Wireless World

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V.H.F. Very Much at Sea

THE world as a whole seems to have got itself into an almost inextricable tangle over international marine radio-telephone communication on v.h.f. The trouble started with the Atlantic City conference in 1947, where, we can now see clearly, insufficient thought was given to the framing of regulations for this branch of communications. As a result, frequency modulation is used in the Americas while almost everywhere else amplitude modulation has been adopted.

So far as purely local marine services are concerned, the lack of universally accepted standards is not necessarily a serious handicap. But it is a different matter when we come to ocean-going ships, which, to derive the fullest benefit from v.h.f. equipment, should be able to communicate freely with coastal stations, as well as with tugs and possibly other ships, in all parts of the world. For these vessels, universally agreed standards are clearly desirable.

America, as the principal champion of frequency modulation, has suggested that Great Britain should change over to that system, and it has been implied in reply to questions in Parliament that this change has been considered. The Post Office, however, in a memorandum issued as long ago as 1949, showed itself very much in favour of amplitude modulation. Whatever may be the advantages of f.m. for broadcasting and for some other services, it certainly has not been proved that these hold good for marine communication. A strong argument advanced against f.m. for marine applications is that it would prevent intercommunication between ships and a.m.-equipped aircraft in case of accidents.

All these matters are discussed at length in a statement, summarized on another page, recently issued by Rees Mace Marine. For an ultimate solution of the various problems, the company, appreciating the necessity for a completely new international agreement, pleads for the setting up of a truly representative marine international body. For such a highly specialized branch of communications, a body of this kind would appear to be essential, but, inevitably, the framing of new international regulations and their universal acceptance would take years. As a matter of short-term policy, Rees Mace face the inevitable, and suggest that ships sailing to those countries which have adopted f.m. should be fitted with equipment for dual modulation as soon as the other factors involved can be agreed internationally. This proposal does at least provide a realistic solution of an awkward problem.

Safety in the Air

IF we wireless people had our way, ships and aircraft would become merely floating or flying platforms for the carrying of radio equipment. So runs an oft-repeated gibe and, in our more dispassionate moments, we must admit there is a grain of truth in it. We must always bear clearly in mind the fact that the primary function of craft navigating sea or air is to carry passengers and freight as economically as possible. There is, particularly in the air, a distinct upper limit to the amount of space and weight that can be allocated to wireless gear. Then there are the associated problems of operation and maintenance; both of these are mainly economic.

These thoughts are provoked by recent correspondence originating in *The Times*, where it was suggested that passenger aircraft could be made a good deal safer if more extensive use were made of airborne radar for preventing collisions with mountain peaks, other aircraft and dangerous clouds.

All this raises problems that cannot be summarily disposed of, one way or the other. Elsewhere in this issue a contributor who cannot be accused of undue partiality in either direction examines dispassionately some of the problems inherent in the use of airborne radar for civil aviation. Very roughly, his conclusions are that the installation of cloud warning radar may be justified on certain routes at certain times of year, but the practicability of its general application is extremely doubtful.

No doubt, however, there will be considerable technical development in this field. A device combining the functions of radio-altimeter and cloud-warning indicator, with sequential scanning in different planes and simultaneous but independent presentation of the two kinds of information, should not be beyond the bounds of technical practicability.

"Chameleon" Oscillator

Versatile Modified Hartley Circuit Giving High Frequency Stability

By THOMAS RODDAM

ALTHOUGH you might not think so, if you took these columns as a statistical guide, oscillators are our bread and butter: or perhaps our bread, with modulators playing the role of butter. Without these two essential devices the whole of the radio field would be non-existent. It is rather surprising, therefore, how rare it is to see any description of a newish oscillator circuit, while every variant of a variant of an amplifier circuit is described in detail. One reason is that oscillators are fairly easy to build, and, apart from the traditional reversal of the feedback winding, they usually work after a fashion as soon as they are connected. When the oscillator is to work over a frequency range the requirements for stability are normally fairly lax, and any of the textbook circuits will do.

For more advanced work there is always the crystal oscillator, the Meacham bridge circuit,[1] the Gouriet circuit[2] or the Tillman circuit.[3] But these are complicated, or difficult to design, or use a lot of components, or give rather a small output, or don't give a sinusoidal output. There appears to be room for a good middle-class oscillator giving a fairly large sinusoidal output and good stability, and not using too many components.

