Wireless World

ELECTRONICS, RADIO, TELEVISION

NOVEMBER 1959

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FRAME GRID VALVES FOR TELEVISION

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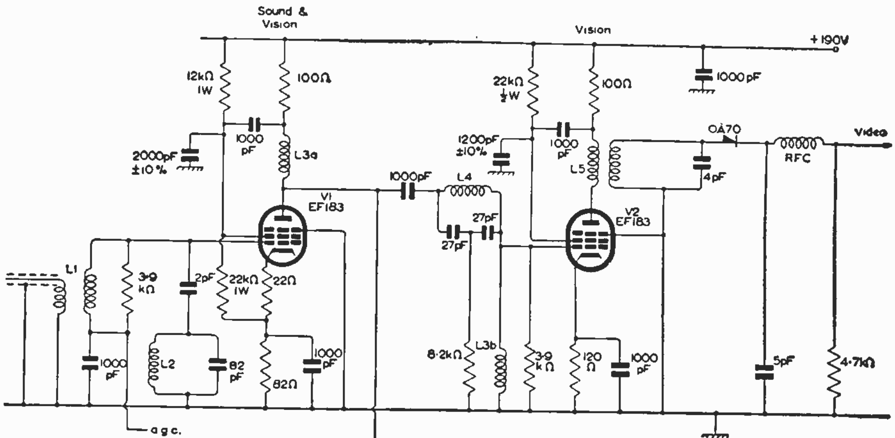
The first advertisement in this series discussed the frame grid valve in general terms, and outlined the advantages which it brings in the tuner and i.f. stages of a television receiver. We shall now look at the i.f. stages in more detail, with particular reference to the needs of fringe areas.

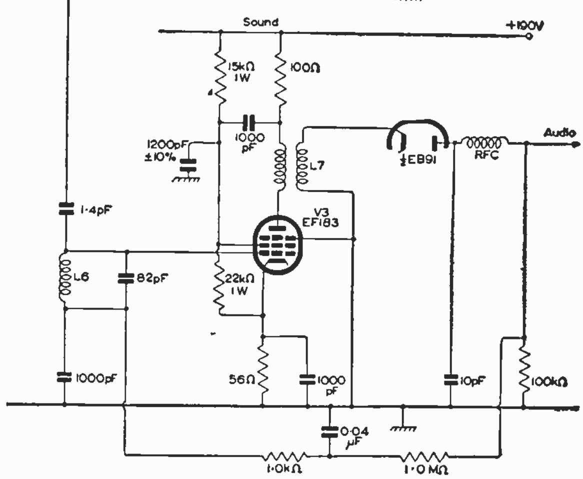


A circuit for an i.f. strip using the new frame-grid variable-mu EF183 is shown. It consists of a first i.f. stage which is common to sound and vision, followed by a second i.f. stage in each channel. Apart from component value changes, the only difference from normal practice is the use of ±10% neutralising capacitors. When the strip is used with the frame-grid PCC89 in a cascode r.f. stage and the conventional PCF80 mixer, adequate gain is achieved for use in fringe areas without the addition of a further vision i.f. stage.

For Band III reception the maximum sensitivity required of a fringe area receiver is 20μV for a picture of normal contrast level. Even for signals weaker than 20μV a receiver of this sensitivity will give the best picture possible. (A higher sensitivity will produce excessive noise on the screen.) The Band I requirement is slightly less stringent and will in practice be easily met in a receiver which satisfies the requirements for Band III.

With the strip shown, and with the PCC89 and PCF80 in the r.f. and mixer stages, 11μV at the aerial will provide 2·0V of video. A typical receiver with a conventional valve line-up (PCC84, PCF80, EF85 first i.f., EF80 sound i.f., EF80 vision i.f.) requires 63μV. Thus the conventional receiver fails to cover the required signal range for fringe areas, and it would need another i.f. stage. The frame-grid receiver, on the other hand, covers the range and has an adequate margin for production tolerances.

It will be noticed that the conventional PCF80 has been retained in the mixer stage. If the frame-grid PCF86 is substituted, then the second i.f. stages can be modified to take the conventional EF80, with the EF183 retained in the first i.f. stage. With this new line-up, a 2·0V video output is obtained with 9μV on Band III and 5μV on Band I.



The circuit shown provides adequate a.g.c. on sound, and approximately 80dB vision gain control without serious cross-modulation. Comparable performance is obtained with the PCF86 variant. Both versions are notably superior to conventional line-ups.

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National Science

SCIENCE is a method, a habit of thought which is practised not only spontaneously and individually for its own sake, as a rewarding personal activity, but collectively and deliberately as a means to an end in solving efficiently the problems of technology and economics. Pure science is at the same time infra- and supra-national in the sense that original thought is the work of individuals who have an affinity of interest with other workers in the same field regardless of race or creed. Applied science, on the other hand, has a military and market value and is consequently, and quite properly, a subject of political interest.

Under the pressures of expediency and in circumstances where the well-being of the community as a whole is involved the Government has voted money and accepted responsibility for scientific work of all kinds, from agriculture to atomic energy and from roads to radio. While some of this work is necessarily secret, much that should be more widely known is lost to view because it is considered either too esoteric or too dull to catch the popular fancy. At times like the present when satellites and moon rockets serve to make the man in the street conscious of the vast scale of scientific effort throughout the world it is natural that he should want to know what we in this country are doing to keep pace with the march of events.

Although questions of detail can be put to the Ministers responsible for the separate departments, it is not always easy to find where the responsibility lies because the labyrinth of Government Science is so complex that many of its byways are obscure, even to those with some knowledge of its main structure. The feeling is widespread that not enough is known about the deployment of national resources and effort in the scientific sphere, and this was no doubt partly the reason for the inclusion in the Conservative Party's election manifesto of a promise to appoint a Minister for Science responsible to the Cabinet for the overall promotion of scientific and technological development.

Wisely, we think, the new Government has resisted pressures to form a whole new Ministry of Science. This would have proved altogether too unwieldy and would have involved wholesale shifting of responsibilities, general disruption, and diversion of effort from the main business of research and development. The Government's policy is to leave the various Departments to get on with their work, but to provide greater facility for the removal of possible antagonisms and to increase co-operation where this would be beneficial.

It is unfortunate, but inevitable, that there must always be a conflict of interest as far as the claims of civil and military science are concerned. In our own field this shows itself in the arguments over the allocation of radio frequencies. Whereas the claims of broadcasting and civil communications must be justified in the greatest detail, those of the fighting services are safe from public criticism behind the wall of "security." As we have said before, these conflicts can be resolved only by a minister of Cabinet rank who can be entrusted with the full facts on either side. In this respect the powers of the Minister for Science will be similar to those which he held as the Lord President of the Council. We hope that they will be exercised and that some means may be found of allaying suspicions that the military are hoarding wavebands as they sometimes do land.

The main functions of the Minister for Science will be to listen sympathetically and to talk persuasively, to release tensions and to reassure, and, if any real malfunction is diagnosed, to recommend treatment. The choice of Lord Hailsham for this post is, we think, a good one. Although not a qualified scientist he has already shown himself, as Lord President of the Council, to be *en rapport* with the scientific world. He will continue to have first call on the services of the Advisory Council on Scientific Policy and he will maintain contacts with the Royal Society, the Universities, the Ministry of Education and the Research Councils. Already he has said that one of his first tasks will be to forge closer links between Government research stations and the Universities in the belief that both stand to gain in prestige and effectiveness by more intimate association.

Not since the Restoration have the portents for British science been more favourable, and in Lord Hailsham this country has found the man to match the hour. His long political experience, his forthright approach, his interest in science and scientists and his ability to command and hold public attention qualify him not only to do those things which ought to be done, but also to let it be seen that they are being done.

Travelling-Wave Valves

Mechanisms of Interaction Processes between Electrons and Fields

By C. H. DIX*, B.Sc., A.M.I.E.E.

THE object of this article is to describe in a rather more mechanistic way than is usual the interaction processes in the two principal types of travelling-wave valves. By a travelling-wave valve is meant a valve in which two essential features are present:—

(1) The valve contains a guiding slow-wave structure which propagates an electromagnetic wave over the frequency range considered at a speed slower than in free space.

(2) There is a continuous interaction between the fields due to this wave and an electron beam.

There is then a convenient and important division which can be made.

(*a*) "*O*" *Type Valves.* These are valves in which the interaction takes place in a region in which there are no d.c. electric fields. In these the electrons are injected at a velocity higher than that of the propagating wave, and cause it to grow by giving up kinetic energy. Focusing of the electron beam is usually maintained by a magnetic field parallel to the electron beam. The best known valve of this type is the helix-type travelling-wave tube, but as will be seen there are many others.

(*b*) "*M*" *Type Valves.* These are valves in which there exist in the region of interaction electric and magnetic fields perpendicular to each other and to the direction of propagation. In these valves the velocity of the electrons in the direction of propagation remains constant, and the electrons can be thought of as providing a pivot for the interchange of potential energy between the d.c. and r.f. fields. Here, undoubtedly the most familiar example is the magnetron.

The nomenclature of "O" and "M" types is due to R. Warneche and his colleagues of the Cie. Generale de Telegraphie Sans Fil in Paris, who were prominent early workers in this field, and used the names "Carcinotron O" and "Carcinotron M" for the two corresponding types of backward-wave oscillator.

"O" Type Valves.—In this division the well-known helix-type travelling-wave tube, due to R. Kompfner and J. R. Pierce, provides an easily understood introduction. The action of this can be described in the following way. Consider the r.f. fields due to a wave propagating along a helix. If the helix is wound so that there are (say) four turns per wavelength, so that approximately $2\pi a \sec \psi = \lambda_0/4$ where λ_0 = free space wavelength (see Fig. 1), then the instantaneous r.f. electric fields produced in it will be as shown in Fig. 2. These fields also, of course, extend outside the helix, but we shall only be concerned here with the fields within it

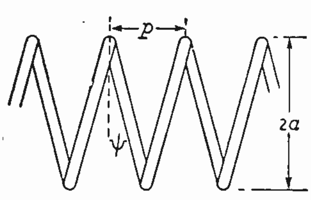


Fig. 1. Helix dimensions.

Roughly speaking, a wave propagates along a helix as though it were travelling at the velocity of light along the wire of the helix. The velocity of axial propagation is therefore approximately $v = c \sin \psi$, where c = velocity of light.

Let us now consider a beam of electrons injected at just the velocity of this wave. If we imagine ourselves to be travelling with the electrons and the wave, we see that a given electron will experience a constant force due to the r.f. fields. Referring again to Fig. 2, it can be seen that electrons in the region AB will be accelerated towards B, while electrons in the region BC will be decelerated towards B. As the beam and wave move together along the tube, therefore, the electrons in the whole moving region AC will gradually collect in a small bunch at B, and this process will continue until the space-charge forces of repulsion of the electrons for each other intervene. (This repulsion gives rise to a saturation in the output power).

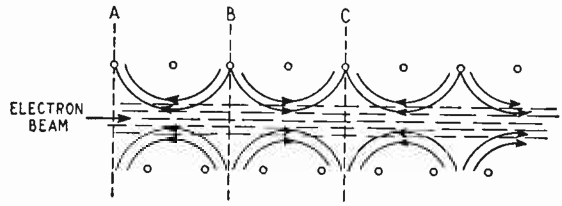


Fig. 2. R.F. fields inside helix.

Considering now average velocities over the region in which this has been taking place, the electrons in the region AB have been accelerated by the r.f. field. They have, therefore, absorbed energy from the r.f. field, causing it to decay. Similarly, electrons in the region BC have been decelerated by the r.f. field, and have given up the same amount of energy to it. Thus there is no resultant gain of energy by the r.f. field.

Looking at the beam, two additional properties have been added to it. These are a velocity modulation of the electrons, i.e. a periodic change in electron velocities along the tube, and a density modulation, or bunching of electrons.

Suppose now that the beam is injected at a velocity slightly higher than that of the wave, bunching will still occur, but since the electrons now start with a slight excess velocity, as the bunches start to form, they drift forward relative to the moving wave. Hence the bunches start to form not at B,

* G.E.C. Research Laboratories.

the point of zero r.f. field, as in the first case, but a little in advance of it, in the region BC, and hence are in a retarding r.f. field. We now have more electrons in the retarding r.f. field region than in the accelerating region. These electrons continue to be retarded by the r.f. field so that there is a resultant gain of energy by this field, thus causing it to grow. The most forward electrons may pass right through this region, having given up only a little energy, and be rapidly accelerated through the next accelerating r.f. field region into the next bunch, when they again give up not only the energy gained in the brief acceleration, but also more of their initial energy. As the fields grow, they are more able to influence the electrons and hence to grow faster, and this can be recognized as typical of an exponential process. The wave then continues to grow as it travels along the helix, until saturation effects occur. The form of the gain curves is shown in Fig. 3, where output power is plotted against input power on logarithmic scales.

This process of bunching of electrons, i.e. ensuring that there are more electrons at places where the r.f. fields are such as to retard them and to gain energy, and less where the r.f. fields are such as to accelerate them and lose energy, is an extremely important and fundamental one, and forms the basis of all amplification by electron tubes.

This is an attempt at a physical description of the interaction in an " O " type travelling-wave tube. It is clear that the energy that appears on the r.f. circuit has come from slowing down the electron beam, i.e. decreasing the kinetic energy of the beam.

The essentials of an " O " type tube would therefore appear to be:—

(1) An electron gun, to form a parallel beam and inject this into the circuit at an appropriate velocity.

(2) A slow-wave circuit, such as a helix, with coupling to a wave-guide or coaxial line input or output circuit at each end.

(3) A collector to receive the beam after it has passed through the circuit.

In addition, two other components are necessary:—

(4) Some means of preventing the beam from spreading out due to space-charge repulsion as it passes along the tube. A uniform magnetic field parallel to the beam is most frequently employed for this.

(5) An attenuator. The necessity for this is seen when it is realized that the bandwidth of the interaction process given by a helix is over an octave. If any reflection occurs at the output end of the tube, the reflected wave will be propagated back along the

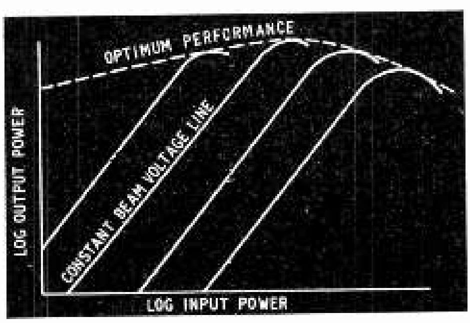


Fig. 3. Gain characteristics of helix type tubes.

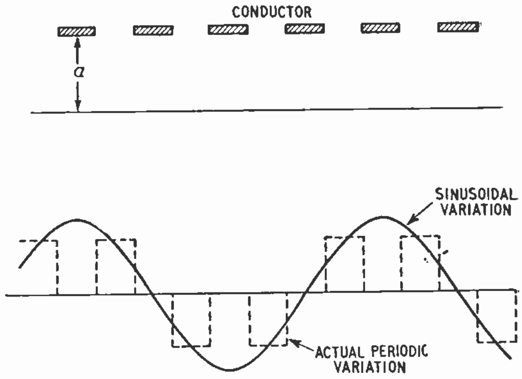


Fig. 4. R.F. fields in a periodic circuit.

helix; if it is then partially reflected at the input end, the reflected part will again be amplified. It can be seen that if the voltage reflection coefficients at the ends are ρ_1 and ρ_2 and the voltage attenuation of the circuit is α, then oscillation will occur if $G\rho_1\rho_2/\alpha^2$ is greater than 1 where G is the forward electronic tube voltage gain. Typically we require G/α to be of the order of 50, hence $\rho_1\rho_2/\alpha$ must be less than 0.02 over the whole bandwidth, a requirement very difficult to meet for small values of α. We therefore arrange to have an attenuating region at least equal to the overall gain, so that, for example, to obtain an overall gain of 30 dB the attenuation might be 35 dB, and the forward electronic gain of the tube 65 dB. Even if total reflection occurs, the combined forward and return cold attenuation is now 70 dB, and the tube will therefore be stable. The attenuation is not usually distributed along the entire circuit, but is concentrated in a relatively short region near the middle of the tube, since if it is placed too near the input, in the region before the growing wave is predominant, it gives an excessive loss, while if it is placed near the output, it leads to a severe reduction in saturated maximum power.

Although a helix has a very great bandwidth it is difficult, especially at high frequencies, to obtain a high thermal dissipation with it. This arises from the fact that if, for a given circuit, we plot gain per unit length against γa ($\approx \beta_0 a$) where $\gamma^2 = \beta_0{}^2 + k^2$, $\beta_0 = \omega/v_0$, $k = \omega/c$, $\omega = 2\pi \times$ frequency, v_0 = velocity of wave on the circuit, a is the helix radius and c the velocity of light, we find that the gain per unit length has a maximum for most practicable circuits which occurs between $\gamma a = 1.4$ and $\gamma a = 2$. Thus γa must be maintained between these limits. Now $\gamma a \approx \omega a/v_0 \approx \omega a/u_0$ where u_0 is the beam velocity. Moreover, as will be shown, there is a maximum value of voltage or beam velocity u_0 which can be used before oscillations interfere. Hence as the frequency, or ω, is increased, it is necessary to reduce the helix diameter to maintain γa within the required limits. For high powers, therefore, other circuits are used, which permit operation at higher voltages than can be utilised with a helix.

Space-harmonics.—In all our analysis we make the assumption that axial r.f. electric fields vary as exp $[j(\omega t - \beta z)]$ i.e. the z variation along the tube is sinusoidal. If, however, we consider a practical circuit, it is seen that this cannot be the case, since at $r = a$ the axial field must be zero along the conducting boundaries. Thus, instead of varying as shown by the full line in Fig. 4, the axial field will in fact vary as shown by the dotted line. The total field, therefore, can be considered as consisting of the fundamental component, our original sine variation, plus a series of fields due to waves having the same frequency, but travelling at different velocities. These are known as space-harmonics and it will be shown later that $\beta_n = \beta_o + 2\pi n/p$ where n is a positive or negative integer and p the pitch of the circuit. The complete field is then described by

$$E = \sum_{n=-\infty}^{n=\infty} E_n(r,\theta)\, e^{j(\omega t - \beta_o z)} . e^{-j\frac{2\pi n}{p}}$$

The important thing to note here is that, since n may be positive or negative, both positive and negative space-harmonic velocities are involved, i.e. although the group velocity of a wave is in the forward direction, some of its space harmonics have phase-velocities in the opposite direction. Now we saw when describing helix interaction that the beam and the wave have similar velocities, and interaction then occurs between the beam and what we now recognize as the fundamental component of the wave. If, however, we had injected the beam with the velocity of the nth space harmonic, we should find that the interaction could be quite well described by assuming that it only interacted with that space-harmonic. If we consider field shapes due to periodic boundaries, it can be seen that the spatial distribution of the space-harmonic fields may be quite different from that of the fundamental, and that, in general, higher order fields decay more rapidly as we go away from the circuit.

To consider on a more physical basis how interaction occurs between electrons and space-harmonic fields, consider a circuit which has, at the edge of the beam, periodic conducting regions and gaps. Considering Fig. 5, the condition for forward interaction we have obtained is that the electron should go from A to B in about the same time as it takes the wave to go the same distance, i.e. $n = 0$ so that $\beta_n = \beta_o = \omega/u_o$, where u_o = electron velocity.

However, if while the electron is in the field-free region between A and B, the field at B reverses $2n$ times, the electron, on arriving at B will be unaware of this, and will still interact with the field that it

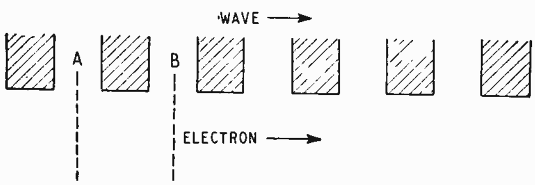


Fig. 5. Space-harmonic interaction.

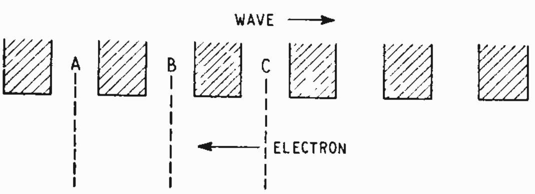


Fig. 6. Backward-wave interaction.

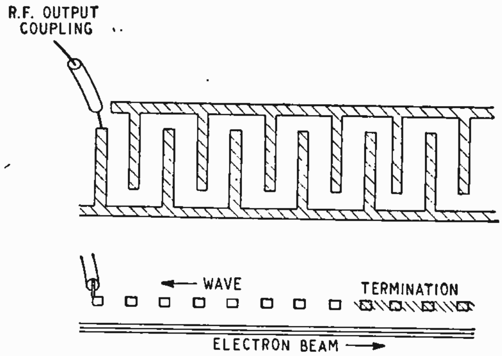


Fig. 7. Interdigital line backward-wave oscillator.

finds at B, since this is just the same field that it met in the synchronous case. If originally the transit time was t_o, the transit time will now be $t_o + n$T where T = period of r.f., i.e.

$$t_n = t_o + \frac{2\pi n}{\omega}$$

The velocity will therefore be

$$u_n = \frac{p}{t_o + \frac{2\pi n}{\omega}} \quad (p = \text{pitch of circuit})$$

$$= \frac{p}{\frac{p}{u_o} + \frac{2\pi n}{\omega}}$$

Hence β_n, which $= \frac{\omega}{u_n} = \frac{\omega}{p}\left(\frac{p}{u_o} + \frac{2\pi n}{\omega}\right)$

i.e. $$\beta_n = \beta_o + \frac{2\pi n}{p}$$

This describes interaction between the nth forward space-harmonic, and would lead to broad-band amplification somewhat as in the case of the fundamental.

Backward-wave Interaction.—Let us now consider interaction between a beam and a wave travelling in the opposite direction. Using still a similar circuit conception, but considering an electron now moving in the opposite direction as in Fig. 6, we see that as before, if the electron moves at a velocity such that it sees a similar field at each gap, interaction will take place. There is here, however, an important difference, since the wave has its group velocity in a direction opposite to that of the beam. Electrons crossing the gap B cause the wave amplitude at B to increase. This increase propagates to C where a still further increase occurs, and thus we have a wave increasing in the opposite direction to that of the beam velocity. Since the amplified wave interacts with the beam, which then increases the wave further back along the circuit, if the beam current is large enough and the interacting length long enough, oscillation will occur, being initiated by r.f. noise in the beam which is always present at all frequencies. Moreover, this oscillation will occur at a frequency which will depend on the beam velocity, i.e. on the beam voltage, thus giving a voltage-tuned oscillator. Such a device is called a backward-wave oscillator (B.W.O.), and consists therefore of a circuit propagating a wave having a phase velocity in the opposite direction to its group velocity, coupled to an external circuit at the beam

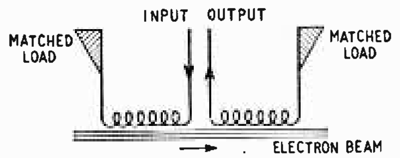


Fig. 8. Cascade backward-wave amplifier.

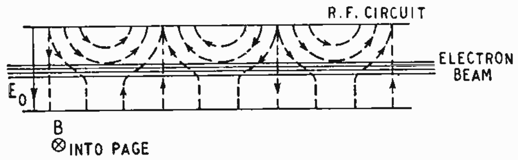


Fig. 9. Crossed-field interaction.

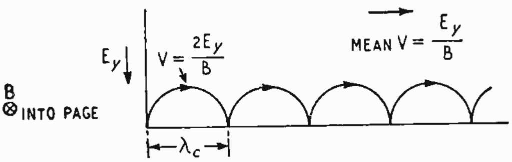


Fig. 10. Electron motion in crossed fields.

injection end, and terminated in a matched load at the other end. The most frequently employed circuit is the interdigital line used in conjunction with a strip beam as in Fig. 7. The helix also can be used as a backward-wave oscillator circuit, but usually the oscillation frequency is much higher than the frequency which the helix would be used to amplify. As the velocity of the helix beam is increased, however, these two frequencies approach each other, and at a velocity corresponding to a beam voltage of about 10kV they become equal. Any high-power amplifier would operate at a beam current far in excess of the start-oscillation current, hence such a valve would turn out to be a backward wave oscillator. This seriously limits the maximum powers which can be obtained from helix-type amplifiers.

If the beam current is insufficiently large, or the circuit too short, oscillation will not occur. An input coupling can be added to the other end of the circuit and we obtain instead amplification over a narrow frequency band, whose centre frequency is again determined by the beam voltage. This thus gives a selective voltage-tuned amplifier. Clearly the gain that can be obtained without oscillation will be limited. It may however be increased by the use of successive circuits, in a cascade backward-wave amplifier, depicted in Fig. 8.

A single circuit B.W. amplifier may run at say 0.9 of the oscillation starting current. This can give a useful gain, but with a very limited bandwidth. If the current is reduced, the bandwidth may be improved at the expense of gain. Using two circuits, it is possible to obtain satisfactory gain at about 0.8 of the starting current, hence giving an improved bandwidth, e.g. 10 dB with a few tens of Mc/s at S-band (around 3,000 Mc/s).

Crossed-field Valves ("M"-type) with Linear Injection.—In the O-type valves, the efficiency is limited by the fact that only kinetic energy can be extracted from the electrons and that the process of efficient bunching is limited by the increase of space-charge repulsion. These limitations are avoided in crossed-field valves, in which potential energy is interchanged, and in which the r.f. bunching is formed by displacement of the beam without causing an increase in space-charge density.

In the simplest type of crossed-field valve, as shown in Fig. 9, there is an r.f. slow-wave circuit and a linear (parallel) electron beam is injected into the interaction region from a separate electron gun. Over the entire beam, and over the entire region of interaction, there is a static electric field E_o between the r.f. circuit and another conductor, and a static magnetic field B at right angles to both the electric field and the direction of motion. Strip beams are usually employed, since it is convenient to use an interacting region of rectangular cross-section. The r.f. electric fields produced by the circuit are then of the form shown by the dotted lines in Fig. 9.

As is well known, an electron starting from rest under the action of crossed electric and magnetic fields follows a cycloidal path as shown in Fig. 10 in which the period of each cycloid is $2\pi/\eta B = 2\pi/\omega_c$ (where $\eta = e/m$ and B is the magnetic field) and in which the mean velocity $V = E_o/B$ where E_o is the electric field. The distance covered in each cycloid due to the r.f. field $E\sim$ is therefore

$$\lambda_c = \frac{E\sim}{B} \cdot \frac{2\pi}{\omega_c}$$

Comparing this with the r.f. wavelength λ_g, $\lambda_g = V\frac{2\pi}{\omega}$

$$\text{i.e. } \lambda_g = \frac{E_o}{B} \cdot \frac{2\pi}{\omega}$$

They are in the ratio

$$\frac{\lambda_c}{\lambda_g} = \frac{E\sim}{E_o} \cdot \frac{\omega}{\omega_c}$$

In a typical device, ω_c is of the same order as ω, but the r.f. field $E\sim$ is many times smaller than the d.c. field E_o. The resultant electron motion is therefore at right angles to the total electric field, in a series of small cycloids.

To see how the gain mechanism occurs, consider again motion in crossed continuous fields (Fig. 10). Electrons move with a mean velocity E_y/B in cycloidal paths in a direction normal to both E_y and B. No mean work is done by the E field over any complete number of cycles, since the total electron displace-

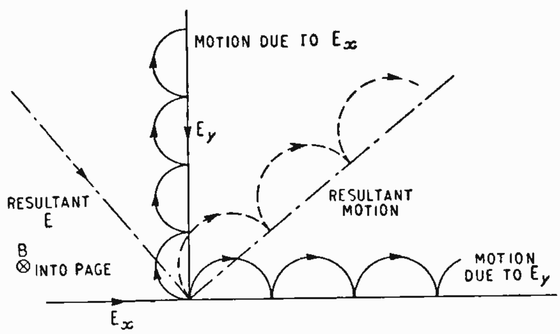


Fig. 11. Electron motion in combined crossed fields.

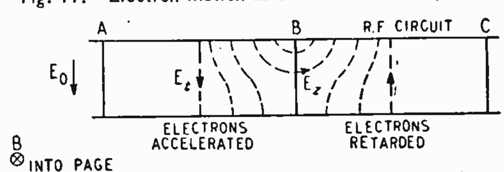


Fig. 12. Bunching mechanism in crossed-field valves.

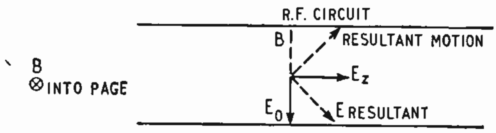


Fig. 13. Effect of axial fields in crossed-field valves.

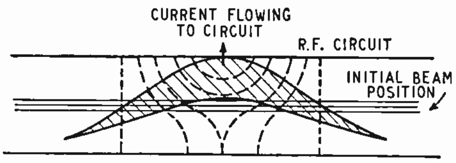


Fig. 14. Displacement of beam in crossed-field interaction.

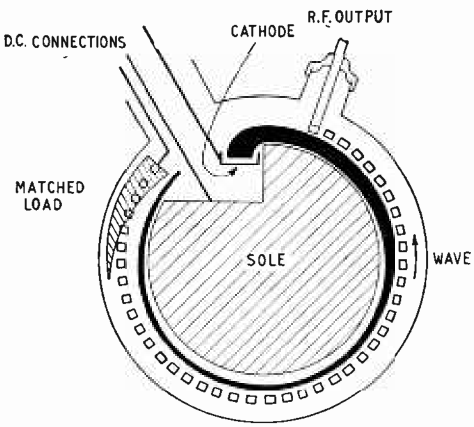


Fig. 15. Crossed-field backward-wave oscillator.

ment in the direction of the field is zero. Consider now the addition of another field component E_x, (see Fig. 11). This by itself will produce net motion in the y direction, at a mean velocity E_x/B. These motions will of course add vectorially to produce net motion at right angles to the total field $\bar{E}_x+\bar{E}_y$ and the resultant motion will be as shown in Fig. 11.

The electron has, however, fallen through the additional potential $E_y.y$ and hence an additional amount of work $e\,E_y.y$ has been done on it by E_y. It has also moved a distance x against the force eE_x, and has therefore given an amount of energy $eE_x.x$ to the field E_x.

If both E_y and E_x are components of the same steady field E, then $x/y=E_y/E_x$. Hence the total energy interchange is $e(E_y.y-E_x.x)=O$, as we should expect.

If, however, E_y and E_x are supplied by different sources, energy is absorbed from one and given up to the other, and the electron acts as a sort of pivot to allow the interchange to take place.

Let us now return to the situation in a crossed—field valve. The r.f. field can everywhere be resolved into transverse and axial components E_t and E_z and in addition we have the steady transverse field E_o (Fig. 12).

The mean axial electron velocity is always $E/B=(E_o+E_t)/B$. Therefore in the region AB, the electron velocities are increased, while in the region BC, where E_t is in the opposite direction to E_o, they are reduced. All the electrons in this whole moving region AC will thus gradually move towards the plane B, i.e., r.f. bunching will occur.

Now consider the axial r.f. field component E_z (Fig. 13). The mean electron axial velocity $u_o=E_o/B$ is changed in both magnitude and direction to $u=(\bar{E}_o+\bar{E}_z)/B$. The electrons again absorb energy from one component of the total field, E_o, and give it up to the other, E_z, and this process continues until the electrons finally arrive at the r.f. circuit, as shown in Fig. 14.

Summarising, the electrons are formed into bunches axially by the transverse r.f. field components, and at the same time displaced transversely by the axial field components. The beam therefore becomes displaced, as in Fig. 14.

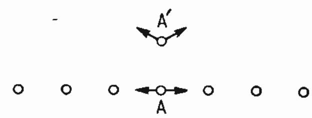
Crossed-field Backward-wave Oscillator.— This valve is the best known of linear-injection (parallel-beam) crossed-field valves. Like its O-type counterpart it has a beam which interacts with a wave having a phase velocity in the opposite direction to its group velocity, and is therefore a voltage-tuned oscillator. The usual arrangement is as shown in Fig. 15. The curving of the axis is done to minimize the weight of the magnet.

Space-charge Amplification—Diocotron Effect. Even if no r.f. circuit is present, amplification can occur in an electron beam under the action of crossed fields. To see how this occurs, we observe first that a thin sheet of electrons is unstable. If we consider a layer of electrons, all repelling each other, as in Fig. 16, initially the electron at A is in equilibrium due to the forces on it from the other electrons. If, however, it is displaced to A′, these forces no longer balance, and it will be accelerated away from the sheet.

Now consider a thin sheet beam in crossed E and H fields, slightly perturbed by some r.f. disturbance. Its initial position is shown dotted in Fig. 17 and it is perturbed to the position shown by the full lines. The space-charge forces at the points A and B will be as shown by the full arrows, and because of the action of the crossed fields, the resultant motions will be as shown by the dotted arrows. There will therefore be an increase in charge density between A and B.

Next, consider a beam in which an r.f. disturbance to the charge density has arisen, as shown in Fig. 18. Due to the increased charge density at C, there will

Fig. 16. Displacement in an electron sheet.



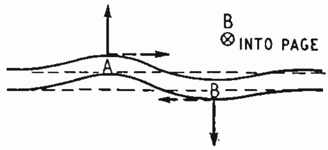
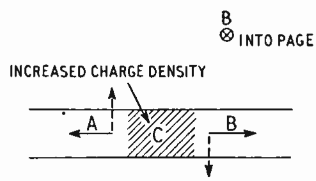


Fig. 17. Effect of r.f. disturbance on a sheet beam in crossed fields.

Fig. 18. Effect of charge perturbation in a sheet beam in crossed fields.

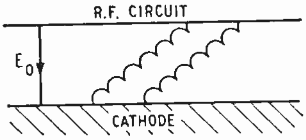


be forces as shown by the full arrows acting on the electrons at A and B, and this will result as previously in motion as shown by the dotted arrows, giving the situation shown in Fig. 17.

Thus it is seen that any displacement perturbation will cause a charge perturbation, which will then increase the displacement perturbation still further, thus leading to a growing wave. Now perturbations are always present at all frequencies in the form of noise, and hence a crossed-field amplifier always acts as a noise amplifier, even without a slow-wave circuit. This limits its maximum useful r.f. gain, and crossed-field devices are principally used as high-power oscillators, or high-power low-gain output amplifiers.

