6-pole, double-throw illuminated switch manufactured in the U.S.A. is available from Litton Precision Products, 503, Uxbridge Road, Hayes, Middlesex. There is a selection of switch actions, switch bases, mountings, pushbutton and filter colours, and bulb types. Switch combinations range from 2 to 6-pole, all with double-throw action. The self-aligning, gold-impregnated, silver alloy contacts are individually isolated to eliminate arcing between circuits. The switching action is completed by 24 oz of pressure in 3/16inch of travel.

WW 328 for further details

Precision Potentiometers.—The law conformity of the Ferranti 11HL potentiometers mentioned on p. 102 of the February issue is better than ± 1%, not ± 10% as stated.

LITERATURE RECEIVED

The 24-page catalogue D.10B lists the specifications of the rectangular D **subminiature multi-way connectors** manufactured by Cannon Electric (G.B.) Ltd., Lister Road, Basingstoke, Hants. There are five shell sizes offered with a range of 9 to 50 gold-plated copper contacts, and information on these (and the combination arrangements available) is provided. Non-magnetic, hermetically sealed connector types are also described.
WW 329 for further details

Available from Rank Audio Visual Ltd., Woodger Road, Shepherds Bush, London, W.12, is leaflet No. PROF 3/C.65/9.66/C. & S. which explains the **Cinemeccanica C 65 solid-state sound system.** This system is intended for cinemas with 70 or 35 mm installations, and gives brief descriptions of the units which make up the system. There are two separate 12-module pre-amplifier assemblies (one for each projector); system control and selector unit; power amplifier assembly; screen and ambient speakers as required.
WW 330 for further details

From Radiospares Ltd., P.O. Box 2BH, 4-8 Maple Street, London, W.1, the 83-page **Radiospares Catalogue** for Jan./Mar. 1967.
WW 331 for further details

Control and measuring instruments for process control systems in industrial and research applications, are specified in the 16-page "**Control Instrument**" brochure issued by Ether Ltd., Caxton Way, Stevenage, Herts. It describes temperature indicators and controllers, transducers, solid-state potentiometric temperature controllers, magnetic amplifiers, saturable reactors, and thyristor control units.
WW 332 for further details

Electro-chemical cells known as VOLTABLOC, are described in an eleven-page booklet, with the same title. Manufacturing processes, assembly of these **cadmium-nickel cells** into batteries, cell and battery data, discharge and charge curves, and physical dimensions are fully covered. Cadmium Nickel Batteries Ltd., Spedant Works, Park Royal Road, London, N.W.10.
WW 333 for further details

B.B.C. and I.T.A. television transmitters is the title of a pocket reference chart by Belling Lee Aerials Ltd., Heysham Road, Netherton, Bootle 10, Lancashire. Channels, frequencies, and locations for BBC-1 television and v.h.f. sound stations are given. BBC-2 stations are listed with channels and expected opening dates. There is a list of I.T.A. transmitters with channel, polarization, and e.r.p. details.
WW 334 for further details

A two-part paper by Nexus Inc., on **operational amplifiers** has been received, and will be of interest to those involved with teaching basic analogue techniques. Part I, "An Introductory Laboratory Manual of Operational Amplifier Experiments," has eight pages devoted to operational amplifiers, and their use as fundamental analogue building blocks. There is an introduction, definitions, a list of required test equipment, and a guide to setting up ten laboratory experiments to illustrate examples of operational amplifier connections. Part II, "Operational Amplifier Quiz" is a 16-page questionnaire, intended to give some indication of a person's familiarity with the technology of operational amplifiers. Nexus Research Laboratory Inc., 480, Neponset Street, Canton, Massachusetts.
WW 335 for further details

A 15-page reprint of the article "**Gas Lasers**" by Dr. A. L. Bloom of Spectra-Physics Inc., U.S.A., has been published by Claude Lyons Ltd., Valley Works, Hoddesdon, Herts. This is available, free of charge, from the above company. Originally contained in the joint issue of the *Proceedings of*

the *I.E.E.E.* and *Applied Optics* for October 1966 it includes an introduction, historic background and a brief classification into types. Also discussed are the characteristics of the various lasers, including wavelength ranges, power output and gain, Doppler width, and the excitation mechanisms required to yield a particular output power. There is a short discussion on noise and coherence properties and a description of the continuous wave r.f. excited, ring discharge, argon ion laser.
WW 336 for further details