The oscillator described in this article appears to me to offer all these advantages. The stability against variations in valves and supplies is high, so that the frequency can be trusted to a few parts in 10^3 without supply stabilization, or better than 1 part in 10^4 if the anode supply is stabilized. It uses relatively few components in its basic form, produces all the output the valve can give, and has a very low distortion content. To date it has been tested at frequencies from 500 c/s to 10 Mc/s, using exactly the same design method, and has worked according to plan every time. This last feature, designability, is one which is often ignored in oscillator circuits: my own view is that if you can't design it you can't trust it.

The title I have chosen for this article reveals one difficulty: there are several different ways of approaching the circuit, all equally valid and all stressing different aspects of the operation. Rather than prejudge the issue, I evade it.

The basic circuit of the oscillator is shown in Fig. 1. Apart from the resistance R, it is just a cathode-coupled Hartley circuit, and the addition of R might be regarded as a bit of whimsy intended to make things more complicated. This is not so, however, because the introduction of R ties the whole circuit down to an optimum design. It also enables us to transform the circuit in several different ways: we shall come back to this point later.

Fig. 2 shows the equivalent circuit, with the valve regarded as a cathode follower and the grid connection dotted. The valve becomes a generator $\frac{\mu}{\mu+1}e_g$ with internal impedance $1/g_m$, acting in series with R: the losses in the tuned circuit are represented by the resistance R_2, which is the dynamic impedance of the circuit at anti-resonance.

The design problem is obviously to determine where the tap A should be on the coil, and what value of R should be used. Clearly a large value of R will be advantageous, because R and $1/g_m$ are in series, so that the bigger we make R, the more we swamp $1/g_m$ and the less effect this term will have on the behaviour of the circuit. A high value of R will help to keep the valve out of the circuit.

The coil acts as an auto-transformer, with a ratio $1:n$, so that at anti-resonance we shall see across AB a resistance of R_2/n^2. The voltage at AB is thus

$$\frac{\mu}{\mu+1}\cdot e_g\left(\frac{R_2}{n^2}\right)\Big/\left(\frac{R_2}{n^2}+R+\frac{1}{g_m}\right)$$

and as the auto-transformer has a step-up of n times, the voltage across BC is

$$n\cdot\frac{\mu}{\mu+1}\cdot e_g\left(\frac{R_2}{n^2}\right)\Big/\left(\frac{R_2}{n^2}+R+\frac{1}{g_m}\right)$$

This, of course, is just e_g, so that we must have

$$\frac{n\mu}{\mu+1}\cdot\frac{R_2}{(R_2+n^2R+n^2/g_m)}=1$$

For any practical valve, μ is large enough for $\mu/(\mu+1)$ to be taken as unity, within a few per cent.

Fig. 1. Skeleton of the modified Hartley circuit: the lettering is carried over to Fig 2.

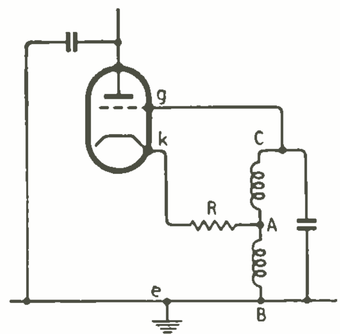
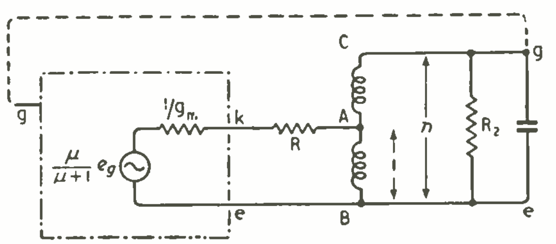


Fig. 2. (below): Equivalent circuit, for calculation purposes. R_2 is the loss in the coil.



[1] *Bell System Technical Journal*, Oct. 1938.
[2] *Wireless Engineer*, April 1950.
[3] *Wireless Engineer*, Dec. 1947.

We intend to have R very much greater than $1/g_m$, to decouple $1/g_m$ from the circuit. A fairly good approximation, therefore, is that

$$\frac{nR_2}{R_2 + n^2R} = 1 \text{ or } R = \frac{n-1}{n^2} R_2$$

In this equation R_2 is fixed, because it is a property of the coil. The maximum value of R is then obtained if $n = 2$, when $R = R_2/4$. You can check by plotting the graph of $(n - 1)/n^2$ that the maximum is a fairly flat one, so that the result is not particularly disturbed by the approximations we have made, and subject to these approximations we find that the centre-tapped coil is the *best* solution.