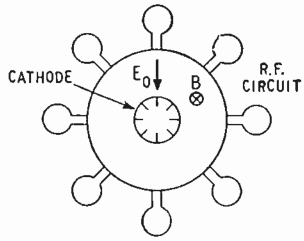
Continuous-injection Crossed-field Valves.—Perhaps the most severe limitation of linear-injection (parallel-beam) valves is the difficulty of designing electron guns with large cathode areas. The maximum current and therefore the maximum r.f. power obtainable is thus limited. However, it is possible to have the cathode at one side of the entire length of the interaction space, supplying electrons as fast as they are removed by the r.f. circuit, as in Fig. 19.

This is, of course, done in the magnetron, which we now recognize as a crossed-field travelling-wave oscillator. Since the circuit is now re-entrant, the magnetron will oscillate whether the interaction is with a forward or a backward wave.



Left: Fig. 19. Continuous-injection cathode.

Below: Fig. 20. Magnetron.



There are also other types of travelling-wave microwave valves, but the "O" and "M" types cover the great majority of the valves now in use.

In the past, travelling-wave valves have found their main applications in radar and communication systems, and perhaps this will continue to be so, but increasing use is now being made of the much more refined performance offered by modern designs. Microwave television and telephone links, tropospheric scatter systems, aircraft navigation and approach systems, missile guidance and control systems and road traffic speed control are but a few of the increasing number of fields of application of such valves.

Commercial Literature

High-Vacuum Equipment including rotary and diffusion pumps, equipment which protects against power supply failures and leaks, solderless couplings, Pirani gauges and Geisler discharge tube pressure indicators. Booklet available from N.G.N. Electrical, Accrington, Lancs.

Regulated Power Supplies giving d.c. outputs from 200V to 400V with 6.3-V a.c. outputs from separate transformers (to avoid effects of d.c. load variations). Stability is 0.02% for ±10% mains change; ripple less than 1mV. Details of the range and prices in a leaflet from Brandenburg, 139 Sanderstead Road, South Croydon, Surrey.

Resistors, fixed and variable; a catalogue giving very complete details of the whole range, and including rotary switches, resistive coated strips, resistive "pills" and ignition suppressors. A price list is included. From Morganite Resistors, Bede Trading Estate, Jarrow, Co. Durham.

Time Calibrator, an electronic instrument producing a crystal-controlled train of marker pulses at intervals of 0.5, 1, 5, 10, 50, 100, 500 and 1,000 microseconds, for checking timebase generators, pulse lengths, etc. Specification on a leaflet from Cawkell Research and Electronics, Scotts Road, Southall, Middlesex.

Storage Oscilloscope using a 5-inch Memotron tube with "infinite persistence" to avoid the need for photographic recording. Writing speed is better than 8μsec/cm. Trace erasure, by push-button or automatic means, takes less than 0.2sec. Two identical Y channels have a sensitivity of 10mV/cm to 30V/cm and a bandwidth of 0-1Mc/s. Technical details on a leaflet from The Solartron Electronic Group, Thames Ditton, Surrey.

Transistor Portable Superhet for m.w. and l.w., a design using six Ediswan Mazda transistors and a germanium diode, delivering an output of over 200mW, with a mean sensitivity of 90μV/m for 5mW output. A ferrite rod aerial is used, and the total weight, excluding cabinet, is 3¾lb. Described in a 20-page Application Report from Siemens Edison Swan, Radio Division, 155 Charing Cross Road, London, W.C.2.

Waveform Sampling Unit called the Nanoscope is an attachment for oscilloscopes which allows fast repetitive waveforms of a few millimicroseconds duration to be displayed on an ordinary c.r.o. with a bandwidth not exceeding 50kc/s. Principle was described in the March, 1959, issue (p. 131). Described in a leaflet from Lion Electronic Developments, Hanworth Trading Estate, Hampton Road, Feltham, Middlesex.

Epoxy Resin Adhesives, a useful booklet showing how to use Araldite for joining various materials. A table lists the materials and indicates which type of Araldite to use and whether any preliminary treatment is required. Another chart gives the properties of the various resins in the range. From CIBA (A.R.L.), Duxford, Cambridge.

Moisture Meters, based on a capacitor detecting element with a hygroscopic dielectric and capable of indicating 1 part in 10^6 of water vapour in dry air or gas. Response time: 1 second. Illustrated leaflet giving details of a large range of instruments from Shaw Moisture Meters, 31 Market Street, Bradford, Yorks.

Independent-Sideband Transmitter, designed for simplicity of operation and economy in operation. Any one of four spot frequencies in the range 2-20Mc/s can be selected readily by an unskilled operator. Output is 250 or 350 watts (peak envelope power) into 50Ω unbalanced coaxial feeder. Technical summary on a leaflet from Marconi's Wireless Telegraph Company, Chelmsford, Essex.

Portable Audiometer for pure tone threshold measurement by air and bone conduction, with a range of 125-8,000c/s. A filtered white noise masking generator provides seven separate noise bands for each test tone used, and each noise band has a width of ±5% of the tone frequency. Described in a folder from Amplivox, Beresford Avenue, Wembley, Middlesex.

Precision Helical Potentiometers, three-turn and ten-turn types, with maximum values between 40kΩ and 500kΩ. They have positive end stops and can be supplied with various bearings and mountings. Linearity is ±0.3% and resistance tolerance 3%. Leaflets from General Controls, 13/15 Bowlers Croft, Honywood Road, Basildon, Essex.

Hall-Effect Devices, mainly probes for detecting and measuring magnetic fields, but also including modulators and multipliers. An informative catalogue, including a section on the principles and construction of the devices, from Siemens and Halske (Germany), through the U.K. distributors, R. H. Cole (Overseas), 2 Caxton Street, London, S.W.1. Also a leaflet on **Semiconductor Photoelectric Devices** of high sensitivity to light.

Words, Words, Words

By P. P. ECKERSLEY, M.I.E.E., F.I.R.E.

Polonius: What do you read, my Lord?

Hamlet: Words, words, words.

"FORCE, Energy, Power, whatever you like to call it"—thus a practical man explaining a practical invention. There seemed to be a considerable scope for making a choice, but the need for a knowledge of fundamentals in doing so.

Those who might smile tolerantly at the practical man's naiveté, do they always use the right word in the right place? I doubt it and it is my purpose to call attention to some of the solecisms of common usage—and, likely as not, when pointing the sins of others, I shall commit like ones myself. I hope so; the subject needs ventilating.

The accusation of pedantry coming from those whose work depends upon accuracy of concept and execution has a hollow sound. The excuse for abusage that "you know what I mean" neglects those, new to some aspect of technology, who do not.

And now for some examples. Circumstances have lately determined that I should become familiar with electro-mechanical relays. A newcomer, I was surprised to find a general use of the term contact pressure instead of contact force. "Fifty million so and so's can't be wrong!" The point is that normally they are; in this case although "everybody uses it" everybody is wrong. Need I add that pressure is determined by area—and that the area of a contact can vary by thousands of times?

I recently attended a lecture on d.c. amplifiers and listened, with growing astonishment, to an exposition which associated—indeed stressed—the characteristic of "bandwidth" in relation to "d.c." So soon as the cognoscenti had contributed to the discussion I sprang to my feet, asking to be put out of my misery—I said that I had hitherto associated zero frequency with direct current now it seemed that a d.c. amplifier was also an a.c. amplifier—why?

"I suppose," said the lecturer, "that you would expect zero bandwidth." Falling into the trap I said "Yes" and rebuked myself for so doing. An amplifier with zero bandwidth would, of course, never respond to any change of input; I did, however, ask why it was necessary to provide any wider frequency response than would ensure a reasonable build-up time.

The answer, which perhaps many readers know, is that a so-called d.c. amplifier is designed to amplify pulses, i.e. waves in which the rate of change of amplitude over a considerable time period may be zero, but also very rapid over short ones. Why cannot we use the term "d.c.-a.c. amplifier" to describe a device which has to amplify both d.c. and a.c.?

It would be quite possible that anyone discussing the performance of "d.c. amplifiers" would have said that they had to amplify "square waves." Here is another inaccuracy, a better term would be "rectangular waves."

An affectionate recollection is an old friend (B.A.Cantab.) talking about "Ohm's Law for Alternating Current." To my inquisition "Tell me, what is this Law, what's its nature—indeed its virtue?" the simple reply was "You know, $I = E/\sqrt{R^2 + X^2}$." We now learn that in fact Ohm never postulated a law and that if he had it would not have been one. We are, I think, more concerned here with the interpretation of the word "law" than any question of confusion between impedance and resistance. The O.E.D. defines a "natural law" as a "correct statement of invariable sequence between specified conditions and specified phenomenon" and gives examples such as "the laws of motion, three propositions formulated by Newton"—I cannot help adding that forty or more years ago I (Certificate of Technology, Manchester) always referred to "Ohm's Law for alternating current." "If age could do and youth but knew."

Overworking the Bel

The Bel is very elegant, but, like the third person singular, it wants watching. If, basing our calculations on voltage or (less likely) on current ratios, we say that an amplifier has a gain of so and so many dB and if we know the input and output resistance no one can cavil. If however the input resistance is that of the grid to ground resistance of a valve when worked in class A connection there can be some indefiniteness about "dB gain." In my submission the right way to define the input resistance of an amplifier, when the grid to ground circuit is not shunted by a resistor of known value (and therefore is very large or, as some say "infinite") is to say that it is equal to the internal resistance of the source which generates the input voltage. We then postulate an optimum input power matching, even though it may not exist, only in this way have we any right to speak of power gain. The gain, using input volts to represent power, as is too often wrongly done, will seem to be 6dB greater than the real power gain with the postulated matching at the input.

All this may seem pedantic—it probably is—but so-called pedantry is the only recourse when terms are defined accurately and used carelessly.

A much-respected author of a textbook on radio furnishes us with a glaring example of this carelessness when he publishes a graph showing the gain in current (by cancelling inductive by capacitive reactance) on a scale of decibels. If the gain had been expressed in nepers, a unit which is, by definition, based on a ratio of currents, no one could object.

There does seem to be a modern tendency to enlarge the scope of the decibel: what we seem to lack is an offspring of the neper, with a base of 10 rather than ϵ, when we should be able to express gains on a logarithmic scale but in terms of voltage and current without the confusion that power too often introduces.

Great fun may be had with detection and demodulation. My authority (B.S.I. 204:1943) deprecates either "Demodulator" or "Rectifier" for "Detector"—the latter, says the Glossary, is "a device, having non-linear conducting characteristics, used for detection."

I should have thought that there is, in fact, a distinction between a detector and a demodulator. While the detector has "non-linear conducting characteristics" the demodulator essentially has not; it involves a modulator in association with an oscillator (or at any rate demands a source of oscillations) to make it function. The process of disentangling information from the carrier which bears it can be consummated either by a detector or by a re-modulation of the carrier (by a so-called demodulator) and agreeable as it is to deprecate confusion between the processes it is surely right to make a distinction between them when each has the same end product.

The term modulator is defined by B.S.I., not very bravely, as "a device for producing modulation" and modulation is defined, very generally, as "the process by which the amplitude, frequency or phase of a carrier wave is modified in accordance with the characteristics of a signal." The significant word here is "signal," meaning, one supposes, the electrical equivalent of some intelligence that is required to be transmitted or, as some say, "modulated on" to a carrier. On the other hand, there is a usage, in line transmission, which embraces the term "group modulation." The process of group modulation adds or subtracts a constant frequency to or from the several carriers of a group of channels of communication, it is therefore basically a method for frequency changing and yet it is characterised as modulation. We know that modulation does in fact produce a change of frequency and so it is possible to look upon carrier transmission as, at the sender (not transmitter), a means to add a constant carrier frequency to the audio frequencies representing the intelligence and, at the receiver, means to subtract it (by detection or demodulation).

Thus transmission involves frequency changing and frequency changing involves modulation! It is also a pet hobby of mine to demonstrate that the action of a detector can be simulated by modulating the carrier by a rectangular wave of unit amplitude.

The only serious criticism relevant to this aspect of terminology is the use of the term group modulation instead of group frequency-changing or something of the sort.

Rearguard Losses

I greatly admire the efforts of those who serve the B.S.I.; they are the standard bearers of a regiment fighting a rearguard action in defence of logical terminology against the ponderous army of lazies who prefer abusage and cite usage as their support.

"Habit," said Wellington, "is ten times nature." The lazy lie back on their comfortable cushions. "I've always called it that and I don't care if it is illogical; you know what I mean."

There is no need to despair. For instance, 50 years ago we called the receptacle for an electric charge a capacity or, worse, a condenser; now, except in proper names remembering the past, all but the belligerently conservative call it a capacitor. The same goes for resistor and inductor. I have yet to hear of the "impedor"; rearguards inevitably suffer their losses.

A friend and colleague, who like myself is sometimes described as pompous when it comes to terminology, seldom misses an opporunity to favour "transconductance" rather than the accepted "mutual conductance." What, he asks, is mutual about it? On the other hand B.S.I. defines "mutual conductance" as "the control-grid to anode transconductance" . . . leaving this writer a little puzzled. Would my friend define transconductance as the control-grid to anode mutual conductance? I must ask him.

Another jehad (jihad I am now instructed) which he eloquently fights is against the term space-factor as applied to windings of insulated conductors. "Copper factor," says my friend, "it points the term with far more precision." I have remarked that we do happen to wind insulated resistance wire on bobbins. Perhaps "conductor factor" or "metal factor" would therefore be more to my friend's point.

Do you, gentle reader, plot a graph or a curve? I think you ought to plot a graph otherwise a straight line becomes a curve! Many refer to an oscillograph when it is not making a graph and an oscilloscope when, plotting a graph, the trace may be invisible.

Ionic Wanderers

I must say I defend the term valve, most of all when it is "hard." Of course the word valve has many meanings, for instance it is "one of the halves or sections of a dehiscent pod, pericarp or capsule (1760)," but in a less esoteric category, it is "that which controls the flow of vapours or liquids" so why not that which controls the flow of electricity? Tube! Pooh!

But I doubt "thermionic," certainly the cathode is hot but does it emit ions or if it does are these what are chiefly present? I was taught to believe that while "ion" is "neut. part. of *eimi*, to go," it also has an association with a wanderer. An Ionian was a "member of part of the Hellenic race which occupied Attica, Western Asia Minor, etc." I sense movement of tribes as inquisitive wandering rather than purposive going. So if ions are wanderers and surely electrons, rushing down a potential gradient cannot be classified as such; their movements, once escaped from a space charge, are purposeful; even their bunching is controlled, few are in a condition to wander.

My purpose has been to cite a few examples where usage is either cruel to logic or murders it. There are many more examples, for instance binaural (I always listen to my loudspeaker with both ears), shot noise (it is an effect not a noise), resistance coupling (not so good for a.c. amplification without an associated capacitor), volume control (when used instead of gain control), potentiometer (which measures nothing), mixer (which sounds culinary but is too often a synonym for a frequency changer) the term constant (when coefficient is usual) envelope (when bulb is less pompous) frequency distortion (how do you distort a frequency?) electronic relay (the term relay belongs to electro-mechanics, the similarity to, for instance, a thyratron is too remote)—and so on and so forth.

I ask for short terms which read as directly as possible on to the concept, or the devices which they describe. Most of my examples have been concerned with devices; it will be perhaps of some interest to examine some terms of a less concrete, more abstract nature.

With the Editor's consent I will live dangerously and dare to consider the term "wireless". I must condemn its general use (and therefore range myself for once with a majority) but welcome its continuance when forming part of a proper name. Contrary to the implications of the dictum that "a rose by any other name would smell as sweet" I believe the world would lose a very proper name if "wireless" were divorced from it. The same sentiment attaches to the name of a famous company. Names are in a different category from technical terms, they have ancestry, they are property, they preserve tradition and therefore support history.

Picture Broadcasting

A certain dubiety about using the word television to define picture broadcasting arises from an anticipation of a semantic embarrassment (a truly "precious" sentence!). What name shall we give to it when we can see as well as hear through the telephone? Telegraph, telephone, television—these are names describing a logical evolution of line and radio communication. We do not however describe sound broadcasting as "telephone": why is picture broadcasting called "television"? It would be a quixotic task to attempt to do away with the term television (and its degradation to "the Telly") and I doubt if it will concern me personally when, many years hence, one subscriber to the telephone service may see another when speaking to him (notably her) but, always seeking logical terminology, I am concerned with another defiance of it.

How I dislike the compressions, but I can be sure that the utilitarians will justify their uglies. A product now has "manufacturability," a picture "viewability" (why not fightability or boxability for the man with a fast right hand?) Mocking laughter would doubtless be the only comment on a suggestion that a product was "susceptible to manufacture," that a picture had some particular quality which the lazy writer hides under an ugly compendium word which might just as well be "good" for all it says. For an example of a different nature the hideous plural of spectrum as spectrums is not only a barbarism but offends the modern compulsion to shorten—it has two more letters in it than spectra. But what's the good of being an angry old man? Perhaps jargon is a necessity to those whose minds are crammed full of facts.

I propose now to discuss the art and practice of writing, meaning putting thoughts into sentences which are both clear and concise.

I say (with fear of contradiction) that it is the poet who reaches the heart of the matter more surely than any philosopher, idealogue, or man of science ever does or did. It would be altogether unfair to my thesis to interpret it as denying value to prose writers and thinkers who with their disparate styles and contrasting idioms have contributed so much. I still maintain that the penetration to the heart of the matter is more illuminatingly discovered, more concisely expressed when the poet speaks. In an attempt to lower technical eyebrows let me explain by example. Read Pope's Essay on Criticism, and take as an observation relevant to my text about accuracy of expression that "a little learning is a dangerous thing"; *learning*, be it clear, not, as so often misquoted, knowledge. It is the little learning, badly digested and sickeningly regurgitated which offends. Again when the poet wrote that

"The strongest poison even known
Came from Caesar's laurel crown"

was not this the heart of the matter, concentrated into two lines of verse?

What saner outlook upon the evils and joys of drinking than Chesterton's.

"Good drink that is dishonoured by the drunkards of the town"?

And in the admirable example in the lines which follow the dictum about the dangers of a little learning

"Drink deep, or taste not the Pierian spring.
There shallow draughts intoxicate the brain,
And drinking largely sobers us again."

It would be possible to multiply examples page by page but let a simple story suffice. A young man was taken to see Hamlet. Asked what he thought of it he replied, "Not much, it's full of quotations."

Only the "pale cast of thought," the evil of thinking divorced from sensibility can, and probably will, attempt to deny the truth of what I so confidently preach.

The false deduction from my argument that I want all technical writing done in verse would be as silly as it would be unfair. What I am driving at is to ask technical people to take an interest—a deeper interest unfortunately than some modern education permits—in the humanities, in literature, in poetry; because not only will they thereby find more numerous sources of enjoyment but also, when they write about their discoveries, inventions, or the more pedestrian accounts of laboratory experience, they will do it better and enjoy doing it more. The exemplar for any writer is the poet, for, in the final issue, he goes to the heart of the matter, he expresses himself concisely, and his compression gives his words a pungency which for ever preserves them.

I must say, in passing, that I mean by "poet" one whose works are or will be immortal and not one who, for fear that someone will discover the barrenness of his mind or heart, hides all meaning behind a thick shrubbery of words.

Faraday's "Researches"

There is, in the sense I am trying to express, a poetic quality behind for instance Faraday's "Experimental Researches in Electricity." Here is the proud humility of genius, simply and nobly expressed. I think students of science and technology should be made to commit paragraphs of it to mind and so to heart. Notably those Victorians who studied "natural philosophy" (which was the synonym for what we now call science) always wrote well; some wrote excellently; all of them had an education which embraced the arts; many of them could be described as cultured.

Without wanting even to seem to sneer I would wish that more of those who are growing up to be engineers, scientists, technicians (what you will) were given a better opportunity to study, understand and enjoy the humanities. For it is my conviction that not only would the style of technical writing be improved by more familiarity with the humanities;

but also the value of the work, about which reports might be written.

I sympathize with those who find difficulty in explaining their ideas and observations in writing. Many who excel in talking seem to be overcome by self-consciousness when it comes to the grim business of putting thoughts on paper. There are, of course, cases where a plethora of speech disguises a "little learning" and when writing reveals a vacuum, and other cases where the hand which holds the pen becomes either paralysed or overstimulated. Did I hear a whisper?

The first principle in writing technical reports is simplicity; the first sin, prancing. Simplicity says "the cat sat on the mat," prancing might say "a member of the feline species, classified among the small mammals, took up a recumbently characteristic position upon the fibrous and movable floor covering." A second principle is order, meaning the logical development of the story from its basic simplicities to its more complex aspects and so to a clearly expressed conclusion. For instance, signposting the way for a development report, I would suggest this order, namely, objective, methods of achieving the objective, difficulties encountered, the outcome, and so a conclusion.

I have used the word prancing to describe what is to me an altogether abhorrent style of writing. Rather than attempt precisely to define what I mean by the term I will give an almost perfect example of it. The writer is concerned with an explanation of why a thermistor does not produce amplitude distortion in alternating currents flowing through it; he writes:—

> "Now the current arising from the application of an e.m.f. *if allowed to flow long enough* (the writer's italics) will cause a change (of) resistance and therefore voltage/current ratio. By a process of confused thought this change is often adduced as a reason for saying that the device is a non-linear resistor, but, in the interests of clarity, this error should be avoided."

Here is a pawky sentence, smarmed over with tautology, that ends up (by "a process of confused thought") in arriving at a totally wrong conclusion. Maybe it's just forgivable to get all superior when you are right, it's damnable to prance publicly when you are all wrong.

It is, however, not so easy to explain the action of the thermistor simply, but a good exercise to try. In attempting the difficulty we might say that the resistance of a transistor varies markedly with its temperature and hence with the amplitude of a current flowing through it. However, the mass of material comprised by a thermistor is large enough to prevent its resistance from following rapid changes of current amplitude. Thus when the currents passed through a transistor are alternating the resistance of the device attains a mean value and therefore does not cause sensible waveform distortion; albeit a thermistor is properly classified as a non-linear resistor.

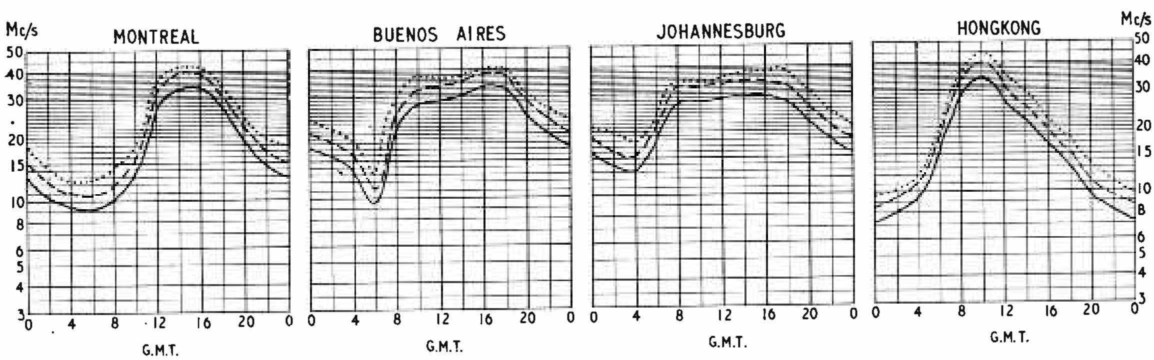
My objection to the original, apart from its sneer at those who "often adduce" a reason for saying what is in fact true, is that it combines tautology with pretentiousness; we do know the relationship between resistance and the voltage/current ratio and generally speaking there is no need to talk down to us.

But when all's said and done, writing, be it of *belle-lettres* or technical reports, is beset with difficulties. Someone described it as "chipping words out of one's breast bone"; the sharper the pen the more painful the process. It is the very fact of its difficulty which makes the practice of writing so fascinating, so worth while. Moreover, as many have discovered and many more will discover, the business of attempting to write a description of a technical process, a device, a discovery, or whatever often proves to the writer that he may not understand the subject he is forced to write about as clearly as he thought he did.

Coming to an end of this preaching and reading over what has been written leaves me with the usual dissatisfactions. If I have, here and there, given to any one reader the desire to do well what, without false modesty, I feel I do not do well enough, then perhaps a labour of love is not lost.

SHORT-WAVE CONDITIONS

Prediction for November



•••••••••• FREQUENCY BELOW WHICH COMMUNICATION SHOULD BE POSSIBLE FOR 25% OF THE TOTAL TIME

— — — PREDICTED MEDIAN STANDARD MAXIMUM USABLE FREQUENCY

——— FREQUENCY BELOW WHICH COMMUNICATION SHOULD BE POSSIBLE ON ALL UNDISTURBED DAYS

THE full-line curves indicate the highest frequencies likely to be usable at any time of the day or night for reliable communications over four long-distance paths from this country during November.

Broken-line curves give the highest frequencies that will sustain a partial service throughout the same period.

WORLD OF WIRELESS

Public Radio-Telephone Service

THIS country's first mobile radio-telephone service linking suitably equipped cars with the public telephone system was inaugurated by the new Postmaster General, Mr. Reginald Bevins, on October 28th. Initially the pilot scheme is limited to cars operating in the southern half of Lancashire, the Wirral and parts of north Cheshire. These areas are covered by two base stations, one at Liverpool and the other near the I.T.A. television station at Winter Hill, near Horwich.

The service is conducted on five channels around 160 Mc/s with a 50-kc/s separation. One channel is used for calling, for which a loudspeaker is fitted in the receiver. The conversations are conducted on one of the remaining four channels; the exchange operator advising the occupier of the vehicle to which he should switch, depending on the position of the car in relation to the two stations. Frequency modulation is used and the standards employed are those adopted for the v.h.f. maritime services—a maximum deviation of ± 15 kc/s, pre-emphasis and de-emphasis of 6dB per octave within the band 300-3,000c/s and frequency tolerances of ± 2kc/s for the base station and ± 3kc/s for the mobile station.

Transmitters and receivers for the base stations have been supplied by Pye, whose mobile equipment, Type PTC8205, has received Post Office approval for fitting into vehicles. The car installation costs £195, or it can be rented at 30s a week. The Post Office licence for the "Radiophone" service, as it is called, is £7 10s a quarter. A three-minute call costs 2s 6d.

Technical Training

IT has become the tradition for the new president of the Institution of Electrical Engineers to review in his inaugural address the sphere of industry with which he has been most closely associated. The new president, Sir Willis Jackson, who, to use his own words, "is identified with the preparation of young people for careers in electrical engineering," did not depart from this practice at his installation on October 9th, and took for his subject "The making of professional engineers." Having first reviewed the contribution made by schools, universities and colleges to the education of technologists, Sir Willis went on to discuss the shortage of industrial training facilities which has become "the Achilles' heel of our national plans for the further development of technological and technical education."

In the past comparatively few firms have "had the foresight to provide training facilities," but "responsibility for training the increasingly large national pool of technologists and, no less important, of technicians and craftsmen" cannot continue to be carried by these few firms. Sir Willis stressed once again that this problem could be solved only if the smaller and more specialized firms will collaborate in the organization of group schemes in which their limited individual resources are properly co-ordinated.

B.B.C. Annual Report

REFERENCE is again made in the annual report of the B.B.C.*—as it was last year—to "the very serious threat to television reception in Band I" which the continued expansion of forward-scatter services represents. The interference is particularly bad in areas served by stations operating in Channel 1. Guidance has been given by the B.B.C. to dealers on methods of reducing the effect of the interference which depends to some extent on the design of the receiver, and the attention of set manufacturers has been drawn to this point.

The 161-page report covers most aspects of the Corporation's work and administration. Here are some points:—

A total of 26,689 schools (about 71% of the country's total) were registered as listening to school broadcasts in the year under review.

The Corporation's income from licence fees increased by over £2M to £27,323,115 and its net revenue from publications rose to £1.14M.

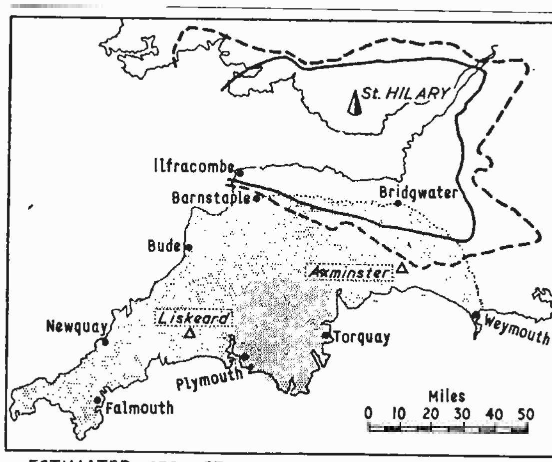
Of the £7.29M expenditure under "engineering" for the national sound and television services £4.62M was for television—an increase of £0.75M during the year.

Rental paid to the Post Office for lines exceeded £1M.

* "Annual Report and Accounts of the B.B.C. 1958-59" Cmnd. 834, H.M.S.O. 8s.

Broadcasting in Kenya

SINCE 1931 the broadcasting service in Kenya has been conducted by Cable and Wireless and its predecessor Imperial and International Communications. The 25-year charter held by Cable and Wire-



ESTIMATED SERVICE AREA of the two I.T.A. stations which will serve the south-west of England is shown (shaded) in relation to the primary and secondary service areas of the St. Hilary station. The two stations, one near Axminster and the other near Liskeard, will be operated jointly by one programme contractor. They are planned to be in service early in 1961.

less, which was extended for a further three years, expired on September 30th and the Kenya Broadcasting Service set up by the Kenya Government came into operation the following day. The director of broadcasting is C. P. Jubb and the chief engineer Graham Phillips, both seconded from the B.B.C.

Four new 10-kW transmitters at the main transmitting station at Langata, near Nairobi, have been supplied by Marconi's—two for operation in the m.f. band and two in the h.f. band. The service also uses a number of existing transmitters at Mombasa, Kisumu and Nyeri, which have been transferred from Cable and Wireless.

Test Card C.—Since our correspondent, K. Dice, wrote his letter (see page 507) referring to "Diallist's" recent plea for more test card transmissions, the B.B C. and I.T.A. have announced a new schedule. This provides that at any time during the morning trade tests from 10.0 to 1.0 a Test Card C will be available from one or other of the two stations (B.B.C. or I.T.A.) serving an area.

I.T.A. Northern Ireland television transmitter at Black Mountain, outside Belfast, was brought into service on October 31st. It operates in channel 9 using horizontal polarization. The directional aerial on the 750-ft mast is nearly 1700ft above sea level and gives an e.r.p. of from 20 to 100kW according to direction. Ulster Television Ltd. are the programme contractors for the station which has been equipped by Marconi's.

E.I.B.A.—Among the donors listed in the annual report of the Electrical Industries Benevolent Association are the Radio Industries Club (London and Manchester), the B.B.C., British Radio Equipment Manufacturers' Association; British Radio Valve Manufacturers' Association; Electronic Engineering Association; Radio and Electronic Component Manufacturers' Federation and many firms in the radio and electronics industry. During the past twelve years the number of people helped by the Association has grown almost ten times and last year totalled 2,392.

University College of North Wales' Department of Electronic Engineering has taken over a new building in Bangor. The present head of the department, which was until last year known as the Dept. of Electrical Engineering, is Professor M. R. Gavin. Power engineering and hydro-electricity, as such, have largely disappeared from the course which is at present being taken by 70 students. The new building can accommodate 120 students.

Press Communications.—The Army Wireless Reserve Squadron, formed some years ago to recruit those interested in radio communication for part-time training as operators and technicians, has a new name. It is in future to be known as 404 Signal Squadron AER (Press Communications). Details of the training are obtainable from Capt. J A. Bladon (G3FDU), 28 Jack Lane, Davenham, Northwich, Cheshire.

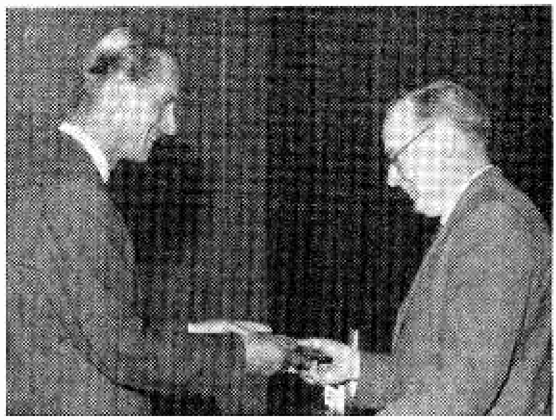
Receiving Licences.—Combined television and sound licences in the U.K. increased by 90,815 during September, bringing the total to 9,718,472. Sound-only licences totalled 5,199,421, including 405,732 for car radio.

Ekco Lightweight Radar.—The weight of the new E190 airborne search radar was incorrectly quoted in our review of the S.B.A.C. Exhibition, Farnborough (p. 431, October issue). The correct weight of this set is only 56 lb.

Mullard Films.—Three more Mullard films—"Modern magnetic materials," "The manufacture of junction transistors," and "The junction transistor in radio receivers"—have been added to the list of films available free from the Central Film Library of the Central Office of Information, Government Building, Bromyard Avenue, Acton, London, W.3.

Gold Medal of the Institute of Navigation for 1959 has been presented to J. E. Clegg, for the development in this country of the Doppler system of air navigation.

The Institute's citation records that "The originality, drive and foresight of Clegg has been the major factor in putting the Royal Air Force ahead in the installation of Doppler equipment in operational aircraft." Mr. Clegg, who was at one time at T.R.E. (now R.R.E.), went to Australia in 1952 to join the Weapons Research Establishment of the Australian Department of Supply, Salisbury, where he is now superintendent of the Trials Division.



H.R.H. The Duke of Edinburgh presenting the Institute of Navigation's gold medal to J. E. Clegg at the Institute's annual meeting on October 22nd.

Institute of Navigation.—Although the Institute records in its annual report for 1958/59 a continued small increase in membership bringing the total to 1,755, the Council appeals for a substantial increase so that it can "acquire the stability which its work demands." The honorary membership of the Institute has been granted to Sir Robert Watson-Watt, who was president in 1949/50. J. Wikkenhauser, chief development engineer of Kelvin and Hughes, is among the five members elected into Fellowship.

Microwave Radio Links.—A coloquium on microwave communication, arranged by the Hungarian Academy of Sciences and the Scientific Society on Telecommunication, opens in Budapest on November 10th for four days.