A range of **solid-state electronic tachometers** and their applications are discussed in an 8-page publication by Airpax Electronics Inc., Seminole Division, Fort Lauderdale, Florida, U.S.A. This instruction manual, number 700-0548 Rev. A, discusses the theory of operation, details tachometer characteristics, as well as giving electrical, mechanical and environmental specifications.
WW 337 for further details

Livingston Laboratories Ltd., Instrument Hire Division, Livingston House, Greycaine Road, North Watford, have issued an "**Instrument Hire Catalogue.**" This 35-page publication gives the weekly hire charges (both short and extended terms) for counters, meters, oscillators, pulse generators, signal sources, oscilloscopes, recorders, and power supplies.
WW 338 for further details

Electroniques, the new S.T.C. component and equipment supply service for the radio and electronics amateur (see *Wireless World*, December 1966, p. 597) has issued its first annual, "**Hobbies Manual**" MG/222X 1967. This 600-page, illustrated publication, lists over 11,000 items of equipment, modules, components, tools, and accessories, of about eighty British and overseas manufacturers. Prices, dimensions, and electrical characteristics are given. It also contains circuits and design data for both valve and semiconductor equipment, a series of abacs, formulae, factors and tables. It is available at a cost of 10s 6d from Electroniques, Edinburgh Way, Harlow, Essex.

PUBLIC ADDRESS SHOW

TAPE recording and reproducing equipment, which is now an essential part of p.a., is only one aspect of this year's annual exhibition organized by the Association of Public Address Engineers, which is intended to illustrate the variety, sophistication and quality of modern public address systems. The show will again be held at the King's Head Hotel, Harrow-on-the-Hill, Middx, from March 14th-16th and will be open from 1400 to 2000 on the first day and from 1000 to 1730 on the other two days. Admission is free on presenting a business card.

This year's list of exhibitors is given below:—

Ampex	Magneta
Amplivox	Minnesota Mining & Mfg.
Audix	Mullard
B.B.C.	Peto Scott
Bauch, F. W. O.	Politechna (London)
C.T.H. Electronics	Pye Telecommunications
Cannon Electric	*Radio & Electrical Retailing*
Cosmocord	Rank Wharfedale
Denham & Morley	Reditune
E.M.I. Records	Rendar Instruments
Electrical & Radio Trading and *Electronics Weekly*	Reslosound
Ferrograph Co.	Robinson & Newbery
Fi-Cord International	Rola Celestion
Goodmans Industries	S.N.S. Communications
G.P.O. Engineering Dept.	Shure Electronics
Grampian Reproducers	Sound Coverage
Hammond, C. E.	Standard Telephones & Cables
International Broadcast Engineer	Vitavox
London Microphone Co.	Vortexion
Lustraphone	*Wireless World* and *Electrical & Electronic Trader*
Lyons, D., & Associates	

MARCH MEETINGS

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

LONDON

1st. I.E.E., I.E.R.E., I.E.E.E. & R.T.S.—Colloquium on " Colour cameras " at 9.30 a.m. at the I.E.E., Savoy Pl., W.C.2.

1st. I.E.E. Grads.—" Measurements and the British calibration service " by H. E. Barnett. at 6.30 at Waltham Forest Technical College, Forest Rd., E.17.

1st. B.K.S.T.S.—" Composition in picture and sound " by H. van der Horst & G. Newberry at 7.30 at the C.O.I., Hercules Rd., S.E.1.

2nd. R.T.S. & I.E.E.—Symposium on " Colour television production techniques " at 2.30 at the I.E.E., Savoy Pl., W.C.2.

6th. C.E.I.—" Making the Bosworth Report work ": Conference sponsored by the Ministry of Technology and the Council of Engineering Institutions at 10 a.m. at I.E.E., Savoy Pl., W.C.2. (Registration fee 15s.)