We are still rather in the air, however, because the design simply says " take one coil." Can we find out anything more? We have seen that across AB we now have a resistance of $R_2/4$, and at the cathode of the valve we shall see $R + \frac{R_2}{4}$, or $R_2/2$. We know that a high μ will help to make $\mu/(\mu + 1)$ more independent of μ, and a high g_m will keep $1/g_m$ small, so that we can choose a valve. The CV455 (ECC81, 12AT7) has a g_m of 5 mA/volt and a μ of about 50 (each section), so that $\mu/(\mu + 1)$ is 0.98 and $1/g_m$ is 200 ohms. A good load for this valve is about 25,000 ohms, which gives a compromise between gain and power output. We must therefore take $R_2 = 50,000$ ohms, so that R = 12,500 ohms. Of this, 200 ohms is in the term $1/g\mu$, leaving 12,300 ohms. Even so, we haven't taken account of the $\mu/(\mu + 1)$ term, which would reduce the 12,500 ohms to 12,250 ohms, giving R = 12,000 ohms as a pretty close approximation.

That final dubious piece of arithmetic, with 50 ohms disappearing up my sleeve, is justified by the fact that the coil is yet to be calculated. We know that we want R_2 to be 50,000 ohms. The next step is to choose a coil type, knowing the order of Q to be expected, and from this value of Q and the value of R_2 just determined calculate the inductance. Since $Q = R_2/2\pi fL$ we have

$$L = R_2/2\pi fQ \qquad \text{and } C = 1/(2\pi f)^2L$$

Having calculated the coil and constructed it, with its centre-tap, the actual value of Q can be determined, and from this the true values of R_2 and R. That is why the calculation of R above was scamped—the data lacked precision, anyway.

It is, unfortunately, necessary to add some more components, because with 10 kΩ odd in the cathode the valve current will be so small that the mutual conductance will be much lower than we have assumed. The necessary modifications are shown in Fig. 3, and as you can see, they are just a conventional cathode bias resistor R_k, which forms part of the total R, and a grid capacitor and leak resistor. The bias resistor should be the ordinary Class A amplifier bias resistor, chosen to ensure that the value will cut off rather than run into grid current. The grid circuit should be generously proportioned, with $2\pi f\, C_g R_g \gg 1$ to avoid any phase shift which might alter the operating frequency. And there is the oscillator circuit, all worked out.

A particular design, operating at 1,600 c/s, made use of a dust-iron cored coil with a Q in the region of 50. For this case, assuming still that we want $R_2 = 50,000$ ohms, we have $L = R_2/2\pi fQ = 50,000/10,000 \times 50 = 100$ mH.

When tested, the coil was found to have a Q of 60, making $R_2 = 60,000$ ohms and the approximate value of R = 15,000 ohms. No attempt was made to calculate the exact value, but a normal-tolerance 15 kΩ resistor was used and the appropriate value obtained by adding in parallel a resistance box covering the range up to 1 MΩ. A final test showed that 330 kΩ could be used for this position.

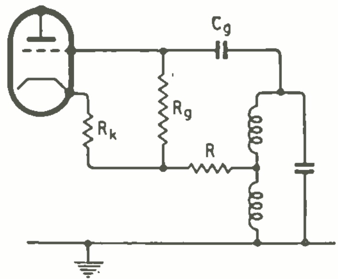


Fig. 3. Adding R_k, R_L and C_g to get the valve biased to the best point.

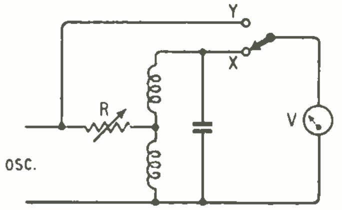


Fig. 4. No Q-meter? You can use this circuit to find the value of R needed in the oscillator. V must be a high-impedance valve voltmeter.

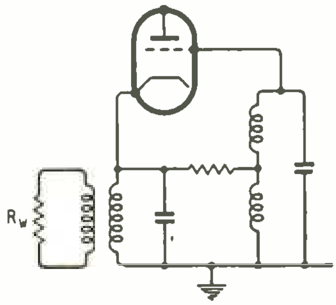


Fig. 5. A transformer in the cathode makes it possible to get the full voltage across the valve: more out, more stable.