Australian Television.—On November 2nd, Queensland's first non-commercial television station—operated by the Australian Broadcasting Commission in Brisbane—was brought into service. The State now has three transmitters, two commercial stations having opened in Brisbane in the last few months. The estimated population within the station's service areas is about 700 000. Australia now has eleven television stations—eight commercial and three national.

Educational Wallchart.—The latest wallchart issued by the Mullard Educational Service is entitled "The Television Picture Tube." It illustrates the principle and construction of the cathode-ray tube and shows how the electron beam is formed, focused and deflected The coloured chart, which measures 43in by 30in, is available to educational establishments free of charge from the Mullard Educational Service, Mullard House, Torrington Place, London, W.C.1.

International Study Groups.—The titles of two of the U.K. study groups listed in the note on the work of the C.C.I.R. on page 432 of our October issue were inadvertently transposed. The title of Study Group IV, of which Dr. R. L. Smith-Rose is chairman, is space vehicles, and that of Study Group V, of which Dr. J. A. Saxton is chairman, is groundwave and tropospheric propagation.

Personalities

Professor R. L. Russell, D.Sc., who has succeeded **Professor J. C. Prescott,** D.Eng., M.I.E.E., in the Chair of Electrical Engineering at King's College, Newcastle upon Tyne, had been on the staff of the University of Bristol since 1946. For the past four years he has been reader in electrical engineering. In 1938 he graduated in mathematics at the University of Leeds, from which he received the degree of D.Sc. earlier this year. Soon after graduating he joined the Admiralty Degaussing Department and then for a few years was lecturer on radio, first at the Royal College of Science and Technology, Glasgow, and later at Robert Gordon's Technical College, Aberdeen. Immediately prior to going to Bristol in 1946 Dr. Russell was in the research department of B.T.H. at Rugby.

P. D. Canning, of the Plessey Company, has been appointed chairman of a new sub-committee (12-7) formed by the International Electrotechnical Commission (C.E.I.) to deal with climatic and durability testing of telecommunications equipment. He recently led the U.K. delegation to Ulm, in Western Germany, for similar sub-committees on electronic components, and also acted as secretary of sub-committee (40-5) on basic testing procedures for electronic components. The C.E.I., with its headquarters in Geneva, is affiliated to the International Organization for Standardization, its main object being to facilitate the co-ordination and unification of electrotechnical standards.

P. D. Canning.

R. C. McCormick.

R. C. McCormick, B.A., M.Sc., has joined Airtech Ltd., of Haddenham, Bucks, as chief electronics engineer. After graduating with first class honours in experimental physics from Dublin University in 1949, he was employed as assistant engineer in the Department of Posts and Telegraphs, Ireland. He later joined Mullard Research Laboratories to work in the line communications section. Immediately prior to joining Airtech Ltd., he was with Ultra's special products division as executive engineer.

Bernard R. Greenhead, who joined A.B.C. Television, the I.T.A. programme contractors, as technical controller in June, 1958, from Alpha Television Studios, Birmingham, has become general manager of Iris Productions Ltd., an A.B.C. associated company concerned with the production of TV programmes. He started his career as a research engineer in television and radar with E.M.I. Ltd. before the war. He joined the B.B.C. in 1950 and in 1956 went to Alpha Television Studios, Birmingham. Mr. Greenhead is a director of the London Video-Tape Recording Centre.

A. N. Christmas, superintendent of the Armament Research and Development Establishment of the Ministry of Supply at Fort Halstead, Kent, since 1954, has been appointed Director, Guided Weapons Research and Development (Techniques). Mr. Christmas, who received a first class honours degree in electrical engineering from London University in 1935, joined the Government service in 1937 as an assistant engineer with the G.P.O. In 1946 he went to the Royal Aircraft Establishment's Guided Weapons Department, to work on control systems for beam-riding missiles. In 1951 he was appointed to the British Joint Services Mission in Washington, U.S.A.

D. J. E. Ingram, M.A., D.Phil., reader in the Electronics Department of the University of Southampton since 1957, has been appointed Professor of Physics at the University College of North Staffordshire. Dr. Ingram, who is 32, was for three years demonstrator in the Clarendon Laboratory, Oxford, before joining the staff of the University of Southampton in 1952. He is author of the book "Spectroscopy at Radio and Microwave Frequencies" (Butterworth).

The appointment of the following three new directors to the board is announced by Ferranti Ltd.:—

E. Grundy, O.B.E., B.Sc.Tech.(Hons.), M.I.E.E., who is 53, joined the company's Instrument Department in 1921 and has been general manager of the Moston factory since 1949;

J. Prince, M.I.E.E., 56, who joined Ferranti's from Salford Electrical Instruments in 1926, was appointed chief engineer of the Meter Department in 1935 and has been manager of the department since 1939; and

O. M. Robson, M.A., M.I.E.E., 56, who after coming down from Cambridge joined Ferranti's in 1925, serving in Transformer Designs and since 1944 has been general sales manager.

M. L. Whelan, M.A., Ph.D.(Cantab.), of the Crystallographic Laboratory, Cavendish Laboratory, Cambridge, has been awarded a Royal Society Research Fellowship to carry out investigations of metals by transmission electron microscopy at the Department of Physics, Cavendish Laboratory.

R. Linton is appointed engineer-in-charge of the B.B.C.'s new television and v.h.f. sound transmitting station near Peterborough, which was brought into service on October 5th. He joined the B.B.C. in 1943 as a maintenance engineer at the short-wave transmitting station at Daventry, becoming an instructor in the Engineering Training Department in 1946. For the past eleven years he has served at a number of the Corporation's high-power transmitting stations including Holme Moss and Sutton Coldfield.

C. Glover, until recently sales manager of the United Insulator Division of the Telegraph Condenser Co., has been appointed general manager of the division. The new sales manager is **B. E. J. Honey,** who was with the R. H. Symonds Group of Companies for thirteen years.

J. E. Green has joined General Controls Ltd., of Basildon, Essex, as chief development engineer. He will be engaged on the development of the range of precision potentiometers to be manufactured in this country. They will be similar to those produced by the parent company in the U.S.A. Until recently Mr. Green was with Taylor Controls Ltd., of Walthamstow.

F. W. Newell, who joined the Marconi Marine Company as a sea-going radio officer in 1940 and for the past three years has been an inspector, has been appointed marine manager of the Brazilian associate company, Companhia Marconi Brasileira. He is now residing in Rio de Janeiro.

C. G. Hutchinson is appointed general sales manager of Data Recording Instrument Co. Ltd., an associate company of International Computers & Tabulators Ltd.

J. Reginald Bevins, M.P., the new Postmaster-General, entered Parliament in 1950 as member for Toxteth (Liverpool) which he still represents. For two years, 1951 to 1953, he was Parliamentary Private Secretary to Mr. Macmillan and was Parliamentary Secretary, Ministry of Housing and Local Government, in the last Government. He is 51. The new assistant P.M.G. is **Miss Mervyn Pike,** M.P., member for Melton.

R. J. Halsey, C.M.G., B.Sc.(Eng.), F.C.G.I., D.I.C., M.I.E.E., who, as announced in our last issue, has been appointed a director of Cable and Wireless Ltd., is well-known for his work on the planning and engineering of the first transatlantic telephone cable. He was made Director of Research in the Post Office last year, and will continue in this position. After five years' apprenticeship at Portsmouth Dockyard he won a Royal Scholarship to the City and Guilds College, London, and took an honours degree in engineering in London University in 1925. Two years later, at the age of 25, he entered the engineering department of the Post Office and was posted to the Research Station at Dollis Hill. In 1947 he became head of the line transmission division and in 1953 was appointed an assistant engineer-in-chief.

R. J. Halsey

OUR AUTHORS

J. G. Spencer, author of the article describing the application of a new type of f.m. limiter and discriminator, joined the Research Department of the B.B.C. in 1946. Much of his work since then has been concerned with frequency modulation, commencing with the early laboratory and field tests which preceded the establishment of the v.h.f. service.

C. H. Dix, B.Sc., A.M.I.E.E., contributor of the article on travelling-wave tubes in this issue, has been on the staff of the G.E.C. Research Laboratories since 1951 and, for the past five years, leader of the travelling-wave tube group. He served for five years in the Royal Signals before going to London University, where he took B.Sc. general and special physics degrees in 1950 and 1951, gaining first-class honours in both.

D. E. O'N. Waddington, who describes a transistor stopwatch on page 521, came to this country from South Africa in 1957, since when he has been an electrical design engineer with Marconi Instruments. Two years before coming to this country he joined Marconi (South Africa), Ltd., at Baragwanath. He is 29.

J. Skinner, author of the article on page 509 describing a simplified method of transformer testing, is manager, electronics and transformer production, at Radford Electronics Ltd., of Bristol, where the system he describes is in use. He joined the company in 1955.

OBITUARY

Dr. Balthazar van der Pol, director of the International Radio Consultative Committee (C.C.I.R.) from its formation in 1948 until 1956, died on October 6th at the age of 70. Dr. van der Pol, who was born in Utrecht, spent three years in this country during the First World War studying under Fleming at London University and J. J. Thomson at Cambridge. From 1922 until his C.C.I.R. appointment he was director of research at Philips, Eindhoven, and for the last ten years of his service with Philips he was also Professor of Theoretical Electricity in the Technical University, Delft. In 1952 he was awarded the Valdemar Poulsen gold medal by the Danish Academy of Technical Sciences for his theoretical and practical work on the propagation of radio waves. In a tribute to his work on his retirement from the C.C.I.R., the *Journal* of the International Telecommunication Union emphasized that "as a man of science he could conceive of no frontiers . . . as an international official he systematically overlooked the nationality of the technical experts he had occasion to meet and treated them exclusively as scientists and engineers with whom ideas and information could be exchanged."

News from the Industry

Cossor.—The Marquess of Exeter, in his report as chairman of A. C. Cossor Ltd., said that the elimination of Cossor Radio and Television Ltd. as a subsidiary has had a marked effect on the accounts for the year ended last March. They show a group profit after taxation of £139,411 compared with a loss of £37,134 the previous year. He concluded: "We have cut out, not without cost, the main source of the unsatisfactory position of the group in recent times. The result has been a comparatively successful year."

Pye.—The report of the directors of Pye Ltd., and its subsidiaries records a trading profit for the year ended last March of £2,834,841 and a profit before taxation of £1,885,423. The consolidated profit of £945,128 after taxation is some £150,000 above the previous year's figure.

Gas Purification and Chemical Co., of which Grundig, Wolsey and A.B. Metal Products are among the subsidiaries, had a net group surplus during the past year of £505,336 before taxation. The year's surplus of £296,876 after deducting all charges has been set against the previous year's deficit of £469,392, which leaves a deficit of £172,516 to be recovered.

Radio and Television Trust Ltd., of which Airmec is the manufacturing subsidiary, announce a profit for the fifteen-months ended in June of £138,482 before taxation. This was about £34,000 up on the previous year's profit. As announced last month, the controlling interest in the company has been disposed of by Crompton Parkinson Ltd., and it has been acquired by D. D. Prenn, of Truvox.

Hagan Controls Ltd. has been formed jointly by Plessey Ltd., who hold 90% of the shares, and Hagan Chemicals and Controls Inc. of Pittsburgh, Pa. The company which is operating from Ilford, Essex, has the manufacturing and selling rights in Great Britain and the Commonwealth (except Canada) for the entire range of Hagan automatic control equipment for the maintenance of physical conditions within given tolerances, and "Kybernetes" data processing equipment.

Plessey Products Directory lists all the products manufactured by the Plessey group of companies alphabetically and also under the division or associated company manufacturing them. The directory also gives the location of the various manufacturing units and laboratories.

Nash & Thompson Ltd. are now the exclusive selling agents in the U.K. and the Commonwealth for KOVO, the foreign trade corporation for the import and export of precision engineering products made in Czechoslovakia. Among the instruments that will be imported into the U.K. for the first time are the Polaroscope and Polarographs designed at Professor Heyrovsky's Research Institute in Prague. Other apparatus includes the Tesla B.S.242 intermediate electron microscope, telecommunication equipment, spectrophotometers and electrolytic analysis apparatus.

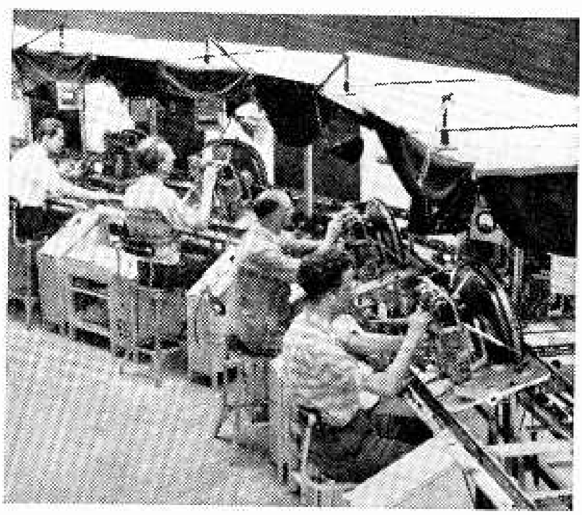
Beam-Echo International Ltd., with offices at 820 Greenwich Street, New York 14, has been formed by H. M. Rahmer, managing director and founder of Beam-Echo Ltd. Mr. Rahmer is vice-president of the American company, of which Michael Muckley, a Canadian, is president. New showrooms for demonstrating Beam-Echo equipment were recently opened in London at 8 Eccleston Street, S.W.1.

Irish magnetic recording tape, which is manufactured by ORRadio Industries Inc., of Opelika, Alabama, U.S.A., is now available in this country from Wilmex Ltd., who have been appointed sole concessionaires for the U.K. Their address is: 131 Sloane Street, London, S.W.1 (Tel.: Sloane 0621).

Gate Electronics Ltd. have moved from Hackney, London, to a new factory at Maylands Avenue, Hemel Hempstead, Herts. (Tel.: Boxmoor 6464.) They are manufacturers of the Gate telephone answering machine and television distribution amplifiers and produce a number of different types of tape recorder for various companies.

Hursant Electronics Ltd., of 13-14 The Mall, Ealing, London, W.5, has been formed by D. C. Adams and R. C. Lever, until recently, respectively, sales manager and chief engineer of Hivolt Ltd. The company is initially producing a range of sub-assemblies for building up a wide variety of high- and low-voltage supply units.

Hall Electric Ltd., exporters of receiving, transmitting and special valves, have moved to new premises at Haltron House, Anglers Lane, Kentish Town, London, N.W.5 (Tel.: Gulliver 8531). The new premises will enable them to increase their present stock of over 3,000 different types of valves.



TAILOR-MADE gravity conveyors constructed from Dexion slotted angle and "Glidewheels" are being used on the television receiver assembly line at the Southend-on-Sea factory of E. K. Cole Ltd.

Levell Electronics Ltd., consulting and manufacturing electronic engineers, have moved from Edgware, Middlesex, to 10-12 St. Albans Road, Barnet, Herts. (Tel.: Barnet 5028).

EXPORT NEWS

Signal Generators.—A second contract for the supply of telecommunication measurement equipment has been placed with Marconi Instruments by the Canadian Department of Defence Production. The order is for 123 a.m. signal generators type TF 801D which will be used in the maintenance of ground-to-air v.h.f. multi-channel equipment of the Royal Canadian Air Force.

A 4MeV linear accelerator for X-ray treatment of deep-seated tumours is being built by Mullard Equipment Ltd., for the Cancer Institute Board of Victoria, Australia. Valued at £60,000 it will be installed at the Board's Peter MacCallum Clinic in Melbourne in the middle of next year. This will be the fourth medical linear accelerator to be built by the Company, and the first to be exported.

Radar Defence System.—Contracts for the design and supply of the electronic equipment valued at approximately £1.5M for Sweden's new air defence system, have been awarded to Marconi's. The system has been evolved by Marconi's in collaboration with the Swedish Air Force. Security forbids a detailed description but it is known that the heart of the system is a very high-speed computer which solves a large number of interception problems simultaneously

Airborne search radar equipment has been ordered from Ekco for use in two de Havilland Comet 4B jet airliners of Olympic Airways of Greece.

Shock Mounts.—Cementation (Muffelite) Limited, manufacturers of anti-vibration and shock control equipment, have received a £5,000 order from Australia for the supply of Barrymount shock mounts for signals equipment fitted to military vehicles.

"British Design," a display of nearly 500 U.K. products, being staged in Copenhagen from November 20th to 29th, includes some radio and sound reproducing equipment. Among the items to be shown are an amplifier and "Transhailer" by Pye, radio tuner units by Acoustical Manufacturing and Jason and a Cossor record player.

Aviation Transmitters.—A £55,000 contract for 37 transmitters for beacons and communications services at Yugoslavian airports, has been placed with Redifon.

CLUB NEWS

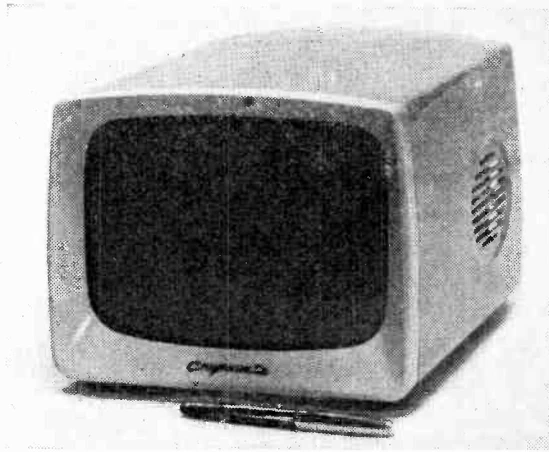
Bexleyheath.—The history, development and manufacturing techniques of the Avometer will be described by J. A. Thomas (Avo) at the meeting of the North Kent Radio Society on November 12th. A fortnight later A. O. Milne (G2MI) will deal with the work of the International Amateur Radio Union. Meetings are held at 8.0 at the Congregational Hall, Bexleyheath.

Reading.—A description and demonstration of modern oscilloscopes will be given to members of the Calcot Radio Society on November 19th by E. D. Taylor of Solartron. On December 10th S. Woodward will give a demonstration lecture comparing mono and stereo sound reproduction. Meetings are held at 7.45 at St. Birinus Church Hall, Calcot, Reading.

Wellingborough.—"Aspects of Tape Recorders" is the title of the talk to be given by G. B. Shaw at the November 19th meeting of the Wellingborough and District Radio and Television Society. Meetings are held each Thursday at 7.30 at the Silver Street Club Room.

RUSSIAN TV PRODUCTION

SOME RECENT FACTS AND FIGURES



The transistor receiver "Sputnik-2" has a 10-inch screen and weighs about 14lb. (Courtesy Brit.I.R.E. Journal.)

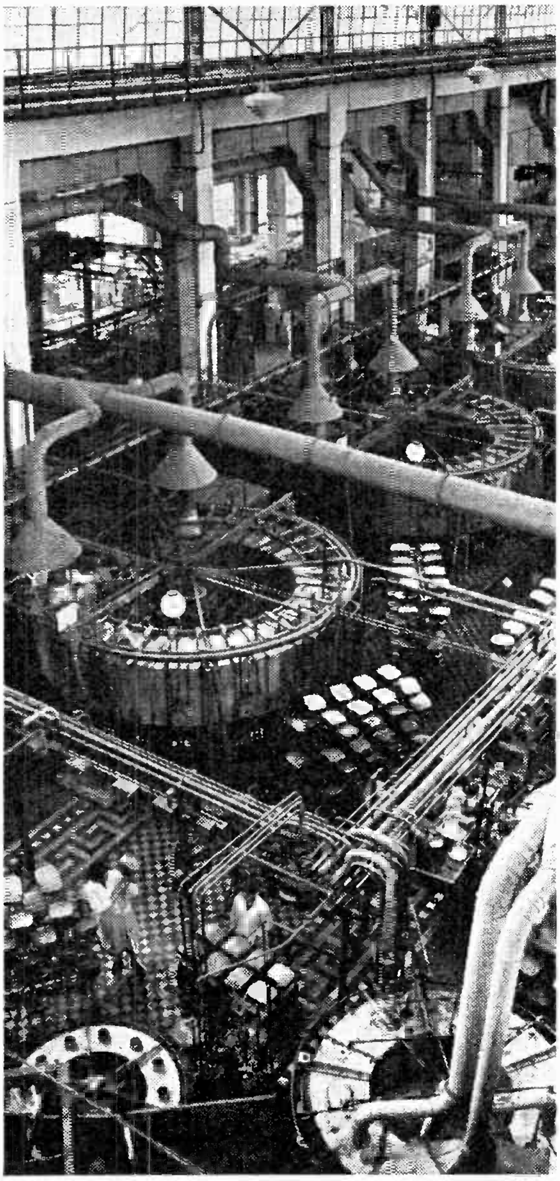
TRANSISTOR television sets are planned for mass production in the U.S.S.R. in 1961-62. For this purpose a 17-inch model has been developed which can be powered from batteries or the a.c. mains. The picture above shows a 10-inch model with 30 transistors, the "Sputnik-2," which was developed last year. It has a resolution of 500 lines and a sensitivity of 100μV, and is intended to run from a 12-volt car battery.

Speaking at the Brit.I.R.E.'s Cambridge convention on television engineering, B. A. Berlin, of the U.S.S.R. State Committee for Radio Electronics, gave further information about the present production of valve receivers. In January of this year, he said, about 3M sets were in use in the Soviet Union. It is expected that 1.2M will be produced in 1959 and that by 1965 the annual output will be 3.5M. In six years' time a total of 18M sets should be in operation.

Manufacturing processes and circuit units are standardized in order to keep prices down and simplify servicing, and the public has a choice of three main classes of receiver. The first class are 21-inch high-quality sets, the second (and most popular) are 17-inch models, while the third are small cheap sets with screen sizes up to 14 inches. There are different cabinet designs within each class, and all first- and second-class models have f.m. sound reception. Small quantities of projection and extra high-quality receivers are also being produced. The last-mentioned sets incorporate sound receivers, tape recorders and record players.

Wide use is made of automatic control and stabilization circuits, and present development aims at introducing a.f.c. for tuners. Picture tubes have 70° deflection angles at present, but a transition to 110° tubes is due to take place this year.

On the transmitting side, the smaller towns are being equipped with 5kW e.r.p. stations and the larger ones with 50kW e.r.p. stations. In 1961 Moscow will have a new transmitter with a power of 200kW e.r.p. and a giant aerial about 1,400ft high. Translator equipments are used for the smallest towns and villages. Colour television development continues, and about 40% of transmission equipment is intended for this purpose.



Cathode-ray tube production in the U.S.S.R. is typified by this photograph taken in one of the factories of the Moscow Electric Lamp Works.

F.M. Receiver Using New

LOW-COST LIMITER/DISCRIMINATOR GIVING GOOD A.M. REJECTION

IN an ideal f.m. receiver, changes of amplitude of the input signal should produce no response at the output; while this condition cannot be achieved in practice, adequate suppression of amplitude modulation is essential if the performance of the receiver is to be satisfactory. In particular, a signal received in conditions of multipath propagation contains both a.m. and f.m. components of distortion; if the former is adequately suppressed the total distortion is considerably reduced[1] and for this purpose an a.m. suppression ratio of some 35 dB is required.†

The simpler types of domestic f.m. receivers usually rely for their a.m. suppression on a ratio detector unassisted, at least over the lower range of input levels, by any other form of limiting. The a.m. suppression ratio achieved is seldom as high as 35 dB and is often considerably lower, with the result that their performance, while satisfactory under most conditions, can be poor in the presence of multipath propagation.

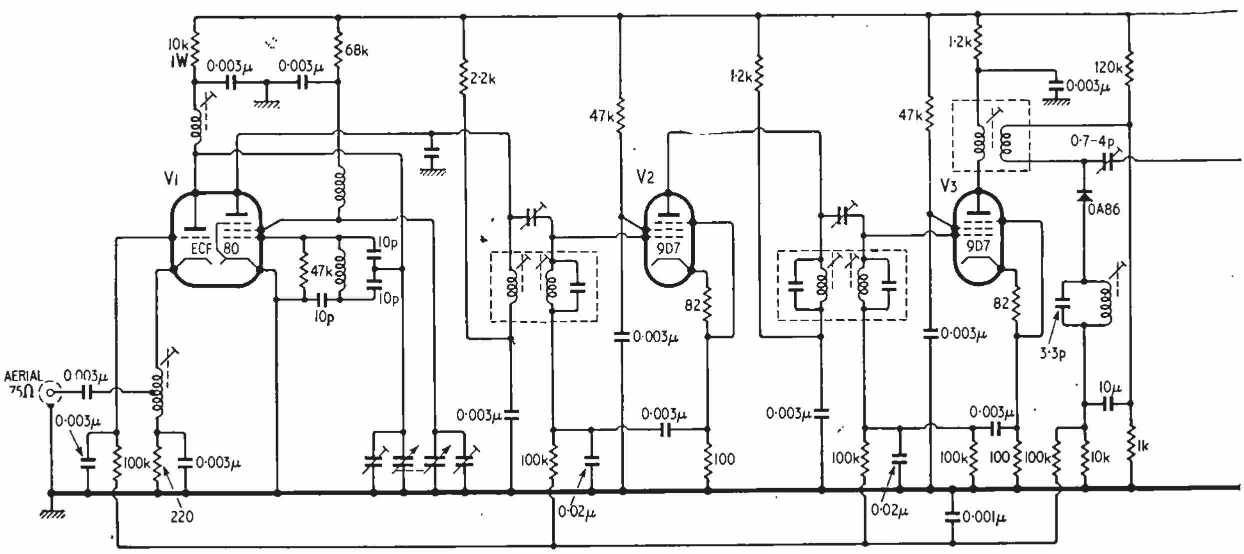
The receiver here described incorporates a recently-developed limiter and discriminator circuit[2,3] and, while it is comparable in cost and complexity with the simpler types of ratio-detector receiver, it achieves better a.m. suppression characteristics without either requiring increased i.f. amplifier gain or sacrificing sensitivity.

The circuit diagram of the receiver is shown in Fig. 1. Apart from the limiter and discriminator the design differs little from established practice; V1 is an ECF80 triode-pentode, the triode section operating as a grounded-grid r.f. amplifier and the pentode section as a self-oscillating mixer. V2 and V3 are two 9D7 i.f. amplifiers; part of the cathode bias resistor of each stage is undecoupled to compensate for changes of input capacitance with variations of a.g.c. bias voltage. The intermediate frequency is 10.7 Mc/s and the local oscillator frequency is below that of the signal. Three germanium diodes, one Type OA86 and two Type OA91, are used in the limiter and discriminator circuit; V4, an ECL82 triode-pentode, is the audio-frequency amplifier and output stage.

Limiter and Discriminator.—The theory of the limiter and discriminator used has been dealt with fully elsewhere,[2] but can be summarized as follows. Amplitude-limiting devices are generally voltage operated and require input levels of one volt or so for satisfactory operation. Such levels do not normally occur in stages before the discriminator unless extra amplification is introduced specifically to drive a limiter. However, the required voltage is normally available at the discriminator transformer itself and, if limiting can be performed there, the extra amplification is not needed. In the design of the Foster-Seeley discriminator it is assumed that it is fed from a high impedance source, i.e., one approximating to a constant-current generator, and the amplitude/frequency response of the transformer is utilized to control the linearity of the transfer characteristic. Thus, a limiting of either the primary or secondary voltage or of a combination thereof would be unsatisfactory. The circuit proposed to overcome these limitations is shown in Fig. 2. In this circuit L_2C_2 and L_3C_3 are the primary and secondary circuits respectively of a conventional

† The a.m. suppression ratio of a receiver is defined for the purpose of this article, as the ratio of the output due to f.m. to that due to a.m. when the input carrier is simultaneously frequency modulated ± 30 kc/s and amplitude modulated to a depth of 40%.

Fig. 1. Theoretical circuit diagram of receiver incorporating new limiter.



Dynamic Limiter

By J. G. SPENCER*

This receiver was designed primarily to show that a low-cost receiver can be produced with the type of a.m.-rejection characteristics usually associated with expensive equipment. The limiter and discriminator section (from V3 anode to V4 triode grid) is eminently suitable for inclusion in new or existing f.m. receivers, where it will offer better performance than even the best ratio detector whilst not requiring the addition of extra i.f. stages or a separate limiter valve.

phase discriminator; L_1C_1 is a parallel resonant circuit across which is connected a voltage limiting device. The presence of this limiter makes the shunt impedance across L_1C_1 very low but if L_1 is loosely coupled to L_2, the coupling acts as an impedance inverter and the discriminator is effectively fed from a high impedance source. Thus, although limiting is carried out at the voltage level of the discriminator, the two functions are independent and the presence of the limiter imposes no restrictions on the design of the discriminator.

The limiting device could take any one of several forms; one possibility is a biased diode which conducts when the peak i.f. voltage across L_1 exceeds the bias threshold. The limiter used here is based on the dynamic-diode type.[4] It employs a diode in series with a load consisting of a resistor and capacitor in parallel, the time constant of the combination being longer than the period of the lowest audible frequency. With this arrangement, amplitude changes having a period shorter than the time constant are suppressed by variation of the loading on the limiter tuned circuit. When the signal increases in amplitude the diode-load voltage cannot change, so the diode current increases very sharply, with a resultant increase in the loading. Conversely, when the signal decreases in amplitude the diode tends to cut off, thus reducing the loading. One disadvantage of this type of limiter is that it gives no protection against a slow amplitude change whose period is

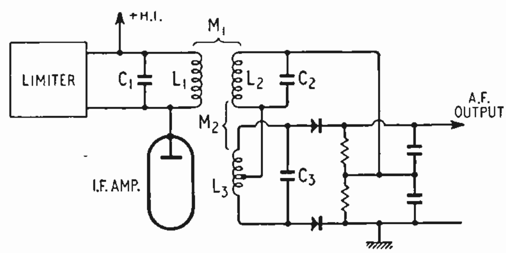


Fig. 2. Basic circuit of limiter and discriminator.

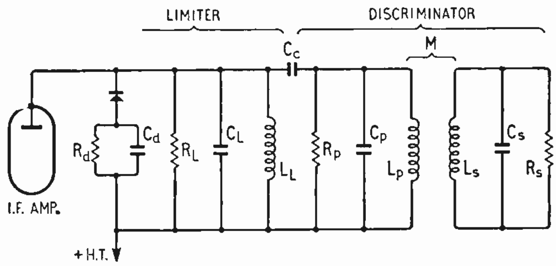


Fig. 3. Equivalent circuit of limiter and discriminator.

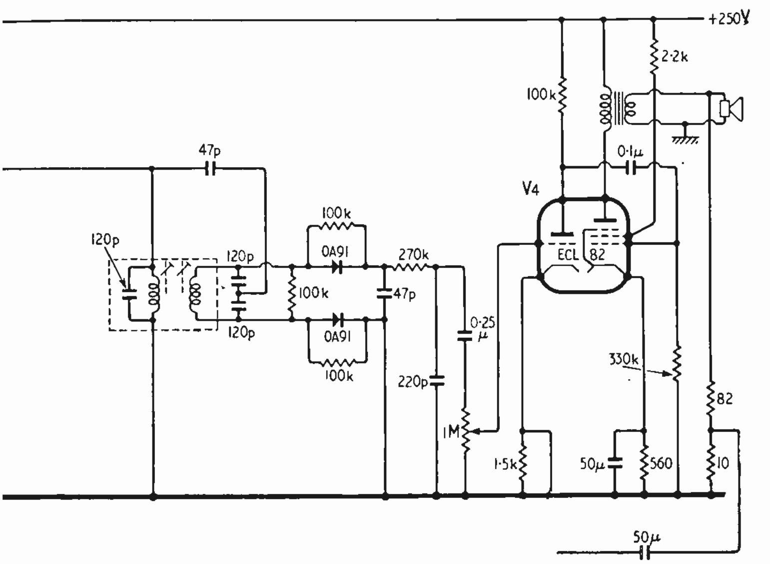
long compared with the diode-load time-constant; the load voltage follows the signal amplitude and the loading imposed by the diode circuit is constant. This limitation has been overcome in the receiver described by using the voltage across the limiter-diode load for automatic gain control.

The practical design of the limiter can best be considered with reference to Fig. 3. The following symbols will be used; the remaining symbols given in Fig. 3. are self-explanatory.

$$Q_p = \frac{R_p}{\omega_0 L_p} \qquad k = \frac{M}{\sqrt{(L_p L_s)}}$$

$$Q_s = \frac{R_s}{\omega_0 L_s} \qquad Q = \sqrt{(Q_p Q_s)}$$

where R_p = total shunt losses of discriminator primary, including diode loading; R_s = total shunt losses of discriminator secondary, including diode loading; R_L = total shunt losses of limiter tuned circuit, excluding loading due to limiter diode, and $\omega_0 = 2\pi f_0$ where f_0 is the intermediate frequency.



*B.B.C. Research Department.

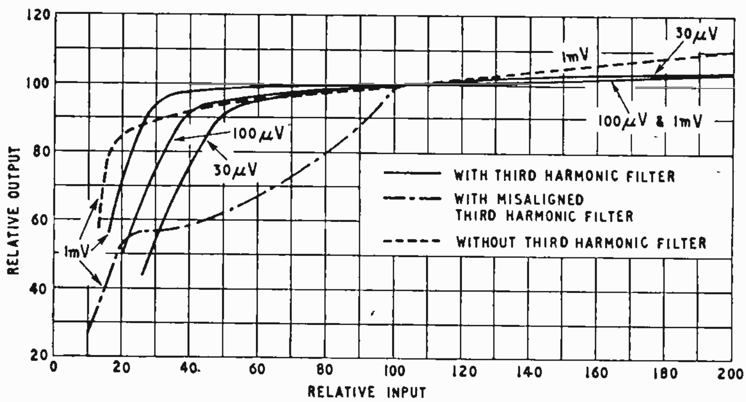


Fig. 4. Correct dynamic-limiter characteristics for various input levels and effect of mis-tuned harmonic filter (two-kneed curve) and absence of filter (dotted curve).