6th. I.E.E.—" A u.h.f. tunnel diode amplifier " by M. K. McPhun and " Short-hop radio-relay systems using tunnel diode repeaters " by Dr. D. L. Hedderly, J. Hooper and M. K. McPhun at 5.30 at Savoy Pl., W.C.2.

8th. I.E.E.—" Thermodynamics in electrical networks " by Prof. P. Penfield at 5.30 at Savoy Pl., W.C.2.

8th. Soc. Environmental Engrs.—" Acoustics in the underwater environment " by T. N. Reynolds at 6.0 at Imperial College, Mechanical Engineering Dept., Exhibition Rd., S.W.7.

8th. S.E.R.T.—" Take care of colour " by E. Rout at 7.0 at the London School of Hygiene and Tropical Medicine, Keppel St., W.C.1.

8th. B.K.S.T.S.—" The design of studio mixers " by H. Burrell Hadden at 7.30 at the C.O.I., Hercules Rd., S.E.1.

9th. R.T.S.—" Problems and solutions of the shadow mask tube " by Dr. R. R. Bathelt and " A survey of colour television display tubes " by Dr. E. F. de Haan at 7.0 at the I.T.A., 70 Brompton Rd., S.W.3.

10th. I.E.E.—" Broadband transmission by radio and cable " by R. W. White at 5.30 at Savoy Pl., W.C.2.

10th. I.E.E.—Discussion on " The future education of electronic engineers " opened by Prof. G. D. Sims and Dr. B. H. Venning at 5.30 at Savoy Pl., W.C.2.

13th. I.E.E.T.E.—" Recent development in education and training aids " by R. C. Winton at 6.0 at the I.E.E., Savoy Pl., W.C.2.

14th. Radar & Electronics Assoc.—" The radar story 1945-1967 " 6.0 at Mullard House, Torrington Pl., W.C.1.

15th. I.E.E.—" Ergonomics in electronic equipment and systems design " by B. Shackel at 6.0 at Savoy Pl., W.C.2.

15th. R.S.A.—Trueman Wood Lecture " Scientific achievements in the Services " by Sir Robert Cockburn at 6.0 at the R.S.A., John Adam St., W.C.2.

15th. B.K.S.T.S.—" Facsimile: pictures across the World " by E. H. Price at 7.30 at the C.O.I., Hercules Rd., S.E.1.

16th. I.E.E. & I.E.R.E.—Discussion on " Automatic processing of nucleonic isotope studies " at 2.30 at the I.E.E., Savoy Pl., W.C.2.

17th. I.E.E.—" Early days in radio research " by Dr. R. L. Smith-Rose at 5.30 at Savoy Pl., W.C.2.

20th. I.E.E., I.E.R.E. & Royal Soc.—Colloquium on " Automated cartography: scientific needs and engineering possibilities " at 2.30 at the I.E.E., Savoy Pl., W.C.2.

22nd. I.E.E.—" The theory of oscillators " by Dr. R. Spence and P. J. Baxandall at 5.30 at Savoy Pl., W.C.2.

22nd. I.E.R.E.—" Dynamic properties of audio frequency compressors " by K. O. Bäder at 6.0 at 9 Bedford Sq., W.C.1.

31st. I.E.E.—" Acoustic behaviour of materials " by Dr. R. W. B. Stevens at 5.30 at Savoy Pl., W.C.2.

31st. R.T.S.—" A history of television equipment " by G. R. M. Garratt at 7.0 at the Science Museum, South Kensington, S.W.7.

BATH

8th. I.E.R.E. & I.E.E.—" Communications and their effect on railway operation " by Prof. Banwell and H. H. Ogilvy at 6.0 at the Technical College.

BIRMINGHAM

2nd. I.E.E.—" Solid state devices " by Dr. G. T. Wright at 7.15 in the Dept. of Electronic and Electrical Engineering, the University.

14th. S.E.R.T.—" Stereo broadcasting " at 7.30 at the University of Aston, Gosta Green.

15th. R.T.S.—" Colour television production problems " by Ian Atkins at 7.0 at the B.B.C. Broadcasting House, Carpenter Rd., Edgbaston.