Measuring " Q "

The next stage in refinement gives further advantages, but before continuing with this it is worth noticing that a Q-meter is not needed in the design of this circuit. It can perfectly well act as its own Q-meter and, indeed, for some types of core material it is necessary to use this technique. The only apparatus needed is an oscillator, a high-impedance valve voltmeter, and a variable resistance unit. The circuit is shown in Fig. 4. The valve voltmeter is first connected to X, and the oscillator, or the circuit tuning, adjusted until a maximum reading is obtained. The switch is then moved to the position Y, and a convenient deflection obtained on the valve voltmeter. Then switching between X and Y the value of R is adjusted to obtain the same reading at both points. By the mathematics already given, $R = R_2/4$, so that Q can easily be calculated. This circuit is also very useful for studying core materials in which the loss varies with the level, because the value of R_2 for any voltage across the coil is easily, and directly, measured.

The ordinary Q-meter is only useful if the Q does not depend on the signal level.

A disadvantage of the oscillator circuit as it appears in Fig. 3, is that a lot of supply power is wasted in R, and that there is nowhere to connect a load. The other half of the CV455 can be used as a buffer amplifier, of course, but it would be advantageous to find some way of keeping the d.c. out of R, for economy, to avoid changes in R caused by heating and to keep g_m high by passing more current through the valve. With the values discussed above only about one-third of the supply voltage is available between anode and cathode, which is a severe limitation. The circuit shown in Fig. 5 was evolved to deal with this question. The transformer primary is chosen to have a resistance equal to the required bias resistance in low frequency designs, and has an added series resistor, which is not shown, in high frequency designs. A tuning capacitor is provided, but the tuning is extremely coarse, since the valve presents a very low impedance in shunt across the circuit. Power can be taken off in a secondary load R_W, thus avoiding the need for a buffer amplifier.

It was found that even though now loaded directly, the performance of the oscillator was not degraded, owing to the fact that the full supply voltage now appeared across the valve. The problem was then to calculate the cathode transformer. As before, we must choose the load which is to be presented to the valve, and we will usually be free to take some compromise between maximum gain and maximum power, leaning now towards the conditions for maximum power. Let us call this optimum load R_t. If all the power goes into the load, and none into the oscillatory circuit, the oscillator will not be stable: if all the power goes into the oscillatory circuit and none into the load it will not be very useful. As a compromise, let us split the power equally between the load and the oscillator itself. This gives us the conditions indicated in Fig. 6, so that if we know R_W, the actual load, the output transformer must have a ratio of $\sqrt{2R_t/R_W}$. The oscillator circuit must be recalculated, with R now equal to R_t and $R_2 = 4R_t$. This does not make so very much difference, because R_t will be lower than the optimum load for gain alone. In a particular design, the one for which the numerical example above was actually used, the value of R_t for a CV455 was taken as 25,000 ohms, and in the embodiment of this design it was found that a change of supply voltage from 150 V to 300 V produced only about 1 part in 1,000 change in frequency. Small changes of anode voltage had very little effect on the frequency, and quite elaborate equipment was needed to measure the changes.

All the best oscillator designers incorporate a.g.c. in their designs: none is used in this oscillator. The reason why it is not needed here is in the vital inequality $R \gg 1/g_m$. Viewed at the point A in Fig. 1, the negative feedback is very large, and the valve is either operating in the linear region, or it is cut off. Even when the valve is not cut off, the impedance at the grid is very high, because of the cathode-follower action: when the valve is cut off, the impedance is, of course, even higher. As a result, the tank circuit is free to swing for a fraction of a cycle, and driven through a high resistance over the rest of the cycle. There isn't really very much which can upset the frequency.

Having decided that this circuit, which doesn't seem to have been analysed anywhere else, though it is mentioned in "Waveforms" (B. Chance *et alia*, M.I.T. Series, McGraw Hill), is a good one, there remains the problem of why it is quite so good. After staring at the circuit for quite a time it became clear that it can be drawn in the form shown in Fig. 7(a). I do not propose to go through the analysis of what

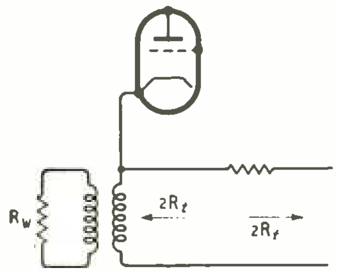