At the mid-band frequency the input impedance of the discriminator, i.e. the circuit to the right of C_c, is

$$R'_p = \frac{R_p}{1+(kQ)^2}.$$

The shunt impedance reflected into the limiter circuit at mid-band is therefore

$$R_o = \frac{X^2_c}{R'_p}$$

where $X_c = 1/\omega_o C_c$. The resulting shunt impedance across which the limiter operates is

$$R'_L = \frac{R_L R_o}{R_L + R_o}.$$

If we assume a rectification efficiency of 100% in the diode limiter, the effective shunt loading of the limiter circuit by the diode, with a constant amplitude input, is $R_d/2$. The ability of the limiter to cope with upwards modulation is virtually unlimited, but the maximum downwards modulation which can be dealt with is determined by the ratio between $R1_L$ and $R_d/2$. In order to deal with a fractional depth of modulation m, we require that

$$R'_L \geq \frac{R_d}{2}\left(\frac{m}{1-m}\right)$$

If this condition is not fulfilled the limiter diode will cut off in the troughs of amplitude modulation and the input to the discriminator will not be stabilized over that part of the modulation cycle. It should be noted that when this occurs the discriminator diodes continue to function, in contrast to the ratio detector in which, if the maximum possible modulation depth is exceeded, the discriminator diodes are cut off over part of the modulation cycle.

Taking as typical values $R_d = 10\ k\Omega$, $R_L = 50\ k\Omega$, $R'_p = 2\ k\Omega$, $f_o = 10.7$ Mc/s, it follows that to achieve satisfactory amplitude modulation suppression for values of m up to 0.8, C_c is required to be 1.8pF. The impedance reflected across the discriminator primary from the limiter circuit is X_c^2/R_x where R_x is the effective dynamic impedance of the limiter and its load. Measurements indicate that R_x is about 500Ω, so that with the conditions specified $X_c^2/R_x \approx 130\ k\Omega$. This is sufficiently high, compared with R_p, to be negligible. As C_c is reduced, the downwards amplitude modulation depth which can be dealt with is increased, but the discriminator slope is reduced; this parameter is therefore a compromise between overall gain and the depth of modulation that can be handled.

The limiter in the form shown in Fig. 3, with an OA86 crystal diode, gives an a.m. suppression ratio of some 30-35 dB; but if a parallel-tuned circuit, resonant at the frequency of the third harmonic of the i.f., is inserted in series with the limiter diode, a further increase in limiting efficiency is obtained. The action of this harmonic filter is to modify the shape of the current pulses through the diode in such a way that its effective dynamic impedance is reduced. The limiter circuit actually embodied in the receiver differs from Fig. 3 in three respects:—

(i) The third-harmonic filter is included.

(ii) The limiter-circuit inductor is wound as a close-coupled transformer; this isolates the limiter from the h.t. line and permits the limiter load to be earthed, thus simplifying the provision of an a.g.c. voltage.

(iii) A delay voltage is applied to the diode to improve the a.g.c. characteristic and hence the suppression of slow amplitude fluctuations.

Dynamic input/output curves of the limiter as embodied in the receiver, for input levels of 30 μV, 100 μV and 1 mV, are given in Fig. 4, together with the 1-mV curve of the basic limiter without the third-harmonic filter. All curves are normalized to the same operating point and the effective reduction of amplitude modulation by the limiter is shown by the ratio of the slope of the dynamic curve to that of the line passing through the origin and the operating point. These curves also demonstrate the reduced capacity to handle downwards modulation at low signal-input levels; this is due partly to the delay voltage applied to the limiter, and partly to the rise in the impedance of the diode at low currents.

Construction and Alignment of Limiter and Discriminator

Details of the construction of the coils in the limiter and discriminator circuits are given below. In all cases the cores used were Neosid Grade 900, Type 6 × 1 × 12.

Limiter Transformer: Neosid Type 5000A/6E former

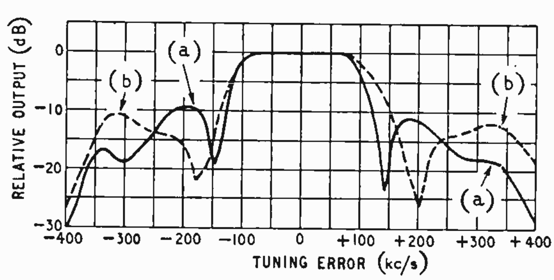


Fig. 5. Tuning characteristic with (a) narrow-band discriminator, (b) wide-band discriminator.

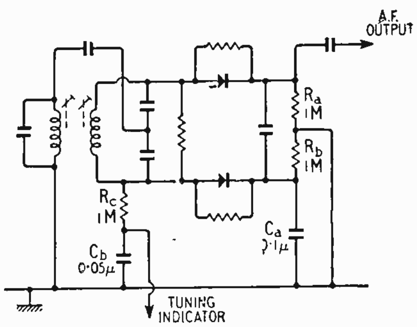


Fig. 6. Circuit modifications to obtain tuning indicator drive from discriminator.

(7.6 mm dia.). Two single-layer solenoids, each 50 turns 38 s.w.g. enamelled wire, close wound, one over the other and separated by one layer of cellulose tape. The external connections are arranged so that the low i.f. potential ends of the two windings are adjacent.

Third-harmonic Filter: Neosid Type 3500 former (7 mm dia.) 25 turns 38 s.w.g. enamelled wire, close wound.

Discriminator Transformer: Neosid Type 5000B/6E former (7.6 mm dia.) Primary: 15 turns 30 s.w.g. enamelled wire wound with 1/1 space ratio. Secondary: 20 turns 30 s.w.g. enamelled wire close wound. The space between adjacent ends of the primary and secondary windings is 6.5 mm.

Alignment of a limiter and discriminator of this type is most conveniently carried out in two stages. First, the third-harmonic filter is short-circuited and the limiter transformer tuned to the intermediate frequency by adjusting for the maximum d.c. voltage across the limiter load: the discriminator can then be aligned in the usual way. To give an oscilloscope display of the limiter input/output curve, the receiver is fed with a 100% amplitude-modulated signal and the Y input of the oscilloscope is connected through a suitable "isolating" resistor (minimum value, 100 kΩ) to one side of the discriminator transformer secondary, thus using one discriminator diode as an a.m. detector. The X input to the oscilloscope is obtained from the signal-generator modulating voltage. This will produce on the oscilloscope a limiter curve similar to those shown in Fig. 4. The short circuit is now removed from the third-harmonic filter and the final adjustment of the limiter-transformer tuning, harmonic-circuit tuning and limiter-to-discriminator coupling is made. The limiter transformer is tuned to obtain the maximum downwards limiting, the value attainable being determined by the limiter-to-discriminator coupling capacitance. The harmonic filter is tuned principally for maximum flatness of the top of the curve, that is, maximum a.m. suppression; but also to ensure maximum downward limiting. Thus it will be found that as the tuning inductance is increased from the optimum value the flat top of the dynamic curve begins to tilt, while if the inductance is reduced, the downward limiting threshold is raised. The adjustment is not unduly critical; a variation of some +20%−10% of inductance from the optimum could be tolerated in the prototype receiver without serious impairment of the limiter performance. Gross mis-tuning, however, causes a considerable deterioration, the effect of an increase of inductance of 80% above the optimum value is shown in Fig. 4. Having set up the limiter, the discriminator tuning should be checked to complete the alignment.

Tuning the Receiver.—One difficulty in tuning an f.m. receiver is to distinguish between the side responses and the central response of the discriminator. If no tuning indicator is fitted it is essential, in order to avoid confusion, that these side responses are either sufficiently low in amplitude or are recognizable by their poor signal-to-noise ratio. Curve (a) of Fig. 5 gives the tuning characteristic of the receiver with an input signal of 1 mV, frequency modulated to ± 30 kc/s. If better suppression of the side responses is required, it may be obtained by increasing the discriminator bandwidth, and curve (b) shows the performance under the same input conditions with a discriminator having a peak separation of ± 200 kc/s. The use of the wider discriminator bandwidth entails a reduction of about 3 dB in adjacent-channel suppression and some loss of gain, but this may be thought justifiable for greater ease of tuning. A difficulty that remains, however, is that of obtaining the best tuning position within the central response.

A better approach to the problem of simplifying

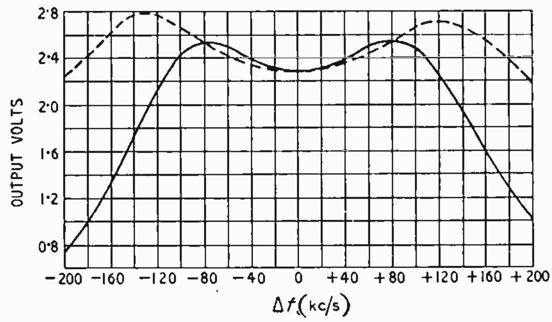


Fig. 7. Potential derived from discriminator to feed tuning indicator (solid line); 1mV constant input to receiver. Dotted line shows response of discriminator alone.

tuning is to provide some kind of indicating device, preferably one which shows the centre point of the discriminator response and is unaffected by the shape of the i.f. amplifier response.

With the normal phase-discriminator circuit the outputs of the two diodes are combined in such a way that a null-point indicator is required. It is possible, however, by making minor modifications to the circuit, to obtain a d.c. output from the discriminator which is suitable for operating a conventional "magic eye" tuning indicator. These modifications, shown in Fig. 6, involve the addition of three resistors, R_a, R_b and R_c and two capacitors, C_a and C_b. The discriminator secondary circuit is now earthed to modulation frequencies by the capacitor C_a, but the d.c. earth is at the junction of R_a and R_b, with the result that a voltage equal to the mean of the rectified voltages across the two diode loads appears at the junction of R_c and C_b. The variation of this voltage with carrier frequency is shown in Fig. 7. The dip in the middle of the curve provides a precise indication of the centre of the discriminator response; because the discriminator is outside the a.g.c. loop,

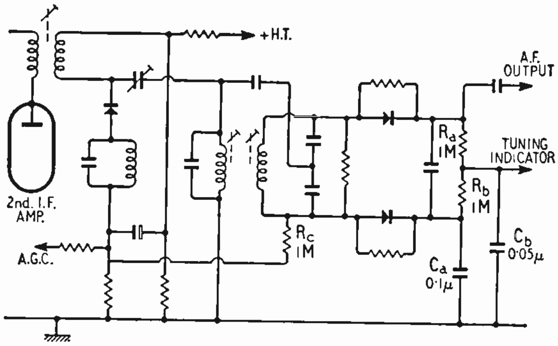


Fig. 8. Circuit modifications to obtain tuning-indicator drive from combination of a.g.c. and discriminator voltages.

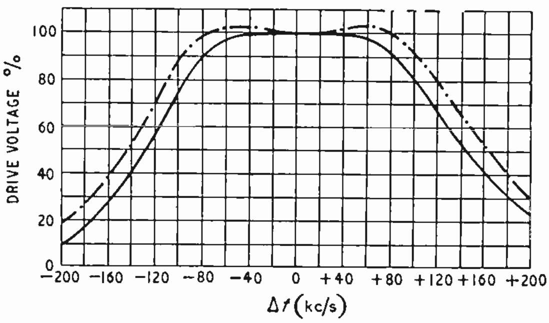


Fig. 9. Potential derived for tuning indicator from combined a.g.c. and discriminator action (solid line). The broken line represents a.g.c. voltage. Indicator drive voltage is relative to that at midband frequency.

while any variations in the i.f. amplifier response are compressed by the action of a.g.c., the accuracy of the indication is not greatly impaired by asymmetry of the i.f. response.

The disadvantage of this system is that it requires the user to adopt an unusual criterion in observing the tuning indicator. This can be overcome, at some sacrifice of accuracy, if the circuit is rearranged as shown in Fig. 8, with the lower end of the resistance R_c connected to the negative end of the limiter-diode load, and the tuning-indicator voltage obtained from the junction of R_a and R_b. With this arrangement the indicator is operated by the difference between the a.g.c. voltage and the discriminator mean voltage. The shape of the resultant curve is shown in Fig. 9; for comparison the curve of the a.g.c. voltage alone is also shown, normalized to the same amplitude at the tuning point.

Performance Tests

It should be noted that all ratios of signal to noise, hum or interference quoted were measured with a mean-square meter preceded by an aural-sensitivity weighting network based on the C.C.I.F. (1934) curve for broadcast-relay circuits.[5] Unless otherwise

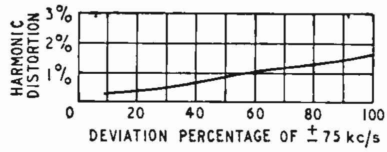


Fig. 10. Variation of harmonic distortion with deviation.

stated all signals levels refer to the open-circuit voltage from a 75-Ω source.

Absolute Sensitivity.—This is the minimum input-signal amplitude, deviated ± 35 kc/s at a frequency of 2000 c/s, which will produce an output of 50 mW with the receiver gain control at maximum.

The measured value was 8μV.

Maximum Deviation Sensitivity for 10% *Harmonic Distortion.*—This is the minimum input-signal amplitude, deviated ± 75 kc/s at a frequency of 400 c/s, which produces a total harmonic distortion of 10% or, if that figure is less than the input required to satisfy the previous test, the distortion occurring at the absolute sensitivity input level.

The distortion at 8μV input level was 5%.

Sensitivity for Standard Signal-to-Noise Ratio.—This is the minimum input signal amplitude, deviated ± 35 kc/s at a frequency of 2,000 c/s, which will produce an output signal-to-noise ratio of 40 dB.

The measured value was 10μV.

Variation of Harmonic Distortion with Deviation.—Fig. 10 shows the total harmonic distortion as a function of deviation with the receiver gain control set to give 50 mW output with ± 30 kc/s deviation at 400 c/s. The input signal level was 10 mV.

Maximum Output Power for 10% *Total Harmonic Distortion.*—The measured value was 1.5 watts.

Modulation-frequency Characteristic.—After correction for a 50μsec pre-emphasis time-constant, the response relative to that at 400 c/s was within the limits ± 1dB from 30 c/s to 15 kc/s.

Selectivity.—The suppression ratio for an interfering signal is measured objectively as the ratio of unwanted-to-wanted signal amplitudes giving an output signal-to-interference ratio of 40 dB when the interfering signal is frequency modulated at 2,000 c/s with a deviation of ± 35 kc/s. The results for adjacent-, second- and third-channel interference (i.e. with 200, 400 and 600 kc/s frequency separations respectively) are given in Table 1, together with the measured ratio for the image channel. The wanted-carrier level in each case was 1 mV.

For comparison with the figures in Table 1, the measured frequency response curves of the i.f. amplifier and discriminator are shown in Figs. 11 and 12.

Local-oscillator Drift.—Local-oscillator drift was found to be comparable with that of the discriminator: the relative drift of local oscillator and discriminator (that is the change of input-signal frequency required to maintain zero d.c. output from the discriminator) was steady at about 30 kc/s after one hour from

TABLE 1

Frequency of unwanted carrier, relative to wanted carrier	**−21.4 Mc/s**	**−600 kc/s**	**−400 kc/s**	**−200 kc/s**	**+200 kc/s**	**+400 kc/s**	**+600 kc/s**
Ratio of unwanted to wanted-carrier levels (dB)	+28	>+40	+35	+6	+5	+34	>+40

switching on. Maximum drift was about 38 kc/s, occurring at about 8 minutes from the switching-on.

Local-oscillator Radiation.—In this test the voltage at the input terminals of the receiver due to the local oscillator was measured, the input terminals being terminated in 75 ohms.

The measured voltage was 1.7 mV.

Co-channel Suppression Ratio.—As for the test of selectivity, but with the interfering signal frequency differing from the wanted signal by less than 1 kc/s.

The measured value was − 6.5 dB.

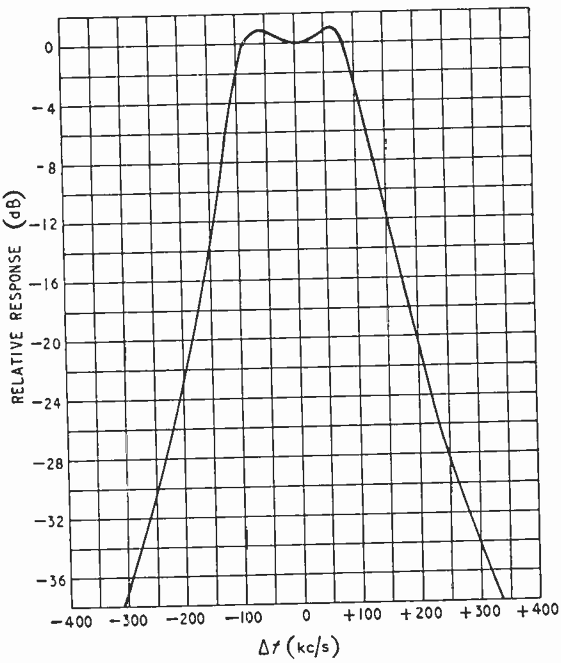


Fig. 11. I.F. amplifier frequency response.

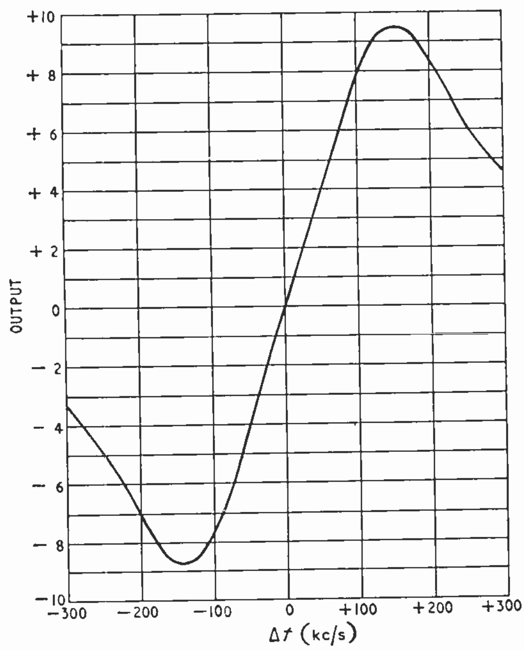


Fig. 12. Discriminator frequency response. Output is in arbitrary units.

TABLE 2

Input Signal Level	A.M. Suppression Ratio
30 μV	35 dB
100 μV	38 dB
300 μV	41 dB
1 mV	43 dB
10 mV	48 dB
100 mV	49 dB

Suppression of Amplitude Modulation.—The a.m. suppression ratio is the ratio between the output due to a carrier which is frequency modulated ± 35 kc/s at 2,000 c/s and that due to a carrier which is simultaneously amplitude modulated to a depth of 40% at 2,000 c/s and frequency modulated ± 30 c/s at 100 c/s, the 100 c/s output being rejected by a high-pass filter. The results for various input signal levels are shown in Table 2.

Dependance of Output on Signal Level.—This is shown in Fig. 13.

Impulsive Interference Performance.—Fig. 14 shows

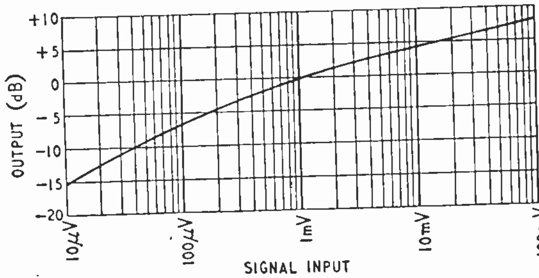


Fig. 13. Variation of a.f. output with input level. Output is referred to 1mV and input level is open-circuit voltage from 75-Ω source.

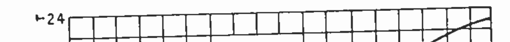


Fig. 14. Input/output characteristic for impulsive interference. Input carrier level 500μV, impulse p.r.f. 2,500/sec; relative output is referred to output with ±35kc/s deviation at 2kc/s and impulse input amplitude is referred to 1μV peak per kc/s bandwidth.

TABLE 3

Frequency of interfering signal relative to wanted signal (kc/s)		−400	−200	<+1 >−1	+200	+400
Amplitude of interfering signal relative to wanted signal (dB) to give the subjective grades of interference	JP	+36.5	+4	−30.5	+ 6	+36.5
	P	+39	+5	−27	+ 7	+38.5
	SD	+40	+7	−22.5	+ 9	+40
	D	>+40	+9	−16.5	+11.5	>+40

the output due to impulsive interference, relative to that due to ±35 kc/s deviation at 2,000 c/s, for various input impulse amplitudes. The measurements were made in the presence of an input carrier of 500 μV, firstly unmodulated and secondly frequency modulated with ±30 kc/s deviation at 12 kc/s.

Subjective Measurements of Selectivity and Co-Channel Suppression Ratio.—For these tests the receiver was fed with two signals, a wanted signal of 1 mV and an interfering signal of controllable amplitude which was set in turn to frequencies within 1 kc/s of, and spaced by ±200 kc/s and ±400 kc/s from, the wanted signal. Both signals were frequency modulated with programme in accordance with standard B.B.C. transmitter practice, the wanted programme being speech and the interfering programme light-orchestral music which gave a consistently high level of modulation. The amplitude of the interfering signal was adjusted to give the following subjective grades of interference:—

JP The interference was just perceptible in the quiet passages of the wanted programme.

P The interference was perceptible in quiet passages of the wanted programme without careful listening.

SD The interference was slightly disturbing when listening to the wanted programme.

D The interference was disturbing.

The results given in Table 3 are the averages for four observers, the receiver having been tuned to give minimum output interference with the wanted and unwanted carriers within 1 kc/s, both unmodulated.

The tests were repeated with the receiver mistuned both above and below the correct tuning point by an amount just less than that required to give audible distortion with speech programme. Table 4 shows the level of interfering signal required to give "perceptible" interference in these two conditions.

TABLE 4

Frequency of interfering signal relative to wanted signal (kc/s)		−400	−200	<+1 >−1	+200	+400
Amplitude of interfering signal relative to wanted signal (dB) to give "P" interference with receiver mistuned as shown	Mistuned high	>+40	+14	−25	−5	+28
	Mistuned low	+28	−11	−25	+18	>+40

Conclusions from Test Results.—The sensitivity of the receiver is regarded as adequate for domestic use. Signals below the level required for satisfactory operation are unlikely to be encountered within the service area of a transmitter unless the aerial is very inefficient or badly sited. In such cases improved reception is far more likely to be obtained with an improved aerial system than with increased receiver gain.

The selectivity more than meets the requirements of the planning standards for v.h.f. broadcasting in the United Kingdom, i.e. a protection ratio of 0 dB for adjacent-channel signals.

The a.m. suppression ratio is maintained at or above the specified target figure of 35 dB down to an input level of 30 μV. The a.g.c. is also operative over a similar range of input levels. While the constancy of output is not as good as that obtained with a static limiter, an input/output characteristic of the type shown in Fig. 13 does enable the user select the local transmission by tuning to the loudest programme. With a static limiter the output level is independent of signal strength and it is possible, particularly in periods of abnormal tropospheric propagation, to tune inadvertently to a distant transmitter on an adjacent channel with consequent fading and poor quality.

The performance in respect of local-oscillator frequency stability and radiation is somewhat below that which obtains in some current commercial receivers. Further development time spent on the r.f. portion of the circuit could have resulted in an improvement, but this was regarded as a side issue, since the design is primarily concerned with illustrating the potentialities of the limiter and discriminator circuit.

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New Mullard Filmstrips

A NEW series of filmstrips designed to assist the teaching of radio engineering in technical colleges, Services training establishments, industrial apprenticeship courses, etc., is announced by the Mullard Educational Service.

The first of the series, "Thermionic Oscillators" (comprising 27 colour frames, arranged in two parts), is now available from the distributors, Unicorn Head Visual Aids, Ltd., 42, Westminster Palace Gardens, London, S.W.1, price 25s, including comprehensive teaching notes. The second deals with non-sinusoidal oscillators and others will cover modulation and transmission.

Automatic Pattern Recognition

NEW MORPHOLOGICAL SYSTEM USING A DIGITAL COMPUTER

By R. L. GRIMSDALE,* M.Sc., Ph.D., Grad.I.E.E.

THE human eye and brain are so efficient at recognizing printing and handwriting that it is not generally realized that recognition is a particularly difficult operation. Various patents have been filed in the past for machines which can read and for devices for aiding blind persons. The majority of these schemes were not exploited, and it is only in recent years, with the advent of digital computers, that the interest in this problem has been revived.

A number of machines have recently been produced commercially in this country and in America. The principal applications are the reading of information printed on cheques and other documents used in commerce. In addition to these applications there are many other important potential fields for more sophisticated reading machines. Intensive programmes of work are now directed towards obtaining systems for the mechanical translation of languages, but it would appear that it is essential, for economical working, to provide an input mechanism which can take the information direct from the printed page.

Another interesting possible future application is the sorting of mail. This might necessitate the printing of the names of the towns with reasonable clarity. However, this problem is not quite so difficult as it might appear, because use may be made of the fact that the town names include a considerable amount of redundant information; there would, for example, be no difficulty in recognizing MA*C**STER or *IV*RPOOL, and the machine could be arranged to reject all envelopes which it failed to identify with certainty.

A further application is that of feeding instructions and information to a digital computer, which at present is done via the medium of punched paper tapes or cards.

Before describing the operation of the present system, some features of other systems will be considered. One of the earliest, the Optophone†, a device to assist blind people to read printed matter, consists of a set of five photocells, each controlling a separate audio frequency tone. As the device is moved across a line of illuminated print, the letters are effectively scanned by five horizontal lines and the tones vary as the parts of the letters are crossed. It is not believed that the device is widely employed because of the difficulties in using it. However, the Optophone cannot be regarded as a true recognition device, because all it does is to convert information from one form to another, with considerable loss of detail. The user must perform the recognition task from the sounds which he hears.

Comparison of Symbols

A large number of the recognition machines which have been devised or constructed are based on the principle of comparison of the unknown symbol with a set of standard symbols. In one particular version, the standard symbols take the forms of cut-outs round the periphery of a rotating disc. The remainder of the apparatus consists of a lamp, a lens system, and a photocell. As the disc rotates, images of the standard symbols fall on the unknown symbol. If the symbol is printed in black ink on white paper, varying amounts of light are reflected as the disc rotates. Recognition of the symbol is possible if the amount of light reflected from the image of one particular standard symbol is much less than from any other. The determination of the number of distinct symbols which can be identified is a problem of information theory, and a great deal of work has been done on designing specially formed symbols for maximum discrimination.

The modern counterpart of the rotating disc uses special symbols printed in magnetic ink on cheques. The symbols are recognized by passing them first through a field which magnetizes them, and then under a reading head. The waveform of the induced e.m.f. is strobed and examined and from this information the symbols are identified. This system, which has been adopted for reading cheques in the U.S.A., and is being developed in this country, is limited to the recognition of about a dozen specially formed symbols. In another system produced by Solartron‡, the symbol is effectively divided into a number of areas and signals are produced depending on whether each of the small areas is black or white. The

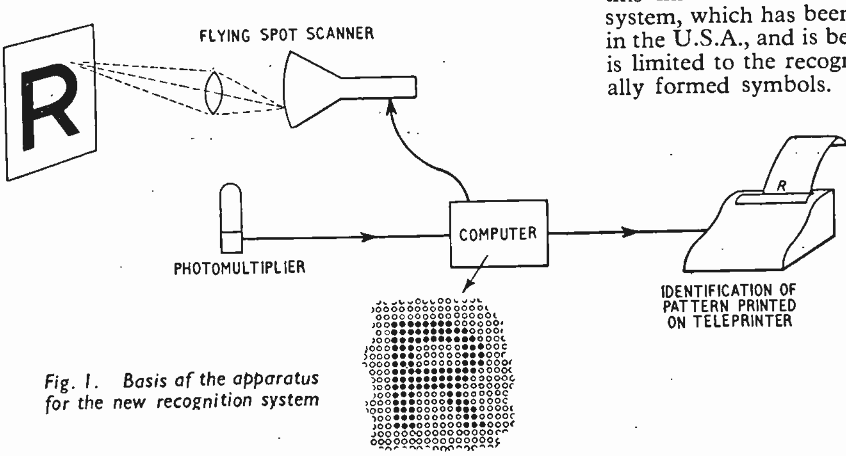


Fig. 1. Basis of the apparatus for the new recognition system

*University of Manchester. A more detailed account of the system is given in "A System for the Automatic Recognition of Patterns," by R. L. Grimsdale, F. H. Sumner, C. J. Tunis and T. Kilburn. *Proc. I.E.E.*, Part B, **106**, p. 210 (March, 1959).

† Fournier D'Albe. *Proc. Royal Soc.*, **90** (1914).

‡ "Reading by Electronics," *Wireless World*, April, 1957.

symbols are then identified by a set of logical circuits.

In all these systems the symbols are effectively identified by a geometrical comparison. There are definite restrictions on the shape, size, and form of the symbols, and they must be correctly oriented in relation to the identification equipment. The new system which has been developed has, as its basis, the recognition of patterns by their shape or form. The system is very versatile because a P, for example, is recognized as a semi-circle and a straight line joined in a particular manner. This description is independent of the way in which the P is drawn and its size. The system is in no way limited to letters or numbers, but can be used for all simple patterns composed of straight lines and curves, and can be extended to include a wide range of patterns of diverse forms.

This morphological approach, or recognition by the shape of the pattern, may closely resemble at least one of the ways in which human readers recognize patterns. The resemblance is particularly apparent when a reader is presented with a strangely written or upside-down letter. In these cases a conscious study is made of the form of the symbol. Even with normal letters the human reader may carry out a detailed study of the shapes, although the process is so rapid that the reader is not conscious of the operation. However, in normal reading, a great deal of use is made of the context and whole words may be guessed before the individual letters are recognized.

Characteristic Features of Patterns

The name "pattern recognition," as opposed to "character recognition," distinguishes the new system from those already devised. Character recognition implies the identification of one out of a given set of symbols, each symbol having a definite form and size, as produced, for example, by one particular typewriter. Pattern recognition, on the other hand, is not restricted to a particular set of symbols. The patterns are recognized because they have certain characteristic features. The pattern of a letter R, for example, can be recognized even when written in different ways by several people. Furthermore, no special restrictions are imposed on the size of the pattern. Another useful feature is that the pattern need not be correctly orientated when presented to the recognition machine, provided it lies within its "field of view."

In order to demonstrate the working of the pattern recognition system, it has been simulated using a universal digital computer. This technique is one which is of great value as it enables the operation of complex systems to be demonstrated and studied at low cost, prior to the construction of special-purpose equipment.

Scanning System

The operation of the system is divided into a number of stages. First of all the pattern is transferred from the paper on which it is drawn to the store of the computer, a flying-spot scanner being used. The scan effectively divides the picture area into a matrix of points. According to the amount of light reflected, each point is classed as "black" or "white" and can then be represented by a binary digit having the value "0" or "1" (Fig. 1). The pattern is stored within the computer as an array of points ("1" digits) on a background of "0" digits.

Although the pattern is stored, the machine cannot yet "see" its shape. The precise way in which the machine examines the pattern is dictated by the type of instructions available on the computer. In general the examination proceeds from bottom to top and from right to left. The pattern is subdivided into divisions of the type shown in Fig. 2 (a). Each division is specified by the length, and the slope or curvature of its edges. The information concerning the latter is determined by forming the values of $\frac{dx}{dy}$ and $\frac{d^2x}{dy^2}$ for the points at the edge of the division. Since the edge may be very irregular, due to the imperfections of the figure, an averaging technique is employed.

Figure imperfections may give rise to other difficulties. A break in the figure may result in two divisions being formed where there should only be one. To overcome this, use is made of a noise factor which gives a measure of the amount of imperfection which may be tolerated. The value of the noise factor is set automatically by a trial scan which determines the overall size of the figure. The noise figure subsequently may be modified if an unduly large number of divisions is produced.

In the next stage of the process the various divisions of the figure are assembled into the basic curves and lines of the figure. It is clear that if the same figure is presented to the flying-spot scanner at a different angle an entirely different set of divisions will be produced (Fig. 2 (b)). The present process is designed to ensure as far as possible that the same result will be obtained for all orientations. The result of this process is recorded as a statement of the number and type of component lines and curves of the figure and the way they cross or join.

At this stage the true recognition process begins. The action so far has effectively reduced a two-dimensional pattern to one-dimensional form. The statement can be considered as a one-dimensional form of pattern because it consists of a succession of symbols which describe the original figure. The true recognition process amounts to the comparison of the new statement with those stored within the machine. The comparison is done on a very flexible basis and a score is given for each test. This method permits the amount of agreement to be determined between the unknown pattern and a range of patterns which have already been presented to the scanner.

An important feature of the system is the ability to learn new patterns. In contrast with the methods for character recognition using geometrical comparison there are no built-in representations of the pat-

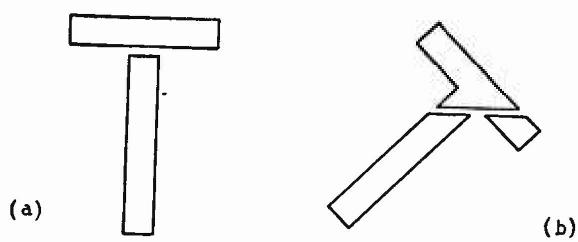


Fig. 2. Pattern divisions produced during examination; (a) with normal orientation, (b) when presented at a different angle to the scanner.

terns. Every pattern which is shown to the machine is converted to the statement form and compared with statements previously obtained and stored. If a satisfactory comparison is obtained the name of the pattern is printed out on the teleprinter attached to the computer. If, after having obtained the statement describing the shape of a new pattern, the machine is unable to find a sufficiently similar stored statement, it will indicate its inability to identify the new pattern. The machine can then be given the name of the new pattern. This act is equivalent to teaching the machine a new pattern, because at any subsequent time the machine will be able to identify this pattern even if it is drawn by a different person.

A valuable feature is the way in which the machine indicates its confusion between two or more possible identifications of a pattern. This will arise when a new statement registers high scores with two or more statements belonging to patterns already "known" to the machine.

Economical Storage

The reduction of the two-dimensional pattern to the one-dimensional statement form leads to an economical method of storing the patterns. A pattern with a resolution equivalent to a 50-line television picture and having an information content of 2,500 bits can be represented by a statement with 40 to 80 bits.

As the number of patterns which the machine "knows" become large the time to compare a new statement with all existing statements would become excessive. To reduce this time, a classification system is employed. Thus all patterns with four ends or two curved lines would be stored in separate classes. A new statement is only then compared with members of suitable classes. The definition of "suitable" is again based on a scoring system. The success or failure in finding the right answers in a short time is used to modify the scores, so that the machine "learns" to recognize faster.