BRIGHTON

8th. I.E.E.—" Analysis and synthesis in control engineering " by R. E. Long and G. W. W. Pontin at 6.30 at the College of Technology, Moulsecoomb.

BRISTOL

21st. I.E.R.E. & Brit. Computer Soc.—" An introduction to microcircuitry " by Dr. R. A. Hyman at 7.30 at the University.

CAMBOURNE

14th. I.E.R.E. & I.E.E.—" Advances in laser technology " by Dr. R. C. Smith at 7.0 at Cornwall Technical College.

CAMBRIDGE

2nd. I.E.R.E. & I.E.E.—" Electronically assisted acoustics " by J. Moir at 8.0 at the University Engineering Dept., Trumpington St.

CARDIFF

8th. I.E.R.E. & I.E.E.—" Satellite control " by E. G. C. Burt at 6.0 at the Welsh College of Advanced Technology.

10th. R.T.S.—" Measuring instruments and techniques for colour television " by L. E. Weaver at 7.30 at the Angel Hotel.

21st. R.T.S.—" Colour receiver design " by B. Rogers at 7.30 at the Angel Hotel.

23rd. S.E.R.T.—" Electronics in photography " by C. W. Hooper at 7.30 at Llandaff Technical College, Western Ave.

CHELMSFORD

8th. I.E.R.E.—" Electronics in radio astronomy " by Dr. D. M. A. Wilson at 6.30 at the Technical High School, Patching Hall Lane, Broomfield.

CHELTENHAM

17th. I.E.R.E.—" Autoland systems " by R. I. Bishop at 7.0 at the North Gloucestershire Technical College.

CHRISTCHURCH

15th. I.E.E.—" Compact frequency standards " by F. P. Newell and C. M. Groves at 6.30 at the King's Arms Hotel.

COVENTRY

21st. I.Prod.E.—" Numerically controlled machines " by A. W. Vickers at 7.15 at the Grosvenor Room, Hotel Leofric.

CROYDON

15th. I.E.E. Grads.—" Hi-fi quality sound reproduction " by J. Moir at 6.30 at the Technical College, Fairfield.

DURHAM

1st. I.E.E.T.E.—" Thyristor convertors " by J. D. McColl at 7.30 in the Science Laboratories at the University, South Rd.

EDINBURGH

8th. I.E.R.E. & I.E.E.—" Static relay techniques in protection " by M. Legg at 7.0 in the Dept. of Natural Philosophy, the University.

9th. I.E.R.E. & I.E.E.—Symposium on " Telemetry in medical and biological research " at 10 a.m. at the Royal Infirmary, Lauriston Pl.

FARNBOROUGH

9th. I.E.E. & I.E.R.E.—" Made to measure integrated circuits " by P. Cooke at 6.30 at the Technical College, Boundary Rd.

21st. I.E.E.—" Future developments in inertia navigation " by Dr. G. E. Roberts at 6.30 at the Technical College, Boundary Rd.

GLASGOW

9th. I.E.R.E.—" Static relay techniques in protection " by M. Legg at 7.0 at the Inst. of Engrs. & Shipbldrs., 39 Elmbank Cresc., C.2.

10th. S.E.R.T.—" Amateur radio " by T. P. Hughes at 7.30 at the Y.M.C.A. Club, Bothwell St.

LEICESTER

14th. I.E.R.E.—" Single-sideband transceivers " by E. T. Wilson at 6.30 at the University.

14th. R.T.S.—" Stereo broadcasting " by G. D. Browne at 7.15 at Vaughan College, St. Nicholas St.

LIVERPOOL

15th. I.E.R.E.—" The early days of ships' radio " by G. R. M. Garratt at the College of Technology, Byrom St.

NEWCASTLE-ON-TYNE

1st. S.E.R.T.—" Computer storage systems " by T. J. Allen at 7.15 at the Charles Trevelyan Technical College, Maple Terrace.

8th. I.E.R.E.—" Time sharing computer systems " by N. E. Heywood at 6.0 at the Inst. of Mining & Mech. Engrs., Neville Hall, Westgate Rd.