The simulation of this system was programmed for the now obsolescent Manchester Ferranti Mark I

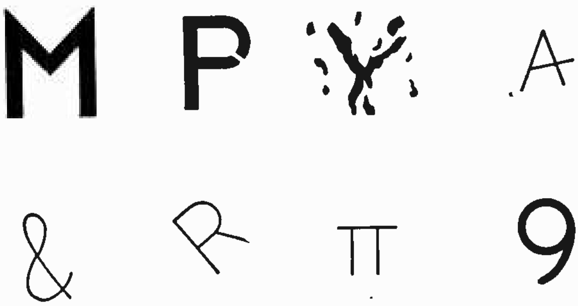


Fig. 3. Example of patterns which the system has shown itself capable of recognizing.

computer and the time to identify a pattern was about 1 minute. Using the Ferranti Mercury computer it can be done in 3 seconds. The provision of a more elaborate scanner, now under construction, with greater facilities for examining the patterns, will reduce this time to under one second, and finally a special-purpose digital computer, working in conjunction with this scanner, will give a further hundredfold increase in speed.

Whereas some of these times may appear long in relation to character recognition devices employing geometrical comparison, it must be remembered that the present system has very great versatility and can deal with any line pattern that can be resolved by the scanner. It has already demonstrated its ability to recognize such patterns as those shown in Fig. 3, some of which have been drawn by hand. It appears possible to be able to recognize good handwriting by a development of the same technique. It is well-known that bad handwriting presents considerable difficulties even to human readers, and it is only possible to recognize certain words by reference to the context in which they are written. Thus the complete recognition of even average handwriting is a formidable task to perform by machine, but might be possible with the development of linguistic study used in the machine translation of languages.

Microwave Data Tables

CALCULATIONS relating to a single specialized field of study tend continually to involve the same few basic mathematical functions of the quantities concerned. A considerable amount of routine sub-calculation can thus be saved by the use of specialized tables in which such functions have been already worked out. Such tables have up till now not been too readily available for microwave data, but this lack has now been remedied by the appearance of the book "Microwave Data Tables" by A. E. Booth, M.I.R.E., Grad.I.E.E. The author is a microwave development engineer for Sir W. G. Armstrong Whitworth Aircraft, Ltd.

Some of the tables in this book are of general as well as specialized interest. An example is the very extensive series of decibel tables which includes decibel gain or loss against power, voltage or current ratios. Also given are tables of v.s.w.r. (voltage standing wave ratio) to voltage and power reflection coefficients. We also meet some familiar tables appearing in a new guise corresponding to their more specialized use. For instance reciprocals appear as v.s.w.r. (<1) to v.s.w.r. (>1), and squares as voltage-to-power reflection coefficients. More specialized tables include frequency to guide wavelengths for the TE_{10} mode in 9 standard British sizes of rectangular guide, and a list of 28 standard British rectangular guides giving their dimensions, cut-off frequency, recommended operating range of frequencies and c.w. power rating. The contents of these latter tables illustrate the waveguide bias which has been given to this book.

In these tables measurable quantities are always chosen for the independent variables and these are tabulated to the normal limits of measurement accuracy. The corresponding dependent variables are given to one more figure than is normally required, so as to avoid imposing any accuracy limitations in practical design and development work. Notes on the use of each table are included, and the formulæ used in calculation stated.

The conditions under which this book is likely to be used have not been forgotten: the tables are clearly printed on stout paper and strongly bound so as to stand up to constant use in the design office or laboratory.

The book contains 61 pages and 26 tables. It is available from booksellers at 27s 6d or direct from our publishers, Iliffe and Sons Ltd., at 28s 8d including postage.

Voltage-Tuned Oscillator

Five-to-One Frequency Range with Grid Bias Variation Point

By G. W. SHORT

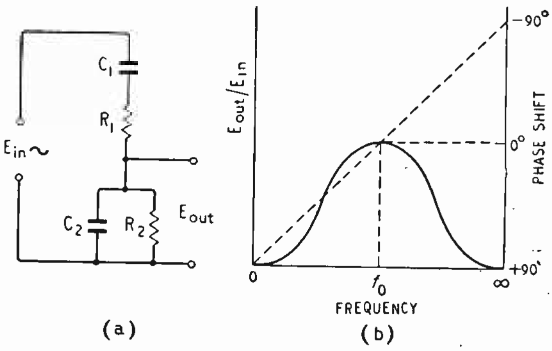
THE oscillator to be described in this article is an R-C oscillator of the "Wien bridge" variety. This makes use of the frequency-selective properties of the network shown in Fig. 1. When connected as shown, the output is a maximum, and the phase shift is zero, at one frequency f_0 given by $1/2\pi\sqrt{(R_1 R_2C_1C_2)}$. If such a network is used as a positive voltage feedback path in an amplifier of adequate gain, oscillation takes place at f_0.

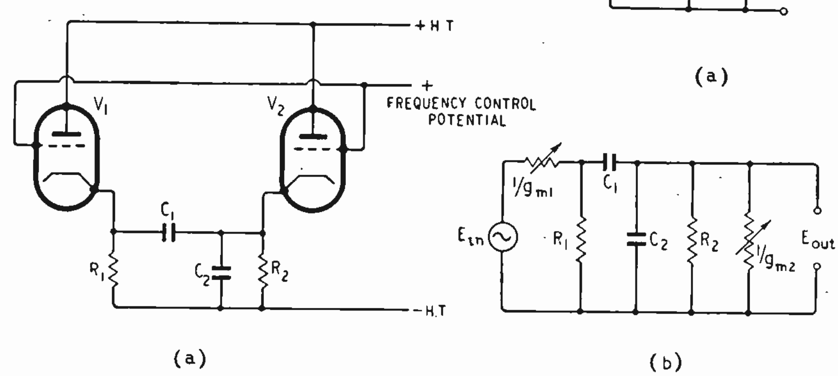
By using valve internal resistance for R_1 and R_2 (Fig. 1.) it is possible to achieve electronically-controlled variation of frequency. The most suitable internal resistance is that ooking into the cathode of a cathode-follower or an earthed-grid amplifier, since this comes in convenient sizes and varies very widely with grid-bias voltage, being approximately equal to $1/g_m$. If a valve with a slope of 5 mA/V under its published normal-working conditions is chosen, then the cathode impedance varies from 200 Ω to infinity (when the valve is cut-off). The frequency range is thus, in theory, infinite; but in practice the cathode impedances are always shunted by finite resistances, so giving a finite frequency range.

The frequency-selective circuit is obtained as shown in Fig. 2. The cathode impedances are shunted by R_1 and R_2, which are made as large as possible. The grid-to-cathode voltages, and hence the slopes of the two valves, are changed simultaneously by applying variable positive (with respect to earth) grid bias. If $C_1 = C_2 = C$, and the valves have the same slope, then $f_0 = g_m/2\pi C$, neglecting the effect of the actual cathode resistors. (A formula including the effect of these is given in the Appendix).

The easiest way to inject a signal into the circuit is to apply it to the grid of the left-hand valve. The output can then be taken from the right-hand cathode. However, it seems a pity not to use the amplifying properties of the valves as a means of obtaining the loop gain necessary to cause oscillation. This leads to the circuit of Fig. 3, which is a complete oscillator. V2 then becomes an earthed-grid amplifier to which the network output is applied, and V1 is a cathode-follower for driving the network. In a Wien-bridge network with both resistors and both capacitors equal, the network output is about a third of the input, so a gain of 3 is sufficient for oscillation. This requires a V2-anode load of less than 1 kΩ when the valve slopes are maximum, but when they are low a much greater load .s necessary. The load resistance is therefore fixed by the low-slope condition, but this results in too large a gain at the high-frequency end of the band where the slopes are high, and the circuit tends to behave as a multi-vibrator. For this reason a limiter is included. This takes the form of two point-contact germanium diodes connected back-to-back effectively across the amplifier load. The resistance of a typical diode is about 10 kΩ under zero-bias conditions; but it falls when a signal is applied, reaching perhaps 300 Ω when 1 mA flows. The form of the grid voltage of V1 now approximates to a square wave, and we rely on the frequency-selective properties of the network and amplifier to get rid of the harmonics, taking a voltage output from the cathode of V2. Other methods of amplitude control may give a lower harmonic content in the output. However, ordinary methods such as grid-leak biasing cannot be used, since changing the grid bias also changes the frequency of oscillation. (If particularly-low harmonic content is required, R_3 can be adjusted so that

Fig. 1. (a) "Wien bridge" frequency-selective network and (b) its amplitude and phase responses.





Left: Fig. 2. (a) Practical arrangement for achieving voltage-controlled variation of R_1 and R_2. (b) Equivalent circuit, showing where the input voltage can be injected. R_k should be much larger than $1/g_m$.

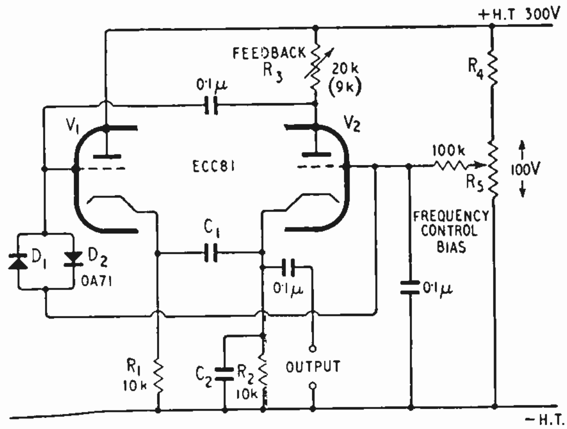


Fig. 3. Complete oscillator circuit. The diodes D_1 and D_2 form a limiter to prevent multivibrator action.

oscillation just occurs, but a different setting is required for each frequency).

An oscillator was constructed using the circuit of Fig. 3 with $C_1 = C_2 = 500$pF. The theoretical frequency (neglecting the effects of $R_{1,2}$ and the anode load of V2) now becomes g_m/πMc/s, and this and the measured frequency are shown in Fig. 4. (In this formula g_m is in mA/V and C is in pF.)

Having got so far, it was of interest to find out the highest frequency at which oscillation could be obtained. At high frequencies, the gain falls off because of the shunting effect of stray capacitances, so there is no point in using high-value resistors. The anode and cathode resistors were reduced to 4.7kΩ, and oscillation was still obtained with anode currents of about 10mA. The capacitors C_1 and C_2 were progressively reduced until oscillation ceased. This raised the maximum frequency of oscillation to about 8Mc/s; but it was felt that this could be improved upon. A frequency of about 13Mc/s was obtained using $C_1 = 50$pF. and nothing except the circuit strays for C_2. The reason why this unequal combination of capacitances gives better results appears on re-examination of Fig. 1(a). As C_1 is increased, or C_2 reduced, the ratio E_{out}/E_{in} gets bigger; because the impedance of the bottom part of the network relative to that of the top increases. Thus less loop gain is required when C_1 is greater than C_2, and *vice versa*. It should be possible, with careful component layout, to improve on the figure of 13Mc/s somewhat. If much-higher frequencies are aimed at, then a valve of higher slope, such as the E88CC (12.5mA/V) should be used.

If mechanical control of frequency is required to provide the main sweep, either or both capacitors C_1 and C_2 can be made variable. It is generally easier to make only one capacitor variable, namely C_2, since the rotor then can be earthed. The frequency ratio f_{max}/f_{min} is then reduced to $\sqrt{(C_{max}/C_{min})}$, which is typically a little over 3. A suitable value for the fixed capacitor C_1 is $\sqrt{(C_{max}/C_{min})}$ which is about 160pF when an ordinary variable capacitor ($C_{max}=500$pF) is used.

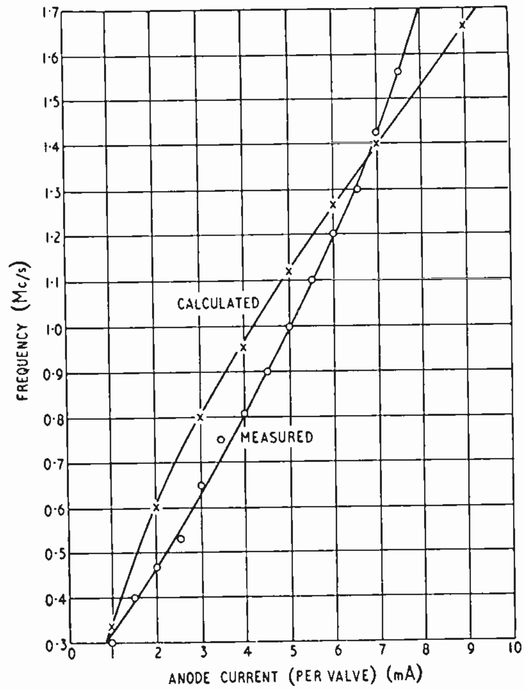


Fig. 4. Measured and calculated frequency/anode-current curves with $C_1=C_2=500$pF.

A sine-wave output is best taken from the cathode of V2, as the harmonic content at this point is the lowest in the circuit. If a square-wave output is required, a small (in comparison with the cathode resistor) resistor may be placed in series with V1 anode feed. A maximum value of 1kΩ is suggested as being reasonable.

Applications.—The oscillator described was built to satisfy the writer's curiosity; but since it works satisfactorily it may be of some interest to speculate about possible uses for it. The obvious application is as a wide-range frequency-modulated oscillator for oscilloscope frequency-response measurements, panoramic receivers and the like (where a rapidly-varying potential is fed in the 100kΩ filter resistor and 0.1uF capacitor are omitted).* Others are the remote-controlled tuning of receivers, and signal-seeking receivers. For narrow-band applica-

* To avoid unwanted feedback *via* the limiter it may be necessary to connect a small (100pF or so) capacitor from V2 grid to earth.

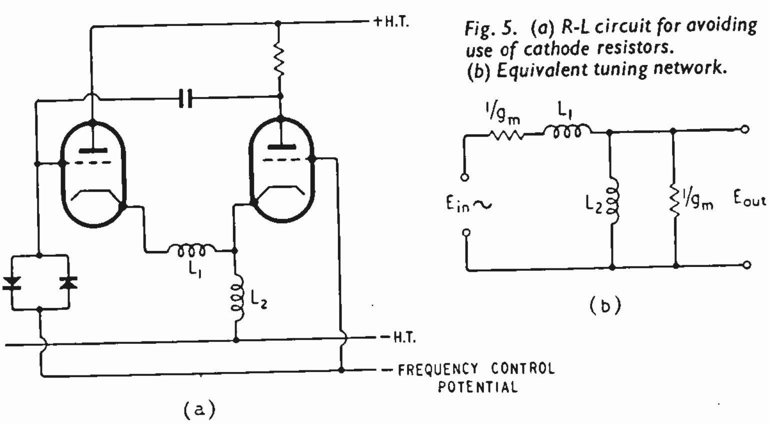


Fig. 5. (a) R-L circuit for avoiding use of cathode resistors.
(b) Equivalent tuning network.

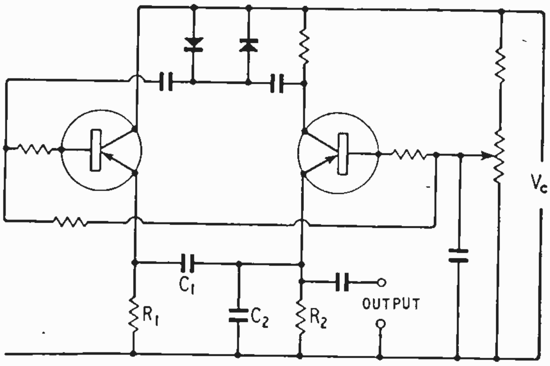


Fig. 6. Transistor-oscillator circuit (equivalent to Fig. 3).

APPENDIX

The effect of $R_{k1,2}$ in the circuit of Fig. 2(b) is neglected above, and so is the effect of the anode load of V2 on the cathode input impedance of V2. The effects on frequency can easily be allowed for. Referring to the equivalen circuit shown in Fig. 7, where r_k stands for the impedan

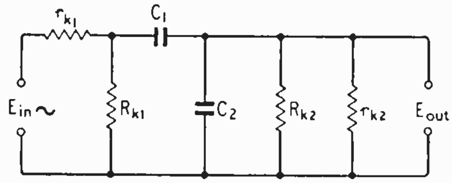


Fig. 7. Equivalent R-C oscillator network.

tions, reasonably-high frequency-stability is required. The stability of the oscillator described here is obviously very poor by normal standards, since the frequency can be pushed about by changing the circuit voltages. However, when a stabilized h.t. supply was used the stability was better than expected, bearing in mind the fact that the frequency is a function of the valve slopes. The reason is probably that the mutual conductance of a valve is a function of the cathode current, and in the present circuit, the cathode current is rigidly controlled by the heavy d.c. negative feedback due to the large-value cathode resistors. To a first approximation, the current is simply V_g/R_k, where V_g is the external bias voltage. The accurate expression is, of course $(AV_g + v_g)/R_k$, v_g being the actual grid-to-cathode bias and A the "gain" of the valves as cathode-followers. It is unlikely that v_g will vary by more than a fraction of a volt as a result of normal short-term emission and heater voltage variations, and since V_g may be as much as 100V, the variations are small in comparison to the total voltage.

The d.c. supplies must be well smoothed as well as stabilized, otherwise hum voltages will frequency-modulate the oscillator, although it may be convenient to dispense with stabilization for the main h.t. supply provided that it is reasonably well regulated; the required tuning potential (100V) may then be developed across a gas-discharge stabilizer, such as a VR105/30. Other causes of f.m. are heater-to-cathode leakage, heater-to-grid leakage, and heater emission, the first being particularly undesirable because of the high-value cathode resistors. A possible way out would be to use an L-R tuning network (Fig. 5) and negative grid bias, or to "tie" the heater supply to the slider of R_5. But a more attractive method would be to use transistors instead of valves and avoid the possibility of cathode hum altogether. The circuit of Fig. 6 is suggested as a basis for experimental determination of circuit values.

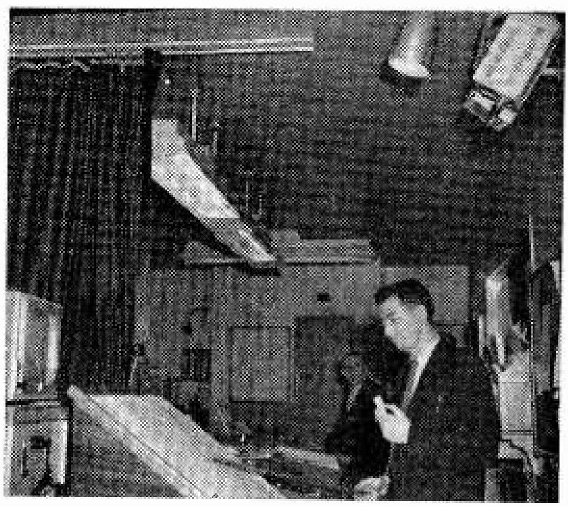
The frequency ratio of five-to-one obtained in the experimental oscillator does not represent the practical limit. At the high-frequency end of the range, the frequency can be raised as far as the valve slopes will allow. If the slope of the valves used had been 10 mA/V, the top frequency would have been over twice that obtained with 5-mA/V valves. The low-frequency limit can be extended by increasing the value of the cathode resistors when the largest convenient values for C_1 and C_2 have been reached.

looking into the cathode, the frequency is obtained by calculating the resistance of R_{k1} and r_{k1} in parallel and substituting this for R_1 in the usual formula $f_0 = 1/2\pi\sqrt{(R_1R_2C_1C_2)}$ and calculating R_{k2} and r_{k2} in parallel and substituting for R_2. The effect of the anode load, R_a, of V_2 on r_{k2} is to increase the impedance looking into the cathode so that it becomes $(R_a + r_a)/(1 + \mu)$ instead of just $r_a/(1 + \mu) \approx 1/g_m$. The effect of the actual cathode resistors is to increase f_0, and that of r_{k2} is to reduce f_0, so to some extent they offset one another.

A more serious effect of R_{k1} is that it increases the attenuation of the network. E_{in}/E_{out} becomes:—

$$1 + r_{k1}/r'_{k2} + r_{k1}/R_{k1} + C_2r_{k1}/C_1R_{k1} + C_2/C_1$$

where r'_{k2} is the parallel combination of R_{k2} and r_{k2}. This has its greatest effect at the low-frequency end of the range, where r_{k1}/R_{k1} is greatest. But in practice one can easily make R_{k1} ten times r_{k1}, and the effect is then negligible for most purposes.



CLOSED-CIRCUIT TELEVISION at Dublin Airport forms part of a system, undergoing trial by Aer Lingus, for the remote display of weather information: this saves the pilots as much as a 20-minute journey to the Met. Office. Installed by Philips Electrical (Ireland) Ltd. the television equipment comprises two camera chains; also two-way speech facilities and a Muirhead facsimile-transmitting and receiving system are provided. A 21-in television display fed by a coaxial cable in the Operations Room provides direct information (the photograph shows the transmission of a weather briefing) and the "Mufax" is used to produce a detailed information folder which is carried in the aircraft.

Transistor A.F. Oscillator

For Use as a Morse Practice Set or a Bridge Source

By H. B. DENT

REQUIRING a small and compact audio frequency oscillator for general-purpose use in place of a rather cumbersome external mains-driven affair, thoughts naturally turned to the use of a transistor. A search through the available literature revealed a surprising lack of practical details of oscillators of this kind, except for one forming part of a larger equipment,* and it appeared that the only course open was to make a few preliminary bench tests of likely circuits before deciding on the final layout.

The first circuit tried is shown in Fig. 1 where an OC70 transistor is used with an orthodox feedback circuit using a triple-wound transformer. The tertiary winding was included to isolate the oscillator from external equipment and so minimize the effect of this equipment on the frequency of oscillation.

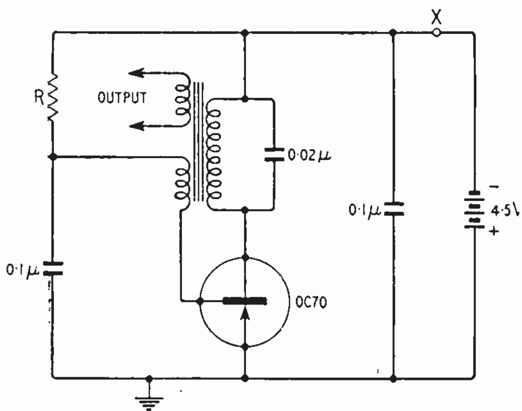


Fig. 1. Transistor oscillator circuit using triple-wound transformer.

It was required to find a suitable value for the resistor R, which determines the base-bias current of the transistor, as the few published circuits encountered had shown very wide difference in values for this resistor, even when a similar battery voltage was employed.

The battery lead was broken at the point *x* and a 0-1mA meter inserted. Fig. 2 shows the current taken by the transistor (oscillating) with different values of resistance at R. A pair of headphones connected across the output winding served for monitoring the audio signal. Unfortunately no means were available at the time of actually measuring the a.f. output as correlating its magnitude with the d.c. input to the transistor would have provided useful data.

In view of the high value of resistance used for R in all cases it can be assumed that the bulk of the current measured by the meter is the collector current (I_c). The information gained from the curve is interesting as with R of 100kΩ or less quite small minus tolerances in resistance can produce very large increases in collector current, so that with this type of oscillator the series resistor in the base circuit ought not to be less than 150kΩ with a nominal collector voltage of 4.5V. Preferably it should be nearer 220kΩ, under which conditions the collector current is about 150μA. This oscillator would be quite satisfactory for many purposes, especially where only a relatively small a.f. output is required.

These crude measurements served their purpose, however, by emphasizing the desirability of a more sure stabilization of the d.c. bias for the base and this led to a trial of the circuit shown in Fig. 3.

The component values were arrived at largely by

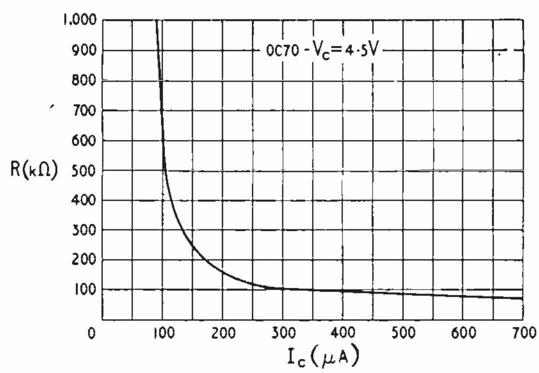


Fig. 2. Collector current with different values of resistor R.

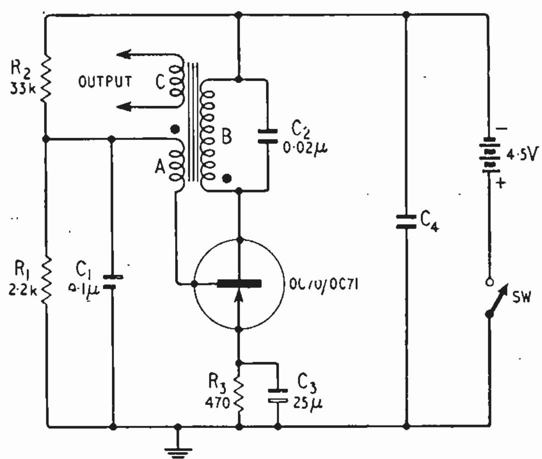


Fig. 3. Oscillator circuit with base current stabilized.

* "Transistor Transmitter," by L. F. Shaw, *Wireless World*, May 1958, p. 242.

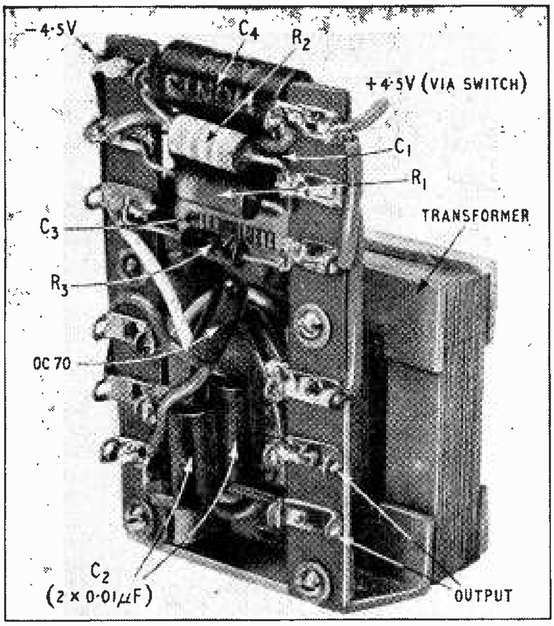


Fig. 4. A convenient form of construction for the transistor oscillator. Components can be identified from Fig. 3.

trial and error, although the working conditions were approximately determined from the maker's data sheets for a current load not exceeding 0.5mA with a 4.5-V battery. This presupposed a base current of less than 10μA so that the potential divider R_1 and R_2 need not consume more than about 100μA leaving about 400μA for the collector current. With the base voltage set to be just slightly more negative than the emitter the nearest preferred 20 – % tolerance resistors for R_1 and R_2 were 2.2kΩ and 33kΩ respectively. R_1 was bypassed by a 0.1-μF capacitor and R_3, which is included as a further safeguard for d.c. stability, by a 25μF capacitor.

With the particular OC70 transistor employed the total current through R_2 was 115μA and the collector current was 260μA, making a total battery drain of 375μA. The a.f. output was uncomfortably loud in high-resistance headphones and thus judged adequate for the purpose of energizing a CR bridge.

No value has been marked for C_4 as this depends on the particular use to which the oscillator is put. For energizing a CR bridge, which is but one of several applications subsequently found for similar units, any capacitance from 0.1μF to 10μF or more can be used. When, however, the oscillator is used as a Morse practice set, and the key inserted in place of the on/off switch (Fig. 3), C_4 should not be larger than 0.1μF. If it is oscillation does not stop immediately the key is released after a dot or dash but is maintained by the charge on C_4. If C_4 is only slightly too large it puts a "tail" on dots and dashes which upsets the relative spacing of the Morse characters and if speed is attempted dots and dashes merge and the signals become unintelligible.

The small transformer was made specially for this oscillator and consists of a 0.4-in stack of No. 74N "E" and "I" "no-waste" stampings (Magnetic and Electrical Alloys) but any similar sized core will do ($1\frac{23}{32} \times 2\frac{1}{16} \times 0.4$in). Thin sheet Paxolin was used for the end cheeks of the bobbin glued (Durofix) to a core tunnel made from thin cardboard covered with several turns of gummed paper. It was made on a wooden mandrel a shade larger, as regards width, than the tongue of the "E" stamping.

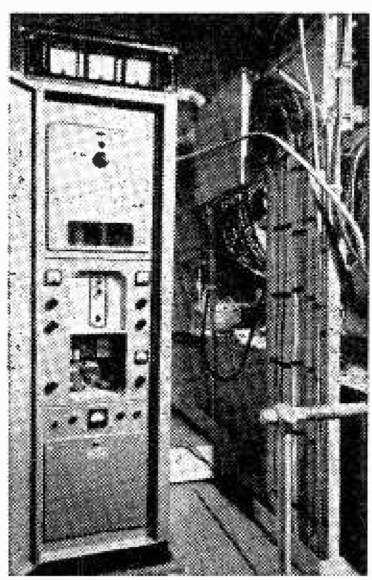
The base winding A was put on first and consists of 50 turns of No. 38 s.w.g. enamelled copper wire. Winding B, with 1,000 turns of the same wire, followed and finally winding C with 200 turns. The black dots adjacent to one end of A and B windings (Fig. 3) indicate the beginning (or inner) of each, all windings being in the same direction. No marking is required for winding C as its phasing with the other windings is not important, but correct phasing is essential for A and B or the circuit will not oscillate.

With windings and components as specified the frequency of oscillation is about 1,000c/s, but any frequency within reasonable bounds can be generated by using a suitable value of capacitance for C_2.

The oscillator in its final form is shown in Fig. 4, which should be self-explanatory. The annotation enables the various components to be identified by reference to Fig. 3. With perhaps the exception of C_4 the capacitors are physically much larger than they need be as 150-volt working type was used whereas 6- or 12-volt types would be adequate. All resistors can be $\frac{1}{4}$W or smaller.

MOON REFLECTION TESTS

THE transmitter used at Jodrell Bank for the successful communication tests during last May with the Air Force Research Centre at Massachusetts *via* reflections from the moon was designed and built by Pye Telecommunications, Ltd., Cambridge. It has an output of 1kW at 201Mc/s and is frequency-modulated with peak deviations variable from $2\frac{1}{2}$ to 15 kc/s. The 250-ft aerial has a gain of 40 dB and a beam width of $1\frac{1}{4}°$ at 200Mc/s (angle subtended by the moon is $\frac{1}{2}°$).



Part of the Pye f.m. transmitter used at Jodrell Bank.

The receiver used for monitoring at Jodrell Bank had a noise factor of 6 dB and bandwidths of $\pm$ $2\frac{1}{2}$, 5 or 10kc/s. Measured signals at the input varied between 0.2 and 1.5 V which is in good agreement with 0.7 V derived from a calculated path loss of 250 dB.

LETTERS TO THE EDITOR

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

"Audion"

IN "Free Grid's" article of September he makes a reference to de Forest's "Audion" and the derivation of the word.

de Forest first used the word for his original two-electrode valve, a device not very dissimilar to the Fleming valve.

I was present in New York at de Forest's lecture on his two-electrode Audion at the American Institute of Electrical Engineers meeting in 1906 and I remember very distinctly the criticism made after the lecture by the famous loading coil inventor Dr. Pupin. Pupin concentrated entirely on the word, objecting to it strongly as a mixture of Latin and Greek—in fact he said it was a *bastard*—as he used the word with some emphasis it caused much laughter.

London, E.C.1. H. J. ROUND.

"FREE GRID," in your September issue, wonders about the derivation of the term "Audion."

Over 40 years ago, I read an article in Mr. Hugo Gernsback's journal *Electrical Experimenter* written by Dr. Lee de Forest, in which the doctor wrote, as far as I can remember:

> "My laboratory assistant, Mr. Harvey L. Gainer, suggested the beautiful and not inappropriate name "Audion," derived from the Latin "*audio*" (I hear) and "*ion*," the latter being the carriers of the electric current in a vacuum."

Unfortunately, I cannot at the moment find my copy of the magazine, to make the quotation strictly verbatim, but believe "Free Grid" can rest assured that this was the origin of the name.

Electronic communications had not then advanced to the point where it was necessary to make distinctions, such as audio, i.f., r.f., v.h.f., etc., to indicate different ranges of frequencies.

Windsor, Ont., Canada. H. S. GOWAN.
Canadian Pacific Communications.

Long-distance V.H.F. Reception

IN the September issue your correspondent J. E. Le B. Terry invited opinions on the subject of long-distance v.h.f. reception.

Here in Aylesbury, which is situated about 65 km North West of London, Italian f.m. broadcasts are generally received between the months of May and September. This year they were heard on June 14th, 20th, 25th and 26th and again on July 22nd. Reception was particularly good on June 14th with Italian stations heard here from 0930 until 1358 G.M.T. At least 26 were being received at 1240 G.M.T. between 88 and 98 Mc/s.

Italian stations on Band II have been received as early as 0715 and as late as 2220 G.M.T. The best periods of reception being the mid-morning or afternoon.

I entirely agree with Mr. Terry that the behaviour of these signals is totally different to that associated with tropospheric propagation.

My own observations have shown that after remaining steady for a short period, signals will go into a sudden deep fade, returning almost immediately to their original strength.

In view of the distance involved, I find it hard to believe that the right type of weather conditions could maintain tropospheric reception over such an area. Long-distance tropospheric reception rarely exceeds 900 km; 500 to 600 km being more usually observed by the writer. It would seem therefore that the reception of signals at considerably greater distances than the above can only be via the ionosphere.

It is interesting to note that long-distance reception in Band II occurs at the time of the year when sporadic-E is known to propagate television signals over similar distances in Band I. The theory that sporadic-E cannot reflect signals higher in frequency than about 60 Mc/s may therefore prove incorrect, especially in view of the fact that amateur radio operators in this country have made contact this year with Italian amateurs on the two-metre band (144-146 Mc/s).

I trust that these notes may interest your correspondent and other readers and in concluding I would like to thank the various European broadcasting organizations who have verified my reception reports of their f.m. stations.

Aylesbury, Bucks. A. H. UDEN.

Finnagle's Law?

WITH reference to the availability of Test Card "C" ("Diallist," Sept. issue), it may not be generally known that this problem may be resolved mathematically as follows:

If the number of receivers to be set up is N, then—

$$N^2 + cf = \frac{tc}{d + tf} + a$$

where: d is the average distance in miles between sets.
t is the total time available in hours.
tf is the Traffic Frustration Factor.
c is the Coefficient of Asynchronization (this is an expression relating to the frequency with which the B.B.C. will transmit the Test Card whilst the I.T.A. is not so transmitting (or *vice versa*),
cf is the card recurrence frequency.
a is the accuracy in % loss or gain, of the service engineer's watch.

N.B.—Serious students of this and similar aspects of servicing, are referred to the standard work on the subject, "Alsoarbeitsitzundweytz—Eine Teleteufelhandlungsphilosophie" (Ewigkeit u. Ewigkeit, Hamburg, Rm 65). This should be read in the original—some of the subtler nuances being virtually untranslatable.

Canterbury. K. DICE.

I WOULD like to add, if I may, to Mr. J. Darr's delightful article on Finnagle's Law. The I.P. of I.O. (Innate Perversity of Inanimate Objects) is immortalized in a little verse which I heard a long time ago. The authorship escapes me, but the lines run thus:

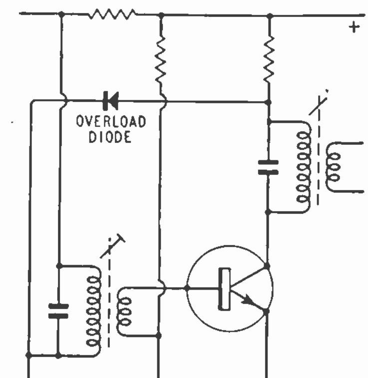
I never had a piece of toast
Particularly long and wide,
But fell upon the sanded floor,
And *always* on the buttered side.

By the way, in our laboratory, the Fiddle Factor is never referred to as such; we always give it the more exalted title of "Cook's Constant."

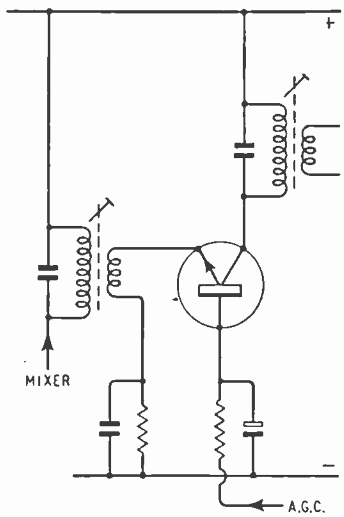
Chelmsford. W. R. MASEFIELD.

Technical Notebook

Transistor A.G.C. Circuits present some problems which are not met in designing valve receivers—the major difficulty being that the transistor cannot effectively reduce the signal below a certain limit. In *I.R.E. Transactions on Broadcast and Television Receivers* for January, 1959, F. J. Banovic and R. L. Miller discuss two methods of applying a.g.c. to transistor i.f. amplifiers and they describe a new method invented by J. A. Worcester. The simplest and most common arrangement is to feed back the d.c. developed at the detector to the base of the first i.f. amplifier, which is connected in the earthed-emitter mode. An improvement to this circuit is the addition of an "overload diode," as shown immediately below. This gives some measure of delay, as the voltage drop across the i.f. amplifier collector



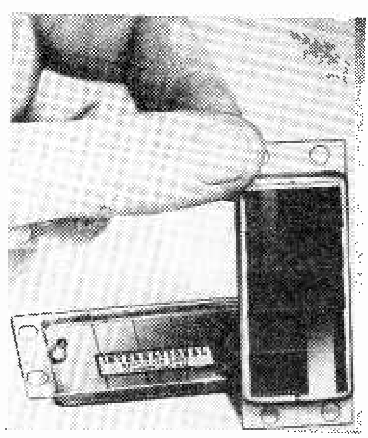
resistor holds the diode cut-off until a certain signal level is reached. When the voltage drop is reduced by the action of the simple a.g.c. on the i.f. amplifier the diode conducts, shunting the mixer o.p.; but this point depends on the d.c. amplification of the transistor, so an individual adjustment of the collector resistor has to be made for the best performance. The new method does away with the need for an overload diode and individual adjustment by reconnecting the i.f. amplifier as an earthed-base stage to i.f. and earthed-emitter to



d.c., with the a.g.c. applied to the base. This causes the i.f. input impedance (input to the emitter) to vary widely with the a.g.c. action: thus, on a strong signal, the input impedance of the i.f. transistor is increased as its gain is reduced. The increase in input impedance disturbs seriously the matching of the i.f. amplifier to the previous stage (usually the mixer) to which it is matched for maximum signal-power transfer at maximum sensitivity, so reducing the signal transfer and giving the effect of a.g.c. applied to two stages. Alloy-junction transistors are more suitable for this circuit than rate-grown types, as alloy-junction transistors exhibit a greater change of input impedance for a given change in emitter current.

Realistic Interference Generator has been developed by Mullard Research Laboratories as an instrument for testing the performance of television sets in unfavourable reception conditions. Realism of ignition interference is achieved by generating sparks with a motor-car sparking plug, while the mains-borne type of interference is provided by an electric shaver motor. Interference signals are picked up by a coil from the sparking plug and by a resistor from the motor and fed to 75-Ω coaxial output sockets via separate attenuators and matching networks. The sparking plug voltage is generated by a valve pulse generator, using a television line-output valve working into a step-up transformer. This generator (a multivibrator) can either be repetitively gated to give bursts of pulses, or varied in p.r.f. by a sawtooth sweep waveform from a Miller transitron circuit. The gate circuit can be locked either to an external 50-c/s signal or to the supply mains (in either phase), and a phantastron delay circuit allows the timing of the gate pulse to be adjusted so that the burst of interference pulses can be located anywhere in the television frame period including the frame sync pulses. Duration of the interference-pulse burst can also be controlled. The p.r.f. of the interference pulses is made variable (between about 30c/s and 170c/s) to simulate the effects of gear changes in a motor-car, which, of course, are accompanied by changes of engine r.p.m. and ignition-spark frequency.

Silicon Solar "Batteries" of high efficiency are now available to provide the same power output, watt for watt, as dry-cell and mercury-cell batteries. Supplied by the International Rectifier Co. (Great Britain), the units are intended for powering transistorized equipment during daylight operation and for charging storage batteries for continuous day and night operation. Each silicon solar battery contains five series-connected 1cm × 2cm solar cells, encapsulated in an epoxy resin to provide a strong, weatherproof housing. The output voltage is 1.75 volts at a temperature of 30°C and 1.5 volts at 65°C (typical operating temperature in direct sunlight). Direct replacement may be achieved by substituting one solar-cell unit for each 1.5-volt dry-cell battery, and adding as many in parallel as may be required to supply the necessary load current. Each unit will supply a load current of



approximately 35mA in direct sunlight. In applications calling for the charging of storage batteries, the solar-cell units can be used in conjunction with sealed nickel-cadmium accumulators.

Simplified Transformer Testing

Defects Revealed by Connecting Output Windings in Anti-phase with Standard Component.

*By J. SKINNER**

THE testing method described in this article was developed to meet the requirement of rapid, accurate testing of large quantities of small power and audio transformers.

In Fig. 1 the arrows represent the relative instantaneous direction of the terminal voltages of each transformer winding. It is obvious that the series connection of the two secondary windings will produce either the sum or difference of the two voltages, depending on the phase of connection. Thus if the number of turns on each secondary are supposedly identical, then zero voltage will appear at the terminals if the windings are connected anti-phase. If a voltage does appear, then the cause is due either to the windings not being identical, or to a non-sinusoidal waveform.

Waveform distortion readings may be eliminated by the use of a non-saturating flux density. Values found to be suitable are (*i*) 8-9 kilogauss (kg) for silicon iron, (*ii*) 13-14kg grain oriented material, (*iii*) 15-16kg for C-Cores. Any measurable reading should now be due entirely to turns differences, the magnitude of error being generally in proportion to the voltage developed.

Fig. 2 shows an alternative and more versatile arrangement. Transformer A is a perfect specimen and is retained as a standard, while B represents the unit to be tested, both units, of course, are expected to be identical. We are, of course, not limited to a single secondary winding. In fact, any number of windings and taps may be tested.

Returning once again to the zero voltage obtained from balanced windings, there is a possibility that one winding is open circuited, or that there is no supply voltage. In fact, the test is a negative one. In addition, a faulty winding will certainly produce a voltage, but the same voltage will be produced by either a negative, or a positive, turns error. Fortunately, all doubts can be easily dispelled by a simple modification. It is apparent that an "out of balance" voltage will be the result of a turns error in either the secondary winding, or in the primary winding. Furthermore, if we deliberately introduce a temporary error in the primary side of our standard unit, then "out of balance" voltages should appear at all test points. The voltage actually appearing at each point is predictable, and errors in turns ratio will be indicated by either an increased or by a decreased reading, thus indicating polarity of error.

It should be observed here that the indication of an error depends upon the turns ratio of the unit, and is therefore quite independent of variations in supply voltage. The magnitude of voltage readings

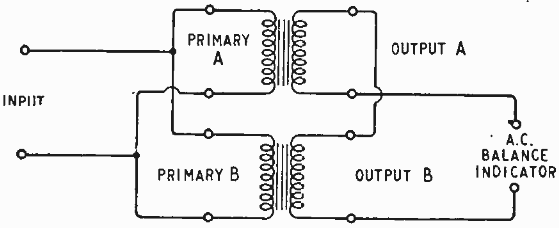


Fig. 2 Basis of testing procedure described in the text. Transformer A is a standard, transformer B the one under test.

are, however, subject to variations in proportion to the mains fluctuation.

The final form of our test set is as shown in Fig. 3. The deliberate error in standard unit A is effected by means of the tapped auto-transformer C. A switch is used to select either the under-voltage, which can be described as "Test Volts," or the ratio balance test voltage, which is described as "Test turns."

Finally a word of warning. If the unit "B" is accidentally connected "in phase" with the appropriate winding of "standard A," then the voltage applied to the indicator will be double that of each

* Radford Electronics, Ltd.

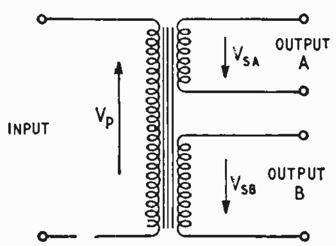


Fig. 1 Relative instantaneous voltages in a transformer is shown by arrows.

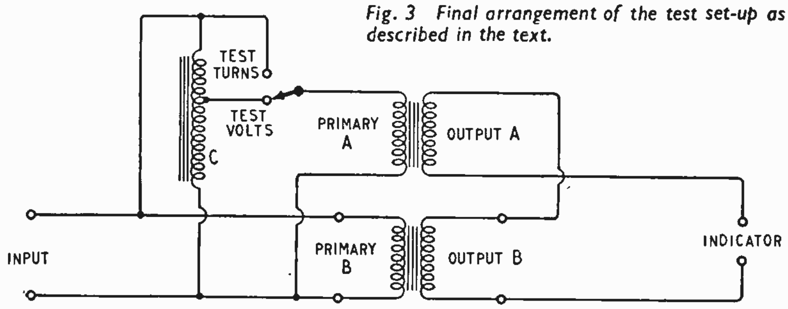


Fig. 3 Final arrangement of the test set-up as described in the text.

secondary. If the indicator is a moving-coil meter, adjusted to give a measurable reading of even 10% VA error, then a 200% VA overload will cause considerable damage. Alternative instruments, such as a valve-voltmeter, could, of course, be utilized, or a limiting device may be used.

Accuracies of the order of ±0.5% have been achieved by this method of testing, as many as seven test indications being made in one operation. Several sets have actually been constructed by the author, and are still in use. They have been proved to be sensitive, accurate and extremely simple to use, even by unskilled operatives.

Acknowledgment.—The author expresses his appreciation of the facilities afforded for the development of this method by A. H. Radford, of Radford Electronics, Ltd., and for his assistance in producing this article.

Elements of Electronic Circuits

7.—AMPLIFYING DIFFERENCE VOLTAGES

By J. M. PETERS, B.Sc. (Eng.), A.M.I.E.E., A.M.Brit.I.R.E.

THE cathode-coupled paraphase amplifier is sometimes known as a "cathode inversion circuit" or, more commonly, as a "long-tailed pair." Although it can perform a variety of rôles its main function is to accept and amplify the *difference* between the voltages appearing at the two grids, and to present them at the anodes as a balanced push-pull voltage.

The basic circuit is shown in Fig. 1. Two similar valves, with equal loads, R_L, and similar mutual conductances, have a common cathode resistor R_k. For the correct functioning of the circuit it is necessary for the cathode current (i.e., the total valve currents) to be as nearly constant as possible and independent of any changes caused by varying inputs to the grids. To achieve this, one end of R_k is taken to a large negative voltage and the value of R_k is adjusted to give the required current sufficient for Class A bias in the absence of signal. A constant-current valve (pentode) can be used instead and is preferable. The constant current in R_k divides equally between V_1 and V_2; therefore if the anode current in V_1 is caused to rise, the current in V_2 must fall by a corresponding amount.

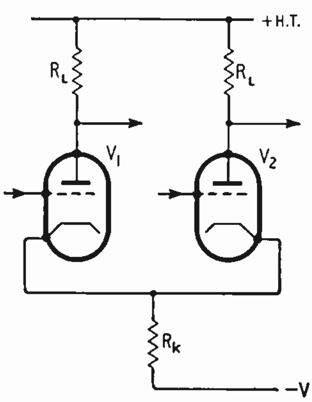


Fig. 1

A symmetrical voltage applied to both grids will produce no effect in the anode circuits. Now suppose an asymmetrical voltage is applied to the grids, $+v$ to V_1 and $-v$ to V_2:

I_{a_1} will increase to $I_{a_1} + g_m v$
I_{a_2} will decrease to $I_{a_2} - g_m v$

(Note that the total current remains constant.) The result of this is that the difference voltage is amplified and appears as a balanced push-pull signal at the anodes. The voltage between the anodes is expressed by the relationship $g_m R_L$ multiplied by the difference voltage at the grids.

Now suppose the voltage on V_2 grid is fixed while the voltage on V_1 grid is permitted to increase. Ultimately all the available current will flow in V_1, and V_2 will become cut-off. The cathode voltage will continue to increase and follow the voltage on the grid of V_1, in other words the cathode voltage will always tend to follow the more positive grid.

An important application of the cathode-coupled paraphase amplifier is to computer circuits, as a means of obtaining sum and difference voltages. Suppose we apply positive-going pulses to the grids of V_1 and V_2. The difference in voltage appearing at the anodes is proportional to the difference between the input voltages. The voltage appearing at the cathode is proportional to the sum of the input voltages. Two trains of voltage pulses occurring at different intervals and applied to the two grids of the amplifier will therefore result in the production at the cathode, and between the anodes, of waveforms proportional to the sum and difference of the input trains.

Before passing on, next month, to somewhat different subjects, it is perhaps appropriate at this point to mention another useful type of two-valve circuit—the cascade amplifier. On account of the very high amplification which can be obtained with the minimum of positive Miller feedback from output to input, the cascade method of connecting two triodes, as shown in Fig. 2, is quite often adopted as an alter-

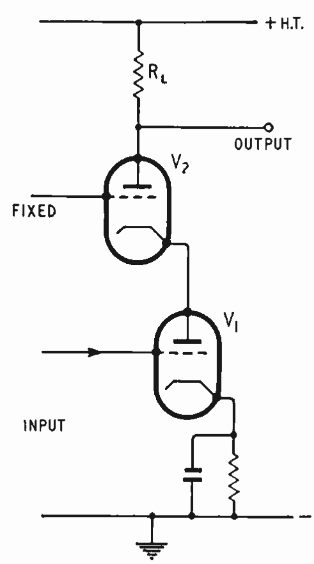


Fig. 2

native to the use of pentodes in wideband amplifiers.

By connecting two triodes having similar mutual conductances in cascade, it is possible to obtain an effective anode impedance of value approaching that of a pentode, thereby permitting the use of large anode loads. If the two triodes have individual slopes $= g_m$, amplification factors $= \mu$ and anode impedances $= R_a$, then when connected in this manner the composite circuit behaves as if it were a single valve of slope g_m, anode impedance μR_a and amplification factor $= \mu^2$.

It is theoretically possible to connect more than two valves in cascade, thereby obtaining very high amplification factors—the index by which μ is raised depending on the number of valves connected in this way.

If the circuit in Fig. 2 is examined it will be noted that the grid of V_2 is held at a fixed positive potential. The input signal is applied to the grid of V_1 and appears at the anode of V_1 in opposite phase but not amplified. The reason for this lies in the fact that the impedance presented to V_1 by V_2 is low. The anode load of V_1 is actually the cathode impedance of V_2 which approximates to $1/g_{m2}$. As this is a small load for V_1 the approximation $g_{m1}R_L$ can be assumed as representing the gain of stage V_1. Substituting $1/g_{m2}$ for R_L, we have that the gain of stage $V_1 = g_{m1} \times 1/g_{m2}$, but as V_1 and V_2 are arranged to have identical slopes, i.e., $g_{m1} = g_{m2}$, therefore the gain of stage $V_1 = g_{m1} \times 1/g_{m1} = 1$. The stage V_1 does not amplify.

The inverted input signal appears at the anode of V_1 and hence at the cathode of V_2. As the grid voltage of V_2 is held at a constant value, the V_2 cathode voltage variations appear at the anode of V_2 reversed in phase but amplified.

AMMONIA-MASER PROGRESS

SEALED-OFF OSCILLATOR UNDER DEVELOPMENT

THE development of a small, robust and lightweight frequency standard with a stability of better than 1 part in 10^9 is a thing many people dream of for use in navigation and communications. At present two devices—the ammonia maser and the caesium clock—offer the required stability, but until recently both have been regarded as research-laboratory items, rather than pieces of apparatus that could, for instance, be used in an aeroplane or at a u.h.f. communications link.

Ammonia masers have been demonstrated publicly*; but, although the size of the maser itself has been acceptable, it has been continuously pumped; the vacuum pumps and other ancillary apparatus bringing the total bulk up to that of a small wardrobe. However, work in progress at Glass Developments, Ltd., indicates that a sealed-off maser and its control and supply equipment will be possible within a volume of about 1 cu. ft., the maser itself being about 12-in long and 3-in diameter. Several improvements in internal design have made this possible—for instance, the shortening to a few inches long of the "tunnel" in which electrostatic separation of the active from the inactive molecules is carried out. The basic principle of operation of the sealed-off maser is that a charge of ammonia gas is placed in the device and frozen in a reservoir behind the collimator, which consists of an array of parallel tubes. As the gas evaporates it passes through the collimator to form a molecular beam which enters the electrostatic separator in the normal manner of the ammonia maser†. The unwanted "inactive" molecules are condensed on the liquid-nitrogen-cooled sides of the maser envelope. After about 100 hours of operation the stored ammonia is exhausted; then the maser is simply inverted in the nitrogen bath. The reservoir behind the collimator is now the coldest part of the maser and, as the gas evaporates from the sides of the vessel it passes back into the reservoir and is frozen there. This re-circulation of the ammonia can be carried out any desired number of times and takes about one hour to complete.

Due to the re-circulation process, it may be possible to use ammonia compounded with the relatively expensive nitrogen isotope N^{15} instead of the more common N^{14}. Swiss work indicates that this will increase the stability of the maser output because the frequency spectrum exhibited by N^{15} ammonia is much narrower than that of the N^{14} variety, thus reducing the frequency-pulling effect that can be exerted by the cavity.

The high-voltage supply for the separator and the cavity-temperature control equipment will use transistors, and these items, together with a frequency divider to give outputs at integral frequencies such as 30Mc/s, 10Mc/s, 1Mc/s and 100kc/s locked to the maser, make up the rest of the equipment.

* See *Wireless World*, Vol 65, p. 126 (March, 1959).
† "Masers" by "Cathode Ray," *Wireless World*, Vol. 65, p. 197 (April, 1959).

"Wireless World" Diary

TECHNICAL and general information of the kind so often needed by radio men but seldom readily available will be found in tabloid form in the 80-page reference section of the 1960 *Wireless World* Diary. Some idea of the diversity of information it includes will be gathered from this selection from the contents: aerial dimensions and aerial sharing circuits, licensing regulations, addresses of radio organizations in this country and abroad, world television standards, radar frequency bands, component coding, U.K. television and v.h.f. sound broadcasting stations and tabulated base connections for over 700 current receiving valves.

The Diary costs 6s 3d (leather) or 4s 6d (Rexine), including P.T. Overseas prices, including postage, are, respectively, 5s 8d and 4s 2d.

Reception of Space Diversity

OBSERVATIONS OVER LONG-DISTANCE PATH TO EVALUATE

THE British Broadcasting Corporation recently provided a series of transmissions to test the effectiveness of transmitter space-diversity on reception at distant points. Both very widely-spaced and relatively closely-spaced transmitters were used in the tests. The transmissions were at a frequency of 9,510kc/s, directed towards the east coast of the United States. Transmitting conditions were switched at intervals of approximately fifteen minutes during the testing period each day.

Observations of the received signals were made at the National Bureau of Standards Laboratories in Boulder, Colorado, from November 3, 1958 to November 14, 1958. The recordings obtained during these observations have been analyzed for fading characteristics and intelligibility, and the results of the analysis are given in this article.

Test Procedures, *B.B.C. Transmissions.*—The transmitters were located at Daventry and Woofferton in England. Two transmitters at Daventry were used for close-spaced diversity tests and one at Daventry and one at Woofferton for the wide-spaced diversity tests. Centre-to-centre spacing of the two antennae systems at Daventry was 1,540ft with one antenna SSW of the other. The wide-spaced diversity transmitting systems were separated by approximately 65 miles in an east-west direction and all antenna arrays were directed on a bearing of 294°. The schedule of transmissions during the test period each day was as follows:—

2345 to 0015 G.M.T.—Daventry transmitter A
0015 to 0030 G.M.T.—Daventry transmitters A and B
0030 to 0045 G.M.T.—Daventry transmitter A
0045 to 0100 G.M.T.—Daventry transmitter A and Woofferton transmitter C

The transmitter carrier frequencies were all phase locked to each other.

N.B.S. Receiving Arrangements.—A horizontal half-wave receiving antenna, elevated one-half wavelength above the ground, was used for the observations at Boulder. The audio output of a Type SP600 receiver was fed to a magnetic tape recorder; this receiver had an intermediate frequency bandwidth of 8,000c/s. A second SP600 receiver, with an intermediate bandwidth of 800c/s, was used for carrier-envelope recordings. The a.g.c. voltage of this receiver was used to operate a strip-chart recorder. Receiver linearity and recorder-circuit time constant are such that voice modulation did not noticeably affect these recordings. The receiving system for the strip-chart recorder was calibrated on the basis of available received power in a matched load at the antenna terminals.

Results of Observations.—Rapid flutter fading, at about 5 to 10c/s, occurred on six of the twelve days that observations were made. A section of the great-circle path from England to Boulder is near the zone of maximum auroral activity, and flutter fading is characteristic of high-frequency ionospheric-pro-

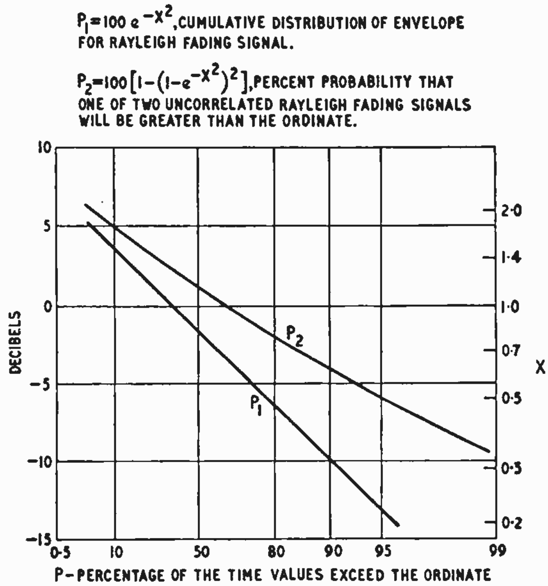


Fig. 1. Theoretical distribution of signal envelope.

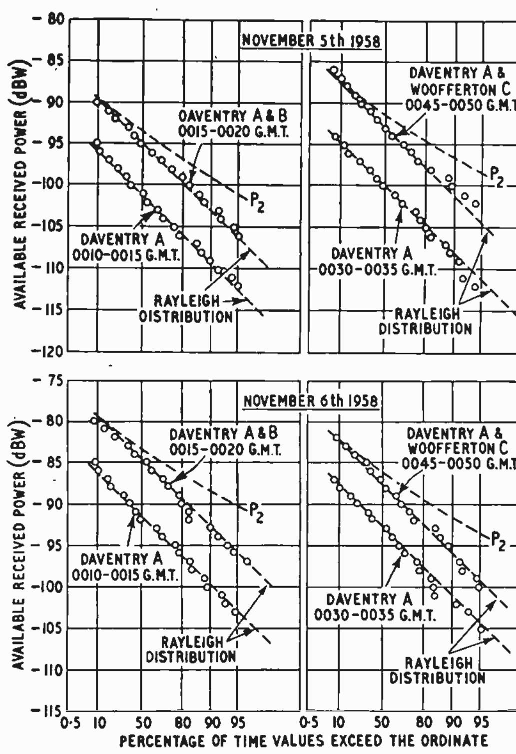


Fig. 2. Distribution of signal envelope amplitude.

Transmitters

By J. W. KOCH*

THE USEFULNESS OF THE SYSTEM

pagated signals passing through auroral disturbed regions. Critical analysis of the received signals was carried out only for days when the flutter fading did not occur.

The variations in the received envelope amplitude for a signal propagated by the ionosphere are expected to have a Rayleigh distribution in time[1]. The fading signal may then be represented by the formula:—

$$P=100\exp(-x^2)$$

where P is the percent probability that the signal voltage will exceed the value x. This expression is plotted as the curve labelled P_1 in Fig. 1. The curve labelled P_2 is a plot of the expression:—

$$P_2=100(1-[1-\exp(-x^2)]^2)$$

This is the percent probability that one of two uncorrelated Rayleigh fading signals will be greater than x. If a system is operating as a two-order diversity system, the amplitude distribution of the received signal envelope would be expected to approach that of curve P_2.

The amplitude distributions of the received signals are plotted in Figs. 2 and 3 for all conditions of the test transmissions on November 5, 6, 7 and 12. The plotted points were obtained by sampling the strip-chart recordings at one-second intervals. It is to be noted that the received signals are very nearly Rayleigh distributed during all periods. This indicates that the depth of fades did not change appreciably for any condition of transmission.

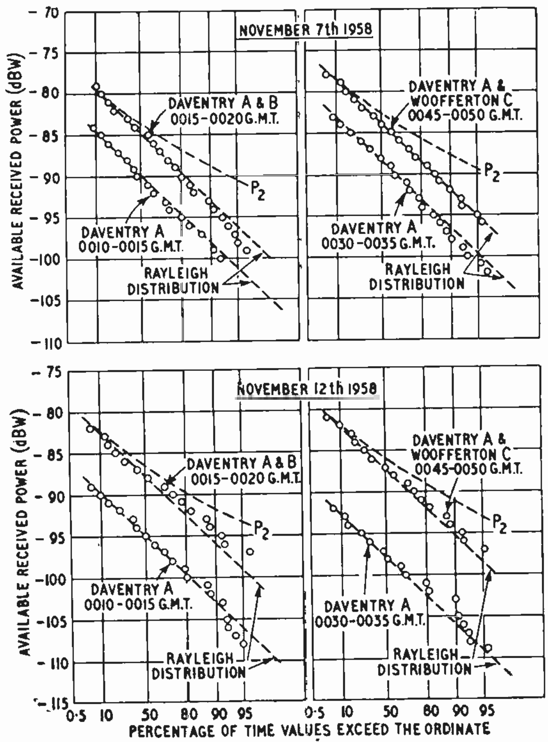


Fig. 3. Distribution of signal envelope amplitude.

Variation of Median Signal Levels.—The variation of received median signal levels from one transmission condition to the next is given in Fig. 4. It is noted that in most instances the level is 5 to 6dB higher with two transmitters than with one. It is not known at the time of writing whether or not all transmitter powers and antenna systems were the same†. If they were, there is an apparent directive gain towards Boulder with two transmitters operating; otherwise a 3dB increase in signal level would be expected.

Fading Rates.—The observed fading rates (positive median crossings) are given in the following table.

TABLE

Average Fading Rates Observed on B.B.C. Transmissions at 9,510 kc/s

Observation period-G.M.T.	Nov. 5, 1958	Nov. 6, 1958	Nov. 7, 1958	Nov. 12, 1958
	c/s	c/s	c/s	c/s
0010–0015	0.943	2.11	1.08	1.66
0015–0020	0.806	1.33	0.98	1.61
0030–0035	0.905	1.19	1.40	2.08
0045–0050	0.714	1.38	1.26	1.66

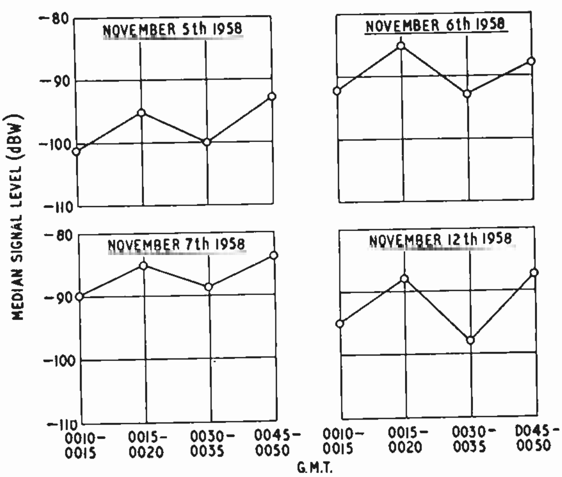


Fig. 4. Median signal level variations.

* Boulder Laboratories, National Bureau of Standards, U.S.A.
† From information obtained antenna gains were almost identical at 20dB with reference to a dipole in free space. Transmitter outputs were not the same, however, some being 50kW others 70kW. Ed.

There is no significant difference in fading rate for any transmission condition.

Recordings.—Tape recordings of the received audio signals were reproduced for several observers. After comparative listening tests most observers indicated a preference for the transmissions when two transmitters were operating simultaneously. The difference in intelligibility and quality was not great, and it is believed the small improvement noted was due to the higher average signal level rather than to any significant difference in fading characteristics.

The rapid flutter fading observed for all transmission periods on some of the days caused a sharp decline in intelligibility, and there was no real difference between any of the transmission conditions.

Conclusions.—There is apparently no advantage to transmitter space diversity for transmission over long distances *via* the ionosphere. The signals from the two transmitters combine in such a manner that the resultant field at the receiver is Rayleigh distributed; hence there is no realizable diversity gain. The fading rate was not significantly changed for any method of transmission.

REFERENCE

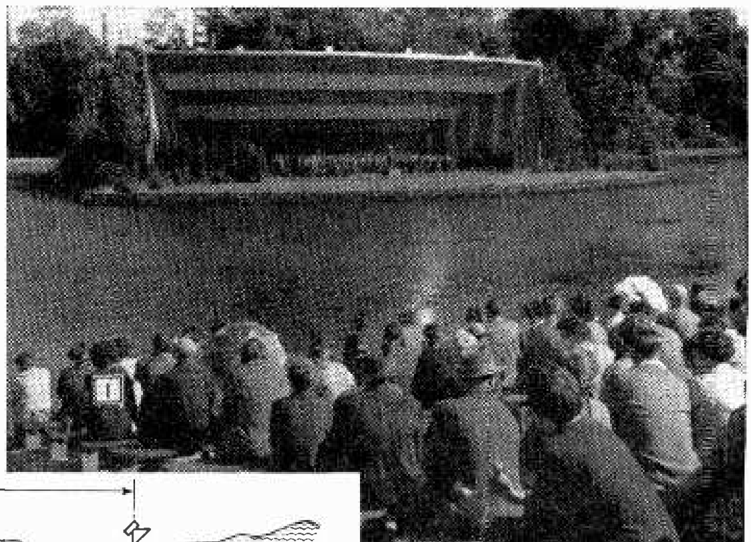
[1] "Ionospheric Radio Propagation," National Bureau of Standards Circular 462, p. 108, June, 1948.

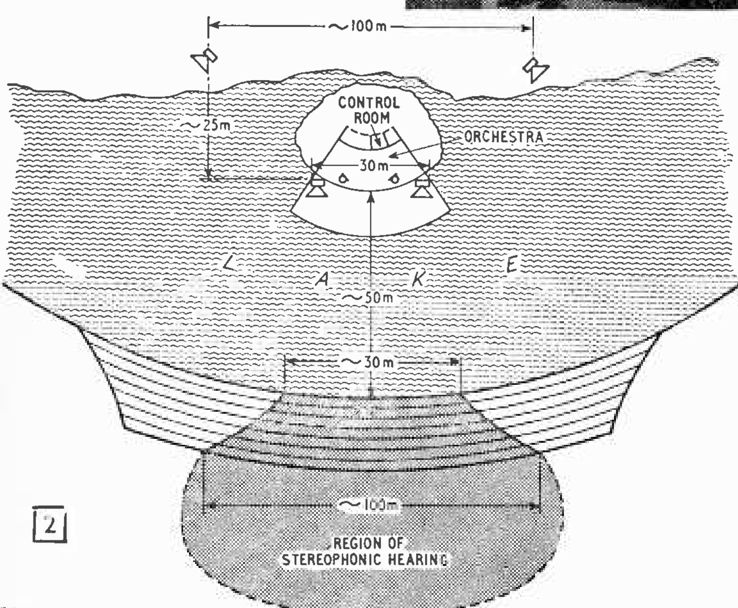
Stereophony in the Open Air

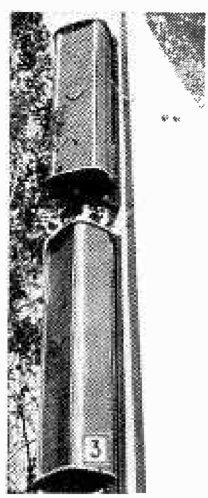
A SUCCESSFUL sound-reproducing system was installed by Telefunken at the Federal Horticultural Show held this year in Dortmund.

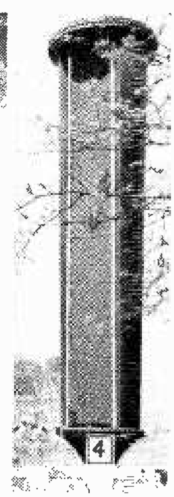
In view of the limited knowledge available of open-air stereophony, tests were first made on a building site in Hannover and the results obtained from these series of trials were used as the basis for the design of the Dortmund installation.