PLYMOUTH

1st. R.T.S.—" Television reception " by P. W. Crouch at 7.30 at the Studios of Westward Television Ltd.

14th. I.E.E.T.E.—" The future of aluminium in the electrical and radio indus-

tries" by A. G. Thomas at 8.0 in the Lower Hall, The Guildhall.

POOLE
1st. I.E.E.—"Adaptive processes for automatic control" by Prof. J. M. Nightingale at 6.30 at the Dolphin Hotel.

PORTSMOUTH
22nd. I.E.E.—"Compact frequency standards" by F. P. Newell and C. M. Groves at 6.30 at the College of Technology, Anglesea Rd.

READING
16th. I.E.R.E.—"The design of linear amplifiers" by Dr. E. A. Faulkner at 7.30 in the J. J. Thomson Phys. Lab. at the University.

SALISBURY
7th. I.E.E.—"Electronics in the automobile" by W. F. Hill at 6.30 at the Salisbury and South Wilts. College of Further Education, The Friary.

SOUTHAMPTON
14th. I.E.E.—Colloquium on "The applications of Gunn effect devices" at 5.30 at the Lanchester Theatre, the University.
16th. S.E.R.T.—"Lasers and their applications" by Dr. D. D. Bhawalkar at 7.30 at the College of Technology, East Park Terrace.
21st. I.E.R.E.—"Electronic equipment design" by T. G. Clark at 6.30 in the Lanchester Theatre, the University.

STAFFORD
14th. I.E.R.E.—"Mathematics for the engineer" by R. Wooldridge at 7.15 at the College of Further Education, Tenterbanks.

TWICKENHAM
16th. I.E.E. Grads.—"Medical electronics" by P. R. Styles at 6.30 at the College of Technology, Edgerton Rd.

WEYMOUTH
31st. I.E.E.—"Radio telescopes" by Dr. D. Herbison-Evans at 6.30 at the South Dorset Technical College, Newstead Rd.

LATE FEBRUARY MEETINGS

LONDON
20th. I.E.E.—Colloquium on "Precision resistance standards" at 2.0 at Savoy Pl., W.C.2.
22nd. I.E.R.E.—"A dual standard colour television receiver" by P. L. Mothersole, D. S. Hobbs and D. J. King at 6.0 at the London School of Hygiene and Tropical Medicine, Keppel St., W.C.1.
22nd. I.E.R.E. & I.E.E.—Discussion on "Electrodes for long-term physiological measurements" at 6.0 at the I.E.R.E., 9 Bedford Sq., W.C.1.
22nd. B.K.S.T.S.—"Colour television for the layman" by H. V. Sims at 7.30 at the I.T.A., 70 Brompton Rd., S.W.3.
23rd. I.E.E.—Discussion on "The Manley-Rowe relations" opened by Prof. J. Brown at 5.30 at Savoy Pl., W.C.2.
27th. I.E.E.—"Storage systems for telephone switching" by J. R. Pollard at 5.30 at Savoy Pl., W.C.2.

Real and Imaginary   *By "Vector"*

The Doomsday Bug

OPEN confession being good for the soul I'll come clean about the title. I've lifted it from the November 1966 issue of *Science Journal* where it headed a " guest leader " written by Lord Ritchie-Calder.

In this the author develops the proposition that psychologically induced inhibition of free discussion provides a cloak of security for the prosecution of biological warfare. He points out that 20 years ago Frederic Joliot-Curie, in a paper called "The Secret War" showed that the next outbreak need never be declared. It could go on for years, he said, with only the hidden aggressors being aware that it was happening. Then, by degrees, the penny would drop; successive crop failures, a series of human epidemics and a catastrophic fall in the birthrate (sterilization by chemicals in the water supplies) would gradually bring to the attacked a realization that it wasn't all bad luck, but that skullduggery was afoot. By which time it would be too late.

Without wishing to emulate the fat boy of " Pickwick Papers " by wanting to make your flesh creep, I must say that it seems to me that there is an astonishing resemblance between Joliot-Curie's prophecy and the present unenviable state of our native electronics industry (using the word " industry " in its Pickwickian sense, of course).