A power of 300 watts is provided for each stereophonic channel. Sound columns, which comprise a total of 48 units are used as loudspeakers. These sound columns are distributed over a base of 100 metres and permit stereophonic sound reproduction over an area with space for about 6,000 persons. The installation can be used either for sound reinforcement of the live orchestra on the stage or for reproduction of stereo records.









1. General view of the open air stage at Dortmund. In the right foreground a technician with microphone and transistor amplifier is giving instructions for quality control and balance. 2. Plan of the Telefunken open-air stereo installation at Dortmund. 3. Pair of column loudspeakers mounted on the sides of the stage. 4. Separately mounted column loudspeaker at one end of the 100-metre stereo base line.

MISSING SIGNPOSTS

By 'CATHODE RAY'

IT DOESN'T ALWAYS DO TO ASSUME EVERYONE KNOWS THE WAY

LAST June, while holding a joint post-mortem with my daughter on her A-level physics and maths papers, I found myself at one with her in disapproval, though not always for the same reason. If I had had to sit the exams (which, thank goodness, I hadn't) I'd have quite often wanted to ask the tight-lipped invigilator what one was supposed to assume. To me, some of the questions were by no means unambiguously put. The actual candidate, having for months past been practising on an endless succession of similar (though, she assured me, much easier) questions, was less worried by that particular aspect. It seems the assumptions were pretty well established according to some unwritten rules of exam papers.

Being rather slow on the uptake myself, perhaps I am excessively sympathetic with students about things they are supposed to know without being told. Nevertheless I feel sure quite a lot of apparent stupidity is really the fault of the teachers.

Take vector diagrams. Fig. 1 (a) and (b), showing an a.c. circuit and its vector diagram, come from a recently published elementary textbook on electrical engineering. I want you to notice particularly the arrow-heads in both diagrams. (But not the blacking-in to distinguish current from voltage, which is my own fancy.) Having looked up a number of other books, both British and American, elementary and advanced, and leaning either to power or electronic engineering, I can assure you that in this respect at least these diagrams are typical; so if the author recognizes them he will have the satisfaction of knowing he sins in bad company.

The accompanying text explains that OA represents the p.d. across R*, and so on, ending with OE as the voltage V across the whole lot. And we are supposed to know (but how often are beginners told?) that the arrow-heads in the vector diagram are there to show which ends are not the pivots, *not* which way anything is moving.

What about those on the corresponding circuit diagram? The one marked "I" is presumably meant to show the direction of current flow (in the conventional sense, as a flow of positive electrical charges) which the author of the diagram has chosen to regard as positive. So if the vector diagram were to show that at any given moment the current was negative it would mean that it was flowing against the arrow-head. This device is commendable, especially if backed up by its consistent use for the other quantities involved.

How then about the arrows each side of "V". According to the system for "I", they would mean that the voltage was acting both ways at once! Perhaps (someone suggests brightly) they are to show that the voltage is alternating. Driving a d.c.? Notwithstanding the one-way current arrow, the generator symbol with its little picture of a sine wave makes the a.c.-ness of the circuit quite clear. No; evidently the "V" arrows are used in yet another sense—to indicate the points between which V exists. Then why, if the author has taken the trouble to show us which he has chosen to be the positive direction of current flow, has he left the matter completely ambiguous as regards voltage?

Why, indeed!

Not having any of the numerous authors who do this sort of thing at hand for interrogation concerning the strangeness of their habits, I must try to guess what they might say. And as I don't find any of these guesses really adequate or convincing, we must hope that some spokesman will come forward to supply the missing key (if any) which so far seems to have been withheld.

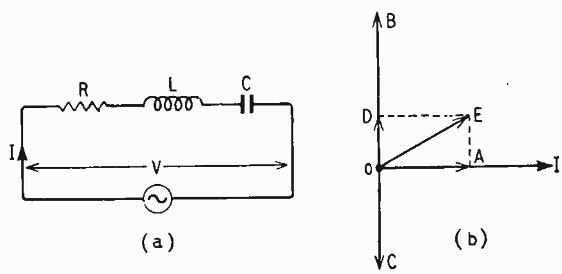


Fig. 1. A typical a.c. circuit diagram and corresponding vector diagram. What are all the arrow-heads for?

One reason (they might say) is that as soon as a choice has been made for "I," the nature of the circuit determines the direction of the voltage, as the vector diagram shows. If, before making a vector diagram or examining the circuit, a direction were assigned to "V," it would be pre-judging the result.

Well, of course, these authors might be excused for resenting my putting such a feeble excuse into their mouths, but I'm doing my poor best for them in very difficult circumstances. If they're not satisfied I'd be delighted if they would conduct their own defence.

Reverting to the role of prosecutor, I would reply that in many circuits (including the one under discussion) a current in one direction is accompanied during each cycle by voltage of both polarities.

"Splendid! splendid!" exclaim the authors, "That's just what we meant by the two-faced direction sign for V!"

But it really won't do. The sort of thing I want the vector diagram to tell me—and which, I imagine, is what most other people expect from it, too—is which terminal of the generator is positive at some phase of the cycle; say the one depicted, at which the current is just changing over from negative to positive.

The authors—or at least the one responsible for

*Incidentally, how few books warn their readers that the "vectors" used in a.c. diagrams are not vectors at all in the strict sense! Without such a warning, one may well wonder how a non-vectorial quantity such as p.d. manages to appear in a diagram as a vector.

this particular diagram—would probably then retort that if I had read his painstaking explanation of how this vector diagram was constructed, or if I had the least clue to elementary a.c. theory, I would know perfectly well that the e.m.f. of the generator would then be acting around the circuit in the direction of the current arrow, and so the left-hand terminal would be positive.

To which I would reply that if the only purpose of the vector diagram was to show something that was already abundantly obvious (or, alternatively, if if were not obvious, something that one had to go all through the construction of the vector diagram to find out) it would be about as much good as a portable signpost which needed a knowledge of where the roads led before it could be correctly set up.

If Fig. 1(a) had been supplied with an earth symbol attached to the right-hand terminal of the generator, then one could reasonably have been expected to gather that the polarity of the vector representing V was the polarity of the left-hand and relative to the other. But it just wasn't supplied. And even if it had been there would have been uncertainty about voltages between points not earthed.

It might be that our authors in the dock would take a different line of defence. They might point out to me (slowly and clearly, as to a small child or mentally retarded pupil) that a positive voltage would be that which, when in phase with a positive current, was in the same direction. That *could* settle the matter if more information were available than is in fact vouchsafed by the authors in question. Consider Fig. 2, together with the information from a vector diagram or otherwise that the voltage is in phase with the current. Which wire is positive; top or bottom?

If the "voltage" we have been talking about is an e.m.f.—the e.m.f. driving the current I—and its source is in one of the boxes in Fig. 2, and *if* we know which box, then we know the answer. If not, we don't.

Whichever wire is positive with respect to the other, each box inevitably has a voltage between its terminals equal *and opposite* to the voltage in the other box in its direction *around* the circuit. So linking the voltage between two points with a current

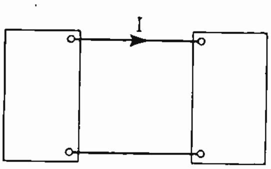


Fig. 2. Which connecting wire is positive when the current is positive ?

arrow gives (in absence of further information) two exactly opposite answers. Such confusion would be avoided by the simple act of omitting one of the arrow-heads associated with V in Fig. 1(a). With Fig. 1(b) as it is, the right-hand arrow-head would be the one to go. If, however, the author had not been such a clever man that he knew it all before he started, but guessing blind had happened to put his one "V" arrow on the right, it would have meant that all the voltage vectors in Fig. 1(b) would have had to point the opposite way. That might not have been conventional but it would have been quite right.

Right, that is, according to the conventions of this particular author, which are not followed by all. They could easily be a cause of confusion in circuits

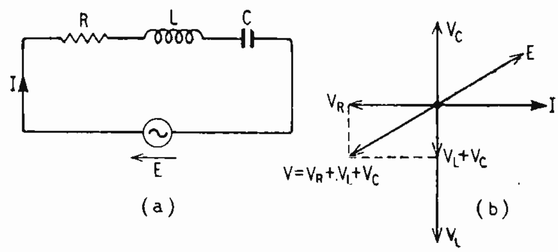


Fig. 3. Alternative and more helpful version of Fig. 1.

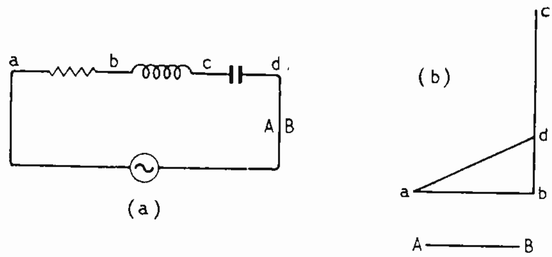


Fig. 4. Another and still more helpful version, if you know the conventions.

which, unlike this one, are not simply a single source of e.m.f. feeding current to passive circuit elements. His convention is to make each voltage vector represent the e.m.f. (coming from elsewhere) needed to drive the current through that part of the circuit. Adding them all up gives the total e.m.f. of the generator.

Personally I prefer to work according to Kirchhoff's Second Law in the form "The algebraical sum of the voltages around any closed loop is zero," because it is based on the obvious fact that the same point cannot be at two different potentials at the same time. So in Fig. 1(a) the e.m.f. of the generator would be equal *and opposite* to the sum of the separate voltages across R, L and C. This version is given as Fig. 3.

But that is only a compromise. The one completely unambiguous, consistent and universal system of vector diagrams, free from d.c.-like arrows and coincident vectors (I might as well be hung for a superintendent as a constable) is my own, expounded in the July-September, 1954, issues. Fig. 4 is how the same circuit looks in that version.

In such a simple circuit it doesn't matter much which system one uses; what does matter is that when the system is applied to circuits about which the vector diagram, once constructed, tells people something they can't easily see otherwise, it leaves no room for uncertainty or error. The circuits I am thinking of particularly are those containing more than one source of e.m.f., so that one cannot assume that the current will be flowing externally from the positive to the negative terminal of any source; some other source may be driving current back through it.

A very simple example of how useless the common system is can be seen by comparing the triode "equivalent circuit" in the same book with the valve circuit it is supposed to represent. They both appear here as Fig. 5. We only have to ask one simple question, to which we might reasonably expect

(Continued on page 517)

a clear and unmistakable answer: When E_i is positive, is V_o positive or negative? Or, since the diagrams are so drawn that the statement that E_i (or V_o) is positive hasn't even any meaning, let's try to be co-operative and word it this way (though we really ought not to be put to such trouble): When E_i is such that the grid is positive with respect to the filament, which end of the load resistance is positive?

Well, this equivalent circuit diagram can't even tell us that! We have to go back to electronics and work it out for ourselves. So what use is the diagram? It does tell us the amount of voltage amplification. But not its sign. If, in the absence of any help from the author, we were to do a bit of reasonable guessing, and assume that he was following the customary convention of reckoning the lowest part of the circuit diagram as "earth," then positive E_i would mean a relatively positive grid, and the end of R not earthed would (according to the diagram) be positive. Which is wrong.

When the system breaks down so lamentably with even such an extremely simple circuit as this, what hope is there with really complicated ones, having numerous branches, unearthed points, negative resistance, feedback, mutual inductances, etc? I just wouldn't know, and that was why I was driven to invent my own system. However, at this moment I'm not asking people to accept that but just to use any system so long as they put in all the necessary signposts.

There is one difference between these electrical signposts and the geographical sort that makes them either easier or more difficult—I'm not sure which. If the local authorities of York set up a signpost in their city marked "LONDON—>", travellers couldn't be blamed for complaining if the direction so marked led straight to Edinburgh. The fact that all the other signposts in Great Britain were similarly reversed would hardly be considered satisfactory. But we have just had occasion to remark that electrical signposts can all be reversed without giving any proper ground for complaint. Considering that in a.c. circuits all the currents and voltages are continually reversing themselves, that is not surprising. The comparison does, however, emphasize the contrast between things that are necessarily so (facts) and things that can be as we choose (conventions). Quite a lot of confusion and argument result from failure to appreciate this.

Take language. "When *I* use a word," Humpty Dumpty said, "it means just what I choose it to mean." And (if Humpty Dumpty is taken to represent the people who speak any particular language) he was perfectly right. Although the present English-speaking people make the word "prevent" mean something quite different from what those living 300 years ago did, neither lot of people can be declared wrong, because both chose to make the word mean those things. The trouble comes when different people choose to make it mean different things at the same time without making that fact clear. "Democracy" is a notable example.

It would be extremely awkward (though perhaps a valuable discipline?) if everyone had to explain what they meant by all the words they used; and so we try by means of dictionaries and otherwise to achieve the maximum agreement, as a matter of practical convenience. We also try to achieve agreement in the use of mathematical symbols, but to make sure almost any reputable scientific book or

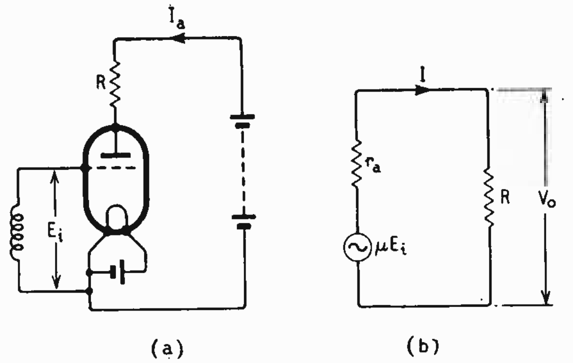


Fig. 5. Simple valve circuit and its "equivalent." In this form, does it really help?

paper is preceded by a list of those used and their meanings.

In all conventions it is desirable that they should be (1) accepted and used by all concerned, (2) convenient, and (3) logically based. Sometimes they are tolerated when they are inconvenient or illogical or both, because they are so widely used that great confusion would be caused trying to alter them. (As readers may have noticed, I am less impressed by this argument than some.) Sometimes, as with words such as "infer," "protagonist," and "anticipate," all three requirements are overthrown by sheer weight of ignorance, and one is never sure whether the correct-by-dictionary use of them will be properly understood.

More trouble comes when conventions and facts are confused. I mentioned some time ago the celebrated controversy about the nature of white light. Does the spectroscope develop coloured light from it, or does it pick out colours already there as ingredients? These alternatives were later seen to be two different ways of looking at the same thing, and the question of right or wrong shouldn't have arisen. In the same way one person might argue that a metal sheet reflects radio waves, preventing them from proceeding further; another might contend that the waves do go on, but are neutralized by waves re-radiated both forwards and backwards by the metal. It would be a pity to come to blows over it. Or over vector diagrams. But do, please, let all necessary signposts be present and their conventions made clear.

I.E.E. PREMIUMS

OVER half the premiums recently awarded by the I.E.E. for 1958 are for papers on radio or electronic subjects. The Institution's premier award, the Kelvin Premium (£25), was given to Dr. P. N. Butcher (R.R.E.) for his paper "Theory of three-level paramagnetic masers." The Blumlein-Browne-Willans Premium (£20) is awarded to Dr. D. Gabor, Dr. P. R. Stuart and P. G. Kalman for "A new cathode-ray tube for monochrome and colour television"; and the Heaviside Premium (£15) to Z. Godzinski, of Poland, for two papers on groundwave propagation.

The Electronics and Communications Section's Duddell Premium (£20) goes to Dr. A. E. Karbowiak for "Microwave aspects of waveguides for long-distance transmission"; and the Ambrose Fleming Premium (£15) to G. D. Monteath for "The effect of the ground constants, and of an earth system, on the performance of a vertical medium-wave aerial."

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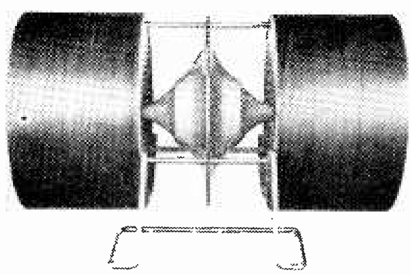
NEW ELECTRONIC EQUIPMENT AND ACCESSORIES

Two Tweeters

IN two new Burne-Jones treble loudspeaker units fixed curved-sided cones in front of the speaker cones provide uniform distribution of the sound in a plane at right angles to cones' axis and also some loading of the sound. The magnetic flux density in the speakers is 7500 gauss, and the recommended crossover frequency 900c/s.

In the "Treble 20" the single loudspeaker faces downwards on to two cone reflectors, the upper reflector having a central hole and being for the sound from the outer part of the loudspeaker cone, and the lower being for the sound from the voice-coil dome and inner part of the cone. When this loudspeaker unit is stood on a flat sound-reflecting surface, this surface acts to some extent as an extension of the lower cone reflector. This unit gives a uniform horizontal distribution of sound.

In the "Treble Twin" two nominally similar loudspeakers are used, thus giving a larger radiating area. Because the sound from the two speakers is combined, any differences between their responses are evened out. The two loudspeakers are connected electrically in phase and face each other; each also faces a single cone reflector as in the photograph. This arrangement gives a uniform distribution of sound in the plane at right angles to the loudspeaker and reflector cone axes (this plane is vertical and at right angles to the paper for this photograph). Moreover, the sound is beamed within a few tens of degrees ($\pm 20°$ at 4kc/s) of this plane. The bracket for mounting this loudspeaker unit on the wall is shaped so as to allow the plane in which the sound distribution is uniform to be made horizontal or vertical, thus giving a choice between uniform or beamed sound in a horizontal plane.

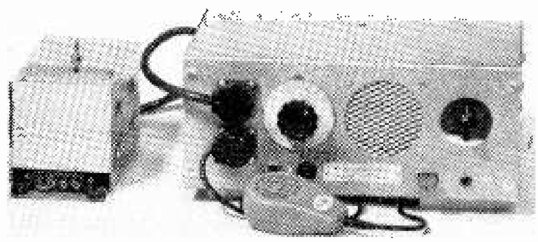


Burne-Jones "Treble Twin" tweeter.

The Treble Twin costs £9 10s 4d, and the Treble 20 £7 (both sums include purchase tax). These units are available from Burne-Jones & Co., Ltd., of 18 Brunswick Rd., Sutton, Surrey.

Amateur V.H.F. Transmitter-Receiver

THE equipment illustrated is a complete 2-metre transmitter-receiver designed for either mobile use in a car or as a fixed station. Designated the "Communicator Mark 2" it utilizes 16 miniature valves, 11 being in a double-superhet receiver covering 143 to 147Mc/s and 5 in a crystal-controlled transmitter, which together with loudspeaker are housed in a metal case measuring 13in × 5½in × 8in only. The transmitter output valve is a QQVO3-10A double tetrode operated at 15 watts with screen and anode modulation. Input impedance of the receiver, and output impedance of the transmitter, is 75Ω.



R.E.E. 2-metre amateur transmitter-receiver, microphone and power unit.

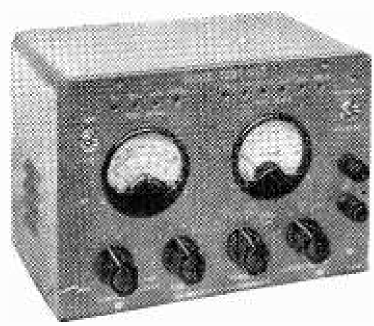
A press-to-talk switch on the hand microphone actuates relays in the equipment which make the necessary circuit changes for send and receive.

Power for mobile use is supplied by a 12-volt rotary converter taking 4A on receive and 5A on transmit. For fixed station use an a.c. mains power unit is available.

The price is £90 including rotary converter; the a.c. mains power unit costs £12 extra. The equipment is made by R.E.E. Telecommunications, Ltd., 15A, Market Square, Crewkerne, Somerset.

Diode Test Meter

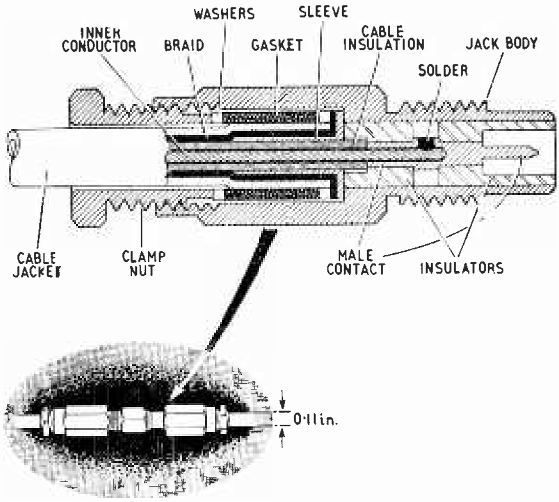
RANGES from 50μA to 5A and 3 to 1200V for a full-scale meter deflection are provided in the Thompson (Instruments) Type ED8 diode tester for simultaneous current and test voltage measurements at dissipations up to 15W. A polarity reversal switch is provided so that both forward and reverse characteristics can be obtained without disconnecting the diode under test. This instrument costs £52 5s, and is manufactured by R. E. Thompson & Co. (Instruments) Ltd, Hersham Trading Estate, Walton-on-Thames, Surrey.



Thompson diode test meter.

Sub-Miniature Coaxial Connectors

A RANGE of precision-made r.f. connectors to take sub-miniature coaxial cables of between 0.08in and 0.155in outside diameter are now obtainable from the Sealectro



Sealectro "Conhex" sub-miniature coaxial connectors Types 3000 and 3001.

Corporation. Known as the "Conhex" series they are made of brass with beryllium-copper sockets and Teflon insulation. Metal parts are gold plated and the connectors are said to be suitable for use at microwave frequencies.

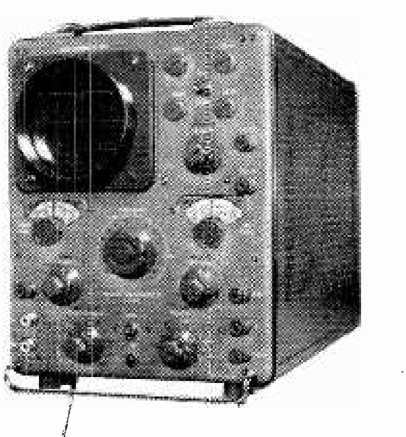
The connectors are available for cables of 50, 75 or 95Ω characteristic impedance and the matching is such that over the frequency range 1 to 9.3 Gc/s the voltage-standing-wave ratio is claimed to be within 1.1 and 1.3. Insulation resistance is better than 10^6MΩ.

The sample illustrated comprises a Type 3000 plug and Type 3001 socket and is a cable-to-cable connector measuring only $1\frac{7}{16}$in long overall and $\frac{7}{32}$in diameter. Other types for chassis mounting are also available. When mated plug and socket parts are secured by a captive screwed collar.

Further details can be obtained from the Sealectro Corporation, Hersham Factory Estate, Lyon Road, Walton-on-Thames, Surrey.

Measuring Oscilloscope

IN the Marconi Instruments TF1330 the d.c. Y-amplifier has a frequency response 3dB down only at 15Mc/s and a maximum sensitivity of 50mV/cm. The time-base sweep speed is variable from 1cm/sec to



Marconi Instruments TF1330 Measuring oscilloscope.

10^7cm/sec in 15 ranges and can be increased up to 5×10^7cm/sec using the X-expansion control. Both times and voltages can be measured to within ±2%. If the trace should be deflected off the screen, a push-button switch is provided to reduce the sensitivity in a non-linear manner so as to return the trace to a corresponding position near the edge of the screen. The trace can then be easily returned to the centre of the screen using the shift controls. This instrument costs £300 and the address of its manufacturer is Marconi Instruments Ltd, St. Albans, Hertfordshire, England.

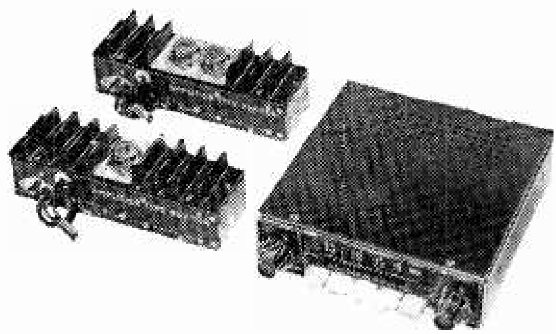
Transistorized Car Radio

TO the Radiomobile range of car radio receivers is now added a new series of hybrid units and a compact single-unit set, also of hybrid type.

Known as the 500T the units consist of a sensitive receiver, or control unit, giving push-button selection of five stations in the medium and long wavebands, as well as full coverage by manual tuning, and operating directly from a 12-volt d.c. supply. This employs four valves and an a.f. driver transistor. With this unit can be used one of two alternative transistor power-output amplifiers; either the Model A, which employs a single transistor giving 2.5 watts output, or the Model B which has push-pull transistors and gives 5 watts output. As can be seen from the illustration the power transistors are, in each case, mounted externally on finned aluminium "heat sinks."

The single-unit version, Model 50T, consists of a four-valve receiver with a single transistor output stage giving 1.75 watts, the whole consuming only 1.2A on a 12-volt d.c. supply. Manual tuning only is provided but medium and long wavebands are covered, although there is a model (52T) which is for medium waveband only. Likewise, in the unit series there is a medium waveband only unit, the 502T, for use where long waves are not required.

These units and sets occupy little space, the 500T receiver, for example, measures only 7in × 7in × 2in while the associated amplifier (A or B) Measures $2\frac{5}{16}$in ×



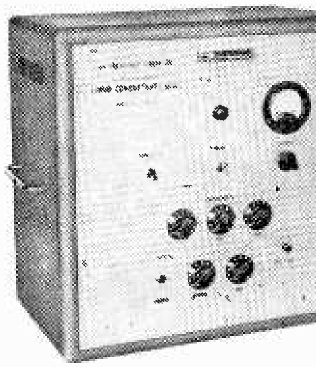
Smith's Radiomobile 500T series car receiver with alternative transistor power amplifiers alongside.

7in × 2in. The overall size of the model 50T is $7\frac{1}{8}$in × 7in × 2in. Six-volt versions are also available.

Current prices are: Model 500TA (receiver with "A" amplifier) £21, plus £7 2s 10d U.K. purchase tax; 500TB ("B" amplifier) £23 1s 6d, plus £7 16s 11d U.K. purchase tax. The makers are, S. Smith and Sons (Radiomobile), Ltd., Goodwood Works, North Circular Road, London, N.W.2.

Two Very Low Frequency Generators

OUTPUT frequencies from 100c/s down to 10^{-4} or 10^{-4}c/s can be obtained from the Servo Consultants Model 111 or 110 generators respectively. In both



Servo Consultants very low frequency generator.

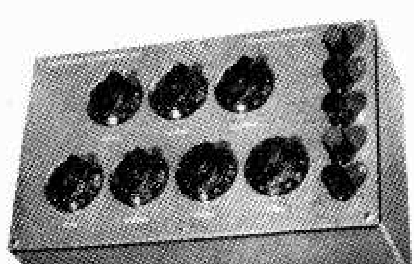
these generators the distortion is 1% at the maximum output of 30V and 10mA; the output impedance is 250Ω. The main part of both generators consists of a resolver whose rate of rotation is the signal frequency, f say, and whose stator is supplied with a 30V carrier signal at 2400c/s. The rotor output at a time t is then proportional to $30 \sin 4800\pi t \sin 2\pi f t$. The signal frequency f is obtained by rectifying this output using a phase-sensitive detector synchronized by the carrier signal. With this method of generation the amplitude of the output signal does not depend on its frequency but only on the carrier amplitude. This type of generator can also start and stop at any point on the waveform without introducing transients. Both these generators cost £265 and are manufactured by Servo Consultants Ltd, of 17 Woodfield Road, London, W.9.

Combined C and R Decade Box

DECADES of capacitance and of resistance are not usually combined in a single box but where bench space is strictly limited the combined unit has many advantages. A decade box of this kind introduced by R. E. Thompson and Company contains three decades of capacitance and four of resistance. In the general-purpose model the increments of capacitance are in steps of 0.001µF, 0.01µF and 0.1µF, while those of resistance are in steps of 100Ω 1,000Ω, 10kΩ and 100kΩ respectively. Other combinations can be supplied by arrangement.

Normally polystyrene dielectric capacitors of 1% tolerance are fitted, but silvered-mica or other types can be substituted. All capacitors are normally 350-volt working and resistors high-stability ½W, 1% tolerance. There is an electrostatic screen connected to the "earth" terminal on the box between capacitance and resistance decades. Separate terminals are fitted for capacitance and resistance.

The box is made of stove-enamelled sheet steel with welded seams and measures 9½in × 6in × 5½in. Price

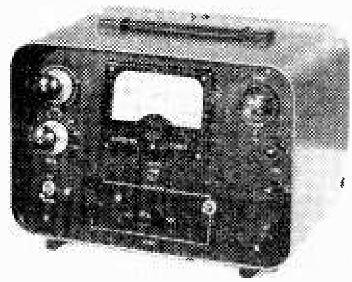


A combined capacitance and resistance decade box made by R. E. Thompson and Co

depends on the particular combination and type of components fitted, but the general-purpose model costs £18. The makers are R. E. Thompson and Co. (Instruments), Ltd., Hersham Trading Estate, Walton-on-Thames, Surrey.

Coil Bonding Equipment

ONE method of securing the turns of a coil wound with one of the new self-bonding wires is to pass an electric current through the coil. Sometimes it is advisable first



Avo coil bonding timer.

to check the insulation between coil and the mandrel (if metal) on which it is wound in order to ascertain what magnitude of bonding voltage is permissible.

The Avo "Bonding Timer" has been introduced to serve the dual functions of insulation measurement and time control of the bonding voltage. Insulation resistance can be measured up to 500MΩ and the application of heating current set for automatic control for periods ranging from 0.75sec to 2.5min.

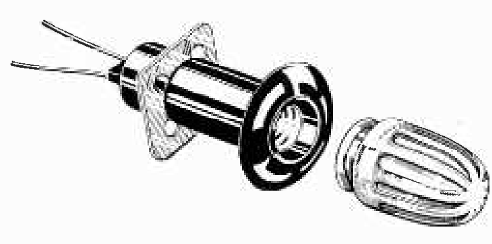
The equipment is a.c. operated and mains voltage is normally used for coil heating, but provision is made for applying, if necessary, bonding voltages of lower value from an external source.

The makers are Avo Ltd., Avocet House, 92-96, Vauxhall Bridge Road, London, S.W.1.

Miniature Moulded Signal Lamp

THE small panel-mounting signal lamp fitting illustrated is a one-piece, thermoplastic moulding with metal inserts to take a low-voltage L.E.S.-cap bulb of the Hivac, Philips or Vitality with rating up to 1.2W. The ribbed plastic lens is a snap-in fit and is available either clear or in colours.

The signal lamp requires a hole approximately $\frac{5}{16}$in in



Bulgin miniature moulded panel-mounting signal lamp.

diameter and it fits panels up to $\frac{3}{16}$in thick. It is secured in position by a simple but effective push-on grip washer. Connection to the lamp is by means of two 3-in fly leads at the back. The body colour is normally black but alternative colours are available by arrangement with the makers, A. F. Bulgin and Co. Ltd., Bye Pass Road, Barking, Essex.

Transistor Stopwatch

By D. E. O'N. WADDINGTON,* Grad.Brit. I.R.E.

Measuring Time Intervals from 0.5 m sec. to 5 sec.

SINCE the development of escapement mechanisms, especially those using resonant control, mechanical methods of time measurement have been developed to a very high pitch. However, mechanical methods suffer from the disadvantage that they are slow to operate and measurement of short time intervals has passed largely into the hands of the electronic engineer. Many electronic interval timers have been designed, most of them having very high accuracy, but some are necessarily complicated and require special instruments for their adjustment. It is possible however to make a relatively simple "timer" which is not too difficult to set up.

There are two main "electronic" methods of measuring time interval. The first method approximates to the clepsydra, or water clock, in that a capacitor is charged through a resistor during the time interval to be measured, and then the resultant voltage across the capacitor is a function of the time. This method, although ideal for simple valve-operated timers is impracticable with transistors as the required high reverse impedances cannot easily be realised. The second method consists of counting the number of pulses of known repetition rate during the period to be measured and displaying this number either by means of a digital presentation or on a meter.

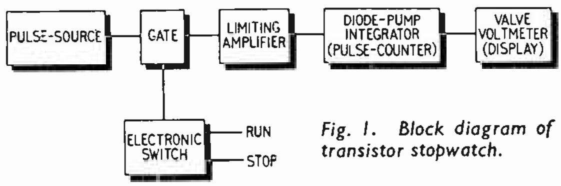


Fig. 1. Block diagram of transistor stopwatch.

The second method lends itself very well to transistor circuitry and it is used in the "Transistor Stopwatch." Owing to the complexity of a digital presentation a meter is used to indicate the time interval and it was found necessary to use two battery-operated valves to do this.

The transistor stopwatch is the electrical analogue of the mechanical stopwatch in that it counts the number of impulses of known frequency between the start and stop signals. However, it has an advantage over its mechanical counterpart as the "inertia" of the system is very low and a higher pulse repetition rate may be used. This factor allows measurement of very small time intervals with good accuracy. In the mechanical stopwatch there is only one pulse repetition rate available; but in an electronic device it is possible to vary this rate almost at will, so making it possible to use one meter scale for all ranges by switching the frequency of the pulse source.

The instrument may be sub-divided into six separate circuits and this breakdown is shown in block form in Fig. 1.

* Marconi Instruments, St. Albans.

Oscillator and Switch Circuits.—The pulse source is a free-running multivibrator (V3 and V4, Fig. 2). As the shortest time to be measured determines the highest frequency to be used, the type of transistor used limits the accuracy of the instrument. However, by using a count of 200 cycles for full-scale deflection of the meter on any time range, the uncertainty error is reduced to $\pm 0.5\%$ and a top frequency of 20kc/s permits a full scale reading of 10msec on the shortest time scale. The uncertainty error is due to counting a free-running frequency source instead of one which starts with the timing pulse. Hence it is possible to count one too many or too few cycles. There is little difficulty in making a 20-kc/s oscillator with commercial "audio" transistors although the waveform tends to deteriorate. As this is compensated for later in the circuit it has no deleterious effect on the operation of the stopwatch. The required frequency for any time scale is given by:—

$$f = n/t$$

where n is the number of pulses for f.s.d. and t is the time interval to be registered as f.s.d. In this instrument 200 pulses correspond to f.s.d. and the frequencies equivalent to the chosen time scales are given in Table I.

Table I

Time Scale	Frequency
5 sec	40 c/s
1 sec	200 c/s
500 msec	400 c/s
100 msec	2,000 c/s
50 msec	4,000 c/s
10 msec	20,000 c/s

The different frequencies are obtained by switching the base-collector capacitors C_1 and C_7 together to keep the mark-to-space ratio and the output amplitude constant. As the frequency stability of this circuit controls the accuracy of the instrument its supply should be kept constant and this is done by a Zener-diode voltage stabiliser (D3, on Fig. 2). The other cause of frequency variation is due to a change of base current with a change in temperature and this is reduced to a minimum by using a relatively-low-value base resistor. These measures limit the frequency variation to about $\pm 2\%$.

Usually only impulses are available from the external control circuit so some form of bi-stable circuit must be used for switching the timer on and off. This is done very simply by using a transistorised version of the Eccles-Jordan flip-flop circuit (V1 and V2, Fig. 2). A positive-going pulse of one volt will trigger the circuit quite effectively—shorting the run or stop inputs to earth has the same effect—so that either electrical or mechanical switches may be used.

A single transistor can be made to act as a very effective gate (V5, Fig 2). When the base is biased towards the positive line the emitter-to-collector resistance is high and when it is biased sufficiently negative it acts almost as a short circuit. Thus by interposing this gate between the output of the multivibrator and the input to the amplifier, it is possible to switch the signal on and off quite simply.

The limiting amplifier (V6 and V7, Fig. 2) is a conventional two-stage direct-coupled amplifier. As the output waveform should be square with a constant peak-to-peak amplitude sufficient input is applied to the first stage so that it switches the second stage on and off. Thus the output is switched from the earth line to the 4.7-V negative line which is stabilised by means of the Zener diode. As a rapid response is important r.f. transistors are used.

Display Circuits.—The diode-pump integrator is used widely in frequency discriminators and pulse-rate meters. Here it is used as a pulse counter. In this application special precautions must be taken to ensure that the reverse resistance of the shunt diode is very high, of the order of thousands of megohms. It is difficult to find even silicon diodes which reach this requirement, so a vacuum diode had to be used; but here again difficulty was experienced as there is no suitable battery-operated vacuum diode readily available. Furthermore most vacuum diodes suffer from " splash " current which could easily cause erroneous readings. However, the writer has found that splash current can be reduced appreciably by running the filament of a battery pentode at half the specified filament voltage and connecting the control and screen grids to the negative side of the filament. This strapping does not impair the diode action of the valve in its application in the pulse-counter. The capacitor which is charged from the diode pump must be a high-quality low-leakage type as any path liable to discharge it must be eliminated where possible. In this circuit the total parallel resistance is approximately 500 MΩ.

An electrometer valve would have been ideal for the valve-voltmeter as it has an extremely-high input resistance, however, electrometer valves are expensive so a conventional output pentode (V6) is used in a slightly unconventional circuit. As in the diode pump, the filament is run at half its normal supply voltage from a battery which is isolated from all other supplies. This allows the centre tap of the filament to be used as a neutral point from which the bias resistor is connected to earth. To set the zero, the meter is connected between the anode and a resistive chain and the sensitivity is adjusted by means of a variable resistor connected in parallel with the meter.

Photoelectric Trigger Circuit.—Although this is not essential for the operation of the stop watch it is a very-useful accessory, particularly when it comes to calibration. Normally a photoelectric cell does not produce a pulse of sufficient amplitude to operate the timer when the amount of light falling on it is changed so it was incorporated in a Schmitt trigger circuit. Under operating conditions the light falling on the OCP71 photo-transistor (connected as a photodiode) causes a current to flow through it with the result that the base of V10 is biased towards the negative line, so switching it on and hence switching off V11. When the light intensity is reduced, the current through the phototransistor is reduced; consequently the bias on the base of V10 will be reduced, switching it off and switching V11 on. This causes the voltage on the collector of V11 to move towards the positive line, thus giving the requisite pulse to trigger the stop watch. As the device will almost certainly be used in varying degrees of illumination a sensitivity

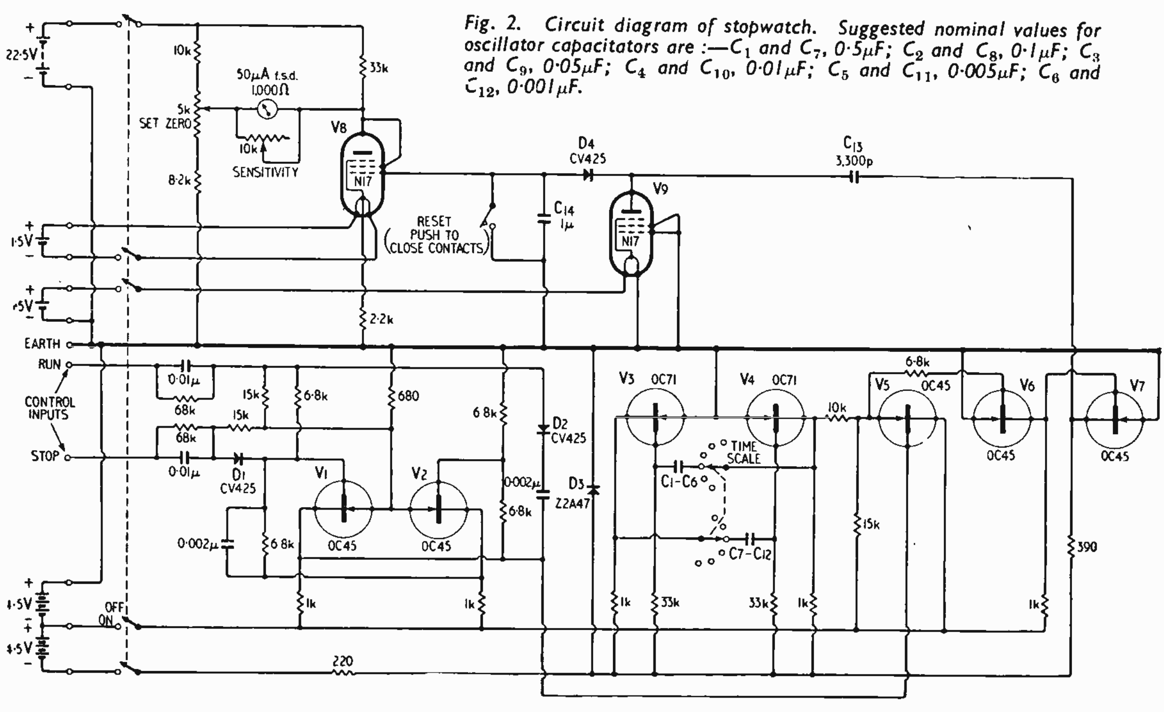


Fig. 2. Circuit diagram of stopwatch. Suggested nominal values for oscillator capacitators are :—C_1 and C_7, 0·5μF; C_2 and C_8, 0·1μF; C_3 and C_9, 0·05μF; C_4 and C_{10}, 0·01μF; C_5 and C_{11}, 0·005μF; C_6 and C_{12}, 0·001μF.

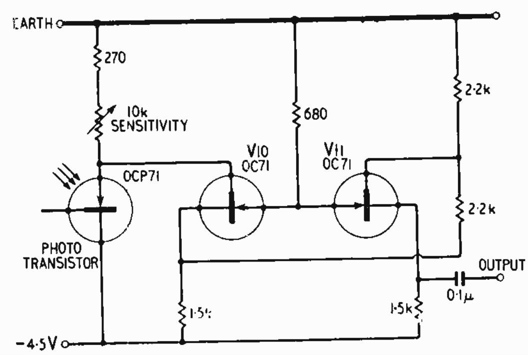


Fig. 3. Photoelectric trigger unit circuit. Note that OCP71 phototransistor is used as photodiode, i.e. base connection is left "floating."

control is included: this allows the sensitivity of the photo-cell circuit to be set so that a small reduction in illumination will operate the trigger.

Notes on Construction.—With the exception of the diode-pump and valve-voltmeter circuits there is nothing critical in the construction of the instrument. The transistor circuits may all be wired on tagboards. The best grouping consists of wiring the electronic-switch section on one tagboard, the pulse source, gate and limiting amplifier on another and the photoelectric trigger on a third.

It was found necessary to use either porcelain or p.t.f.e. valve holders for the pentodes and the 1-μF integrating capacitor was mounted on porcelain stand-off insulators to reduce leakage. A locking device was fitted to the "meter-sensitivity" control to prevent accidental "readjustment" as this would lead to erroneous readings which would not be immediately obvious. The lead from the grid of the voltmeter pentode to the "reset" switch was screened and kept away from the oscillator circuit. A high-grade lead and switch were used to reduce leakage.

Calibration.—The first operation carried out was to check the frequency of the multivibrator. For this an oscilloscope and a calibrated a.f. oscillator were used with the output of the multivibrator connected to the Y amplifier of the oscilloscope and the a.f.-generator output to the X amplifier. The frequency of the oscillator was then adjusted until a stationary square trace appeared on the screen. The frequency of the multivibrator was adjusted by selecting the condensers C_1 and C_7 (larger capacities reduce the frequency and smaller ones increase it). It is not essential that the frequencies should be exact provided that the ratio between them is correct and Table II gives the relation of frequencies for various errors, including a lowest frequency of 50c/s (for calibration from the mains supply).

TABLE II

Correct	2.5% low	2.5% high	10% high
40	39	41	50
200	195	205	250
400	390	410	500
2,000	1,950	2,050	2,500
4,000	3,900	4,100	5,000
20,000	19,500	20,500	25,000

The standard time signals from Rugby, WWV or ZUO could be used for setting up the time scale; but this would involve the use of more complicated circuitry than is contained in the stopwatch. A pendulum was adopted as being the easiest and most practical method.

To minimise the errors, the longest time scale was used, i.e. 5 secs. It is, unfortunately, impractical to obtain f.s.d. directly as the pendulum required for a 5-second half cycle is about 81-ft long! However, a pendulum having a period of 2 sec. is quite practical. The required length is given by the formula:—

$$t=2\pi\sqrt{(l/g)}$$

where t is the period, l the length and g the acceleration due to gravity.

Thus a 2-sec pendulum would be 99.45 cms. or 39.16 in. from the support to the centre of gravity of the bob. A pendulum was made by tying a 1-lb. weight to one end of suitable length of light thread and securing the other end to a rigid support. A light source and the photoelectric trigger were then arranged so that the pendulum hung between them. The time-scale calibration arrangement is shown in Fig. 4.

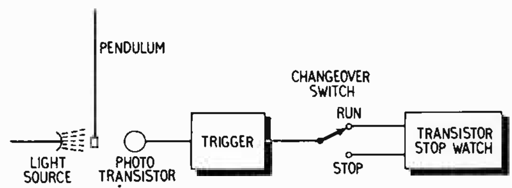


Fig. 4. Arrangement of apparatus for setting up time scale. Pendulum interrupts light beam when in the position occupied when at rest.

The setting up procedure used was as follows:—

1. Switch the stopwatch on and press the reset switch to discharge the condenser.
2. Set the zero of the meter and switch to the 5-sec. range.
3. Move the bob of the pendulum about 4in. from the rest position and release it. It will swing through the light beam, triggering the timer.
4. After the pendulum has completed 2¼ cycles operate the changeover switch so that the output of the trigger is connected to the "stop" input.
5. At 2½ cycles (i.e. 5 sec.) the timer will be stopped. Then adjust the sensitivity control so that the meter indicates full-scale deflection.
6. Repeat the above procedure as a check.

As a further check switch to the 1-sec range and time one-half cycle of the pendulum. If the meter does not indicate full scale correctly, the oscillator frequencies should be re-checked.

The meter scale is very nearly linear (within 3%) but if the refinement of an exactly-calibrated scale is required the calibration points may be calculated from the formula:—

$$V=E\{1-[C_2/(C_1+C_2)]^n\}$$

where V is the voltage measured by the valve voltmeter, E is the supply voltage, i.e. 4.7 V, C_1 is the series condenser, i.e. C_{13} in Fig. 2, C_2 is the shunt condenser, i.e. C_{14} in Fig. 2, and n is the number of charging pulses.

The instrument was originally designed to measure the speed of arrows shot from a bow. The start pulse was obtained by the feather cutting a beam of light, thus operating the photo electric trigger and the stop pulse was obtained from a micro-switch on the target which shorted the "stop" input to earth. This, however, is not the only use for the instrument as it can be used to measure the speeds of camera shutters (using two photo electric triggers), the speed of relay operation, etc. In fact, the limit is usually set by the detecting arrangements; but as the run and stop inputs are at low impedance, it is possible to use long lengths of cable to operate them with no fear that the capacity will damp the pulses. Leads up to 100 yds. long have been used.

"MONO" TAKES A TOSS

AT the Colston Hall, Bristol on October 9th Mr. G. A. Briggs introduced his 17th concert of live and recorded music. In addition to his own evident enjoyment of any experiment in sound Mr. Briggs found three additional pretexts for this occasion: (1) to satisfy many requests from sound reproduction enthusiasts living in the West Country; (2) to offer for judgment for the first time by a public audience a comparison between live performances and mono and stereo reproductions of the same works; (3) to make amends to Harold Blackburn for the admittedly unsuccessful reproduction of his fine bass voice at the Festival Hall concert last May.

Special tape recordings were made at the Abbey Road Studios of E.M.I., using the best available microphone techniques for both single-channel and stereo, of excerpts from piano trios by Dvorak and Mendelssohn played by Gerald Gover (piano), Kenneth Popperwell (violin) and Terence Weil (cello), and also solos by Harold Blackburn. *Wireless World* was privileged to hear playbacks of these recordings both at E.M.I. Studios and in the Colston Hall, with the live performances for reference in both cases. In the small monitoring rooms at Abbey Road there seemed little to choose between mono and stereo, and opinions among those present were equally divided. In the Colston Hall, on the other hand, there could be no doubt of the superiority of stereo reproduction, and this was conclusively supported by a show of hands in the mixed audience. Although neither system could quite compete with the rich quality of Harold Blackburn's voice we had thought earlier that, in the monitoring studio, single-channel came nearest, but this decision was reversed at Bristol where stereo gave a much more natural rendering. Yet the conditions at Bristol, with large omnidirectional speakers, spaced widely apart in the large hall, would be considered by most people to be much less favourable than those of the monitoring studio with only three or four seats placed in the optimum position relative to the loudspeakers.

Although perhaps of less scientific interest than Mr. Briggs' own objective and carefully prepared experiments, a comparison of mono and stereo recordings (Archive) of the Geraint Jones choir singing a Handel chorus was illuminating. The mono recording, which was played first, was completely satisfying from a musical point of view, but the stereo recording which followed put a fire and vitality into the sound quality which was then quite evidently missing from the single-channel record.

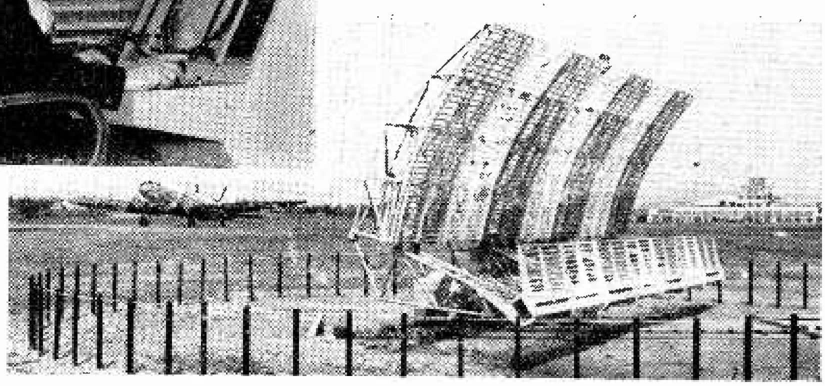
Mr. Briggs is once again to be congratulated on a very successful and enjoyable concert, and for his unsparing efforts to find the best in sound reproduction—this time, as it happened, in two-channel stereo.

JERSEY AIR TRAFFIC CONTROL

TO meet the requirements of air traffic control at the busy airport at Jersey in the Channel Islands, a Marconi S264 radar system has been installed and was, on 26th June, 1959, inaugurated by H.R.H. Princess Margaret.

In addition to very heavy holiday traffic for which a new air lane (Blue One) is proposed between London and Jersey, there is responsibility at Jersey for overflying aircraft on route Blue 32 (Paris to Shannon) and also for supervision of the Channel Islands control zone.

The S264 radar is 50kW installation with provision for conversion to 500kW if necessary. It operates on 50cm (for rain penetration) with a large aerial system of wide vertical aperture, giving coverage up to 40,000 ft at distances of up to 100 miles on medium-sized aircraft.



Marconi S264 long-range and terminal area surveillance radar system at Jersey Airport.

NOVEMBER MEETINGS

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

LONDON

11th. Brit.I.R.E. — " Physiological and acoustical aspects of hearing " by Dr. R. P. Gannon at 6.30 at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

11th. Physical Society Colour Group.—Discussion on the recent work of Dr. Edwin Land on colour projection at 3.30 at Institute of Ophthalmology, Judd Street, W.C.1.

12th. Physical Society Acoustics Group.—" The propagation of Rayleigh waves " by G. Mott at 4.0 at Imperial College, Prince Consort Road, S.W.7.

18th. Brit.I.R.E.—Half-day symposium on " Electronic digitizing techniques " at 3.0 and 6.0 at the London School of Hygiene and Tropical Medicine, Keppel Street, W.C.1.

20th. Institute of Navigation.—" Radiometry, radio-astronomy and infra-red techniques " by C. M. Cade at 5.15 at The Royal Geographical Society, 1 Kensington Gore, S.W.7.

20th. I.E.E. Graduate and Student Section.—" Plastic cables in the telecommunications industry " by G. J. Waddon at 6.30 at Savoy Place, W.C.2.

20th. Television Society.—" Television film production " by J. K. Byers (B.B.C.) at 7.0 at the Cinematograph Exhibitors' Association, 164 Shaftesbury Avenue, W.C.2.

20th. B.S.R.A.—" Loudspeakers " by S. Kelly at 7.15 at the Royal Society of Arts, John Adam Street, W.C.2.

23rd. Radar & Electronics Association Student Section.—" Marine and air radar simulators " by P. Tenger (Solartron) at 7.0 at the Norwood Technical College, Knight's Hill, S.E.27.

24th. Radar & Electronics Association.—" Waveguides for long-distance communications " by Professor H. E. M. Barlow at 7.30 at the Royal Society of Arts, John Adam Street, W.C.2.

25th. I.E.E.—" Radio aspects of the International Geophysical Year " by Dr. R. L. Smith-Rose at 5.30 at Savoy Place, W.C.2.

30th. Royal Institution.—" Faraday, through his manuscripts " by Dr. L. Pearce Williams at 5.30 in the Long Library, 21 Albemarle Street, W.1.

ABERDEEN

13th. I.E.E.—" The application of transistors to line communication equipment " by H. T. Prior, D. J. R. Chapman and A. A. M. Whitehead at 7.30 at Robert Gordon's Technical College.

BIRMINGHAM

13th. Society of Instrument Technology.—" Ultrasonic inspection techniques " by W. B. Emms at 7.0 in the Lecture Theatre of the Byng Kendrick Suite, Gosta Green College of Technology, Aston Street.

23rd. I.E.E.—" Learning machines " by P. Huggins at 6.0 at the James Watt Institute.

BRISTOL

18th. Brit.I.R.E.—" Data recording and presentation " by D. W. Thomasson at 7.0 at the School of Management Studies, Unity Street.

CHELTENHAM

27th. Brit.I.R.E.—" A vidicon television camera channel " by B. J. Pover at 7.0 at North Gloucestershire Technical College.

DUNDEE

12th. I.E.E.—" The application of transistors to line communication equipment " by H. T. Prior, D. J. R. Chapman and A. A. M. Whitehead at 7.0 in the Electrical Engineering Department, Queen's College.

EDINBURGH

9th. Institute of Physics.—" Light waves, radio waves and photons " by R. M. Sillito at 7.15 at the University.

12th. Brit.I.R.E.—" The transistor and its use in communication and control equipment" by E. Wolfendale at 7.0 at the Department of Natural Philosophy, The University.

GLASGOW

10th. Institute of Physics.—" Light waves, radio waves and photons " by R. M. Sillito at 7.15 at the University.

11th. Brit.I.R.E.—" The transistor and its use in communication and control equipment " by E. Wolfendale at 7.0 at the Institution of Engineers and Shipbuilders, 39 Elmbank Crescent.

25th. I.E.E.—Faraday lecture on " Electrical machines " by Professor M. G. Say at 6.0 at St. Andrew's Hall.

HALIFAX

16th. Institution of Production Engineers.—" Electronic copying on machine tools " by R. Lawson at 7.30 at Percival Whitley College, Francis Street.

LIVERPOOL

10th. Brit.I.R.E.—" The use of transistors in communications and control " by E. Wolfendale at 7.0 at the University Club.

11th. I.E.E.—" Vision and position —two electronic aids to marine navigation " by Dr. R. B. Mitchell and C. Powell at 6.0 at The Temple, Dale Street.

MANCHESTER

12th. Brit.I.R.E.—" Progress in permanent magnet materials " by J. E. Gould at 6.30 at the Reynolds Hall, College of Technology, Sackville Street.

MIDDLESBROUGH

12th. Society of Instrument Technology.—" Analogue computers " by R. E. Hare at 7.30 at the Cleveland Scientific & Technical Institute, Corporation Road.

NEWCASTLE

11th. Brit.I.R.E.—" Electronic welding controls " by C. R. Bates at 6.0 at the Institution of Mining and Mechanical Engineers, Westgate Road.

18th. Society of Instrument Technology.—" The principles and manufacture of junction transistors " by P. I. Nicholson at 7.0 at The Conference Room, Roadway House, Oxford Street.

NEWPORT

25th. Society of Instrument Technology.—" Transistors " by S. S. Goldberg at 6.45 at the Newport & Monmouthshire College of Technology.

READING

23rd. I.E.E.—" An introduction to electronic computers " by R. C. M. Barnes at 7.15 at the George Hotel, King Street.

SALISBURY

11th. I.E.E.—" The planning and installation of a television transmitting station " by D. B. Weigall at 6.30 at S.E.B. Showrooms, 17 New Canal.

WOLVERHAMPTON

11th. Brit.I.R.E.—" Recent developments in semiconductor rectifiers " by J. Bulman at 7.15 at the College of Technology, Wulfruna Street.

UNBIASED

By FREE GRID

לְפִי-חָרֶב

THE Editor, wearied of etymological alarums and excursions, and wishing to terminate them, has asked me to bring them to a close by commenting on the following notes he has received condemning my remarks in the correspondence columns of the July/August issue. Mr. Mark Thornton writes:

"Free Grid's exegesis on the word φωνή may seem very erudite, but on closer inspection it fails to convince in almost every detail. I will go through the more controversial things he says point by point.

(a) φονή cannot, as every Greek scholar knows, be derived from a verb with an α stem like φάω, for the α and the ο would contract into ω (as they do in φωνή) not into ο. The word is in fact derived from a verb φένω (never in fact found in the present tense) which is a by-form of φείνω, meaning both 'to slay' and 'to beat.' (All this is to be found in Liddell and Scott's Greek Lexicon—Ninth (latest) edition.)

(b) φωνή is derived from φημί (I speak), which is related to φάω. Thus it will be seen that φονή and φωνή are in no way connected.

(c) φονή may be transliterated 'phone' by 'Free Grid,' but it does not occur as such in any English word. The 'phone' in English is φωνη.

(d) There is not a hint in the whole of classical Greek literature that φονή has anything to do with mouths; the only evidence that 'Free Grid' can adduce in support of his theory is an exceedingly unconvincing passage from Exodus. I admit that the Authorised Version translates this verse 'on the edge of the sword,' but this is erroneous for two reasons. First, 'ἐν' means 'in' not 'on'; secondly, in no other passage does φονή mean 'edge.' No Greek scholar worth his salt would hesitate to translate this phrase 'in a slaughter wrought by the sword.' Clearly, 'Free Grid's' translation of φονή as the 'mouth of the sword' is nothing more than a red herring.

(e) Similarly, classical Greek never used φωνή in the phrase 'voice of the sword.' The nearest to it is Homer's 'battle-cry (φωνή) of the Trojans and Achaeans.' Homer, as in that phrase, always used φωνή of people. Considering that he is the earliest extant Greek author, we may take it that 'voice' is the original meaning of φωνή. Indeed, Liddell and Scott only quote one example of an inanimate use of φωνή in the whole of classical Greek prose—Plato talks of the 'voices of musical instruments,' just as we do.

(f) This being so, 'Free Grid's' remarks about battles are rather pointless; and anyway in a battle surely the battle cries (animate) come before the clash of arms, not the clash of arms first as 'Free Grid' suggests. In a word, 'Free Grid's' case rests on nothing more than a mistranslation of φονή and a distortion of the meaning of φωνή. There is therefore no need for anyone except 'Free Grid' to think of a monophonic gramophone as a 'one sound reproducer.' No doubt 'Free Grid' is still opposed to the word because it 'does not call to mind . . . the rich polyphonic sounds of music and well modulated voices'—but after all is it meant to? Monophonic does refer to the gramophone and not to the music. The polyphony of the music is important but in this case irrelevant."

Readers' etymological excursions.

Naturally I feel a little flattered at being condemned in such illustrious company as the translators of the Authorised Version whose interpretation of Exodus XVII, 13, the Editor's correspondent says is erroneous, and my quotation of it unconvincing.

He tries to "rub it in good and proper" when he says that no Greek scholar worthy of his salt would hesitate to translate this passage in the manner he suggests. But he rather overreaches himself for, of necessity, he condemns not only the translators of the A.V. of 1611 but also the equally learned men who endorsed the A.V. translation of this passage when they gave us the Revised Version in 1881, to say nothing of later translators such as the late Monsignor Ronald Knox, a scholar of no mean reputation who, as recently as ten years ago gave us his own independent interpretation in which he suggested only one trivial alteration—the substitution of "point" (of the sword) for "edge."

But the editor's correspondent stands self-condemned in the two reasons he gives for castigating the A.V. translators, and also myself for quoting them. He gives as his first reason the alleged fact that ἐν means "in" and not "on." Unfortunately his own champions Liddell and Scott, for whom I have the greatest respect, let him down for they tell us that ἐν means "in," "on," "with" and several other things according to the context in which it is used.

This correspondent's second reason is that in no other passage does φονή mean "edge"; but once more Liddell and Scott fail him as they give three other passages, namely, Numbers XXI, 24; Deuteronomy XIII, 15; and Deuteronomy XX, 13; but, of course, it must be admitted that these passages are all the work of the same "erroneous" translators.

Back to the very origins of Greek.

As for φονή having no connection with φάω (and, therefore, with φωνη), Parkhurst, a learned Cambridge scholar of the 18th century, thought otherwise although he did not, of course, deny that its next of kin was φένω just as φημί is the next of kin of φωνή. Parkhurst takes us right back to the old Cadmean alphabet and the very origins of Greek in the second millennium B.C. in which the unhellenistic letters ω and η did not exist, which, incidentally, Plato mentions in his Cratylus.

Some centuries later came Homer (*circa* 900 B.C.) by which time the new letters, and the new word spellings they brought with them, had thoroughly settled down, complete with all the etymological rules with which the Editor's correspondent is obviously so very familiar.

Finally, this correspondent appears to have read his *Wireless World* as carelessly as he has his Liddell and Scott, otherwise he would know that I never said anything about the "rich polyphonic sounds of music and well-modulated voices" as he obviously implies. We must, I think, agree to differ like the learned mental specialists in a recent *cause célèbre* in the Courts.

The Editor has also passed to me a very interesting letter from Dr. Leslie Knopp who writes:

"Free Grid's reply to Mr. Pawley's letter is both misleading and inaccurate, although Mr. Pawley's statement is not strictly correct.

"The primary meaning of φωνή was *the sound of the voice* (principally of men) subsequently it was used to mean any articulate sound, and by some careless writers, to mean any sound or tone. φωνή should be used only for articulate sound as opposed to ψόφος for inarticulate sound and, Mr. Editor, you can kindly inform Master Free Grid that the Greek texts of LXX are very corrupt—but a literal translation of Theodotion's version of Ex. XVII, 13 would be:

"Whereafter the chosen [men of] Joshua made uncomfortable Amalech [and his] people with the slaughter swords [which have very sharp edges] or φωνήσυριγγων for sound from inanimate objects.

"Free Grid had better get off his war-horse! Although Xenophon used φωνή to mean the cry of men in battle, φύλοπις is more correct for *din of battle* or φλούσβος for *confused noise*.

"φονή means *slaughter* or *murder* (always in the plural) and comes from the verb φονεύω which has nothing whatever to do with the anatomy."

Dr. Knopp makes criticisms similar to some, but not all, of those put forward by Mr. Thornton but he condemns also those people responsible for certain corrupt texts of the Septuagint, and in this I have a sneaking sympathy with him. Since this contentious Greek text of Exodus XVII, 13 has proved such a stumbling block, I have reproduced it at the head of these notes in Hebrew, the tongue in which it was originally written. This should make everything clear to everybody. [If not, will they kindly join with me in calling it a day!—ED.]

Cacophonous Caterwauling

WHY is it that nothing seems to be done about the irritating whistles from neighbouring television sets which plague listeners to programmes on the medium-wave band of "blind" broadcasting? Every reader of *Wireless World* knows its cause and the technical problems surrounding its absolute removal; but why don't we who have passed the "eleven plus" and therefore prefer the civilized musical programmes of blind broadcasting to the pædomœous puerilities of so many television programmes raise such a clamour that the P.M.G. is forced to do something about it under the powers which he undoubtedly has? Don't tell me that the obvious answer is to listen on the v.h.f. band; there are some of us who prefer our music from the continent.

RANDOM RADIATIONS

By "DIALLIST"

Service Without Tears

ABOUT this time last year, if I remember aright, I praised the steps that some radio and television manufacturers had taken to make things easier for the serviceman when he's engaged in trouble-tracking. I'm glad to see that the good work goes on this year. There are sets which can be removed easily from their cabinets, hinged panels and many other aids to getting quickly at their innards. But I still don't like to see four-contact components, such as transformers, soldered into sockets in printed circuits. As one dealer put it, to get them out you really need a soldering iron with four adjustable bits! There's always the risk, too, that when they're being removed or replaced the printed wiring may be accidentally damaged. However, there are some components on the market which overcome the disconnection problem by using spring-loaded contacts. One of the latest examples is a potentiometer with spring-loaded contacts on the printed-circuit chassis of R.G.D. and Regentone sets. The interesting point is that the potentiometer is mounted so that the contacts are applied to the *edge* of the printed circuit board, not to its face. Actually, they fit into little indentations cut along the edge of the board. When the solder in each indentation is melted the contact springs away from the printed circuit.

TV Totals

OFFICIAL figures for the increase of television receivers in Europe since 1954 make interesting reading. The latest figures are naturally a little stale, for it takes some time to collect and publish the information. Our own G.P.O.'s licence figures, for example, are generally a good few weeks behindhand. However, at the end of 1954 there were 3,239,000 TV sets in Europe this side of the Iron Curtain and the latest figure is 14,291,000—an amazing advance in about four and a half years. Our own country has always been at the head of the list, with Western Germany, whose sets increased from 1,211,935 to 2,125,130 during 1958, next, but a long way behind. Third comes Italy with 1,098,899, and fourth France, where receivers numbered 988,594 when the list was drawn up, and are now probably well above the million mark. At first sight it's rather surprising that there should be only 50,304 sets in a prosperous country like Switzerland; but there must be large tracts of mountainous country where reception is still impossible unless the Italian scheme of a fly-power satellite station for almost every valley is adopted.

Not Too Loud

IN 1952 the Society of Music Enthusiasts (of which P. G. A. H. Voigt was at one time chairman) was founded in Toronto. Until recently it was a flourishing concern; now lack of support has forced it to close down, which is a pity. It's rather surprising, too, considering what a vogue there is for hi-fi. Talking of hi-fi—which to some people too often means excessive volume—calls to mind some verses by Christine Britton issued some time ago by the Society of Music Enthusiasts. Her "Neighbour's Lament" is very much to the point.

Nowadays, it's smart to be
Hep to high fidelity;
Run and buy them, do not falter—
Naked chassis, plywood altar!

Learn the jargon; rant and rave
About the baffles that you crave,
Speak of speakers reverently
Own a minimum of three.

* * *

Twist the knobs eternally
Speaking sonic symmetry
Accept the plaudits of the town—
But for S.M.E.'s sake TURN IT DOWN!

It's Skill You Pay For

"THE dealer replaced a component costing 1s 3d and charged me 10s 6d for the job." One often hears that sort of grouse from people who don't believe that the serviceman has to be paid for all the time he's away from his workshop, if he comes to your house, that he has to have some pretty expensive testing and measuring instruments available and that above all a fault in a sound or television set may take a long time to track down. There's too much competition nowadays for dealers to be tempted to make excessive charges. There may be odd ones here and there who do, but they don't as a rule stay long in the game, for a bad reputation is soon built up and that's their undoing. What people are apt to forget is that they're paying a good man for his skill.

Bogus Degrees

ANYONE who looks at the advertisement pages of some American papers and magazines can't help being struck by the number of concerns which offer to help those who enrol with them to get degrees or qualifications in a vast variety of subjects. The American Council on Education has recently made an exhaustive survey and reports that whilst there are many reputable organizations there are swarms of dishonest concerns which, they reckon, are cheating students in other countries to the tune of £25M a year—and getting away with it. Such students, officially estimated at 750,000 every year, are induced to pay good money for a completely "phoney" degree, not worth the price of the paper on which the diploma is engraved. I don't imagine that many of the victims who become alleged Masters of Electronic Technology, or Doctors of this, that or the other come from this country, for they'd find it very hard to get their spurious qualifications accepted by prospective employers here. Still, one never knows.

Bankers and Electronics

THE Big Banks are becoming very electronics minded these days. Closed-circuit television enables the manager to have your account put before his eyes when you go to his office in the hope of increasing your overdraft. And recently one of the Big Five has placed an order for a transistor Emidec computer. It is to be installed at a central point in London and will deal with the 40,000 accounts of 15 branches. Each branch will send in its facts and figures *via* the teleprinter and the answers will be returned to it in the same way. The cost is pretty big—£125,000 for the computer alone and additions and gadgets may bring it up to nearly double that figure. But it will save a lot of time —and time, we're told is money. Electronic devices have a great deal to offer to big businesses and it's good to see that this is becoming more and more widely appreciated.