Working on the, perhaps unjustifiable, premise that I have a quorum of three readers I have, by this statement invoked three possible schools of thought, namely : —

(a) That's very true, or
(b) It's wildly exaggerated, or
(c) This man's off his rocker.

Reader (a) as a reward for perspicacity can cut reading the rest of this piece and get down to the small ads. No sense in preaching to the converted. Readers (b) and (c) are advised to try to equate Joliot-Curie's prediction with present events in the electronics industry; for instance, in place of his " crop failures " substitute our own inability to supply the home market with the right goods at the right prices in such areas as computers, peripheral equipment, semiconductors, instruments and many others (as witness the steady increase in imports of these devices). Compare his " human epidemics " with the brain drain which is relentlessly sapping our native engineering effort. Consider his " falling birthrate " in terms of the general decrease in share values of British electronics firms (one example: from 25s in 1964 to 5s 6d in 1966). Ponder also others which come to mind and perhaps the parallel will begin to take shape.

For there are wars and wars and the one in which we are in up to our respective necks is a trade Armageddon. It is an all-out, cut-and-thrust, no-holds-barred, no-quarter-given (and any other appropriate cliché you can bring to mind) kind of war. There are no prizes for guessing who the other side is.

If you still don't believe me, sit back in the old rockin' chair (genuwine hill-billy model) and pause and consider any aspect of the industry you please, comparing it with the situation as it existed ten years ago.

Look for a moment at sound radio and TV. (You'd rather not? Come, come! Steel yourself!) In 1959 there were about 25 British companies in the field. Today, six groups (it may be five by the time this is published) account for almost all our production and the U.S.A. has a financial in-

terest in several of these. And, turning to the components industry, do you realize that in 1964 we were a net importer of semiconductor devices, variable capacitors, resistors, microphones and tape recorder accessories and parts? (I learned this from the recent Electronics E.D.C. Report.)

In aviation you will have noted how the swing-wing aircraft, a British invention, is being sold back to us and that we are now buying Phantoms as well as the F111s for the R.A.F. It's no use saying "Tough luck, chums" to the British aviation industry and forgetting all about it, because those aircraft will be bunged up to the ailerons with electronic equipment and precious little of it will be ours. But the Phantoms and F111s are only the thin end of the wedge, for aviation electronics has now passed out of the phase where it was merely tacked-on ancillary equipment. Subsequent generations of aircraft will be built around the electronics; still, with luck we might, if we're very good boys, be permitted to service the all-American equipment. With all-American test-gear of course.

In the matter of world communications we've put up a very good export showing in the past. But the first satellite which went into orbit bleeped out some very rude words in the sky for us. They were to the effect that world communications is no longer merely a matter of electronics know-how, for before you can catch words from that sky-ranging ball you've got to be able to throw the ball up there. And we can't do it. So, we've got to go cap in hand to the big boy who lives over the way and ask him please will he do it for us?

I needn't dwell on the integrated circuit situation. Things are getting to a stage where you can't put a foot down on this sceptred isle without treading on American i.cs. And it's going to get a lot worse. The crux of the matter is that in the present state of the art you can't turn out competitively priced i.cs in small batches. So the home industry, such as it is, with half its home market already filched, with no export market in prospect and no significant Government orders, can't possibly compete in price with the U.S.A. Thanks to their vast Government-sponsored research, development and production, plus their thrusting business acumen, the Americans have cornered the market.

So, unless we snap out of our trance and come to realize that there's a cold, cold war being waged from the West, we can resign ourselves to a decimated industry which will exist only as an American subsidiary.

Now, in spite of what you may think, I don't go around chalking " Yanks go home! " on walls. We're all in the business jungle and they're only doing to us what we would do to them if we had the chance. The only hard feelings I have are reserved for our own industry which dodders from committee to committee like sheep having no shepherd. Except that sheep have more sense than to go into committee for three years before jumping a fence. Neither, I hope, am I a defeatist. I believe we can still beat the opposition if the industry is first integrated to a common purpose. Sections of the industry have got to stop regarding themselves as isolated sub-industries each trying to fight its own private little battle, for this war is on all fronts of electronics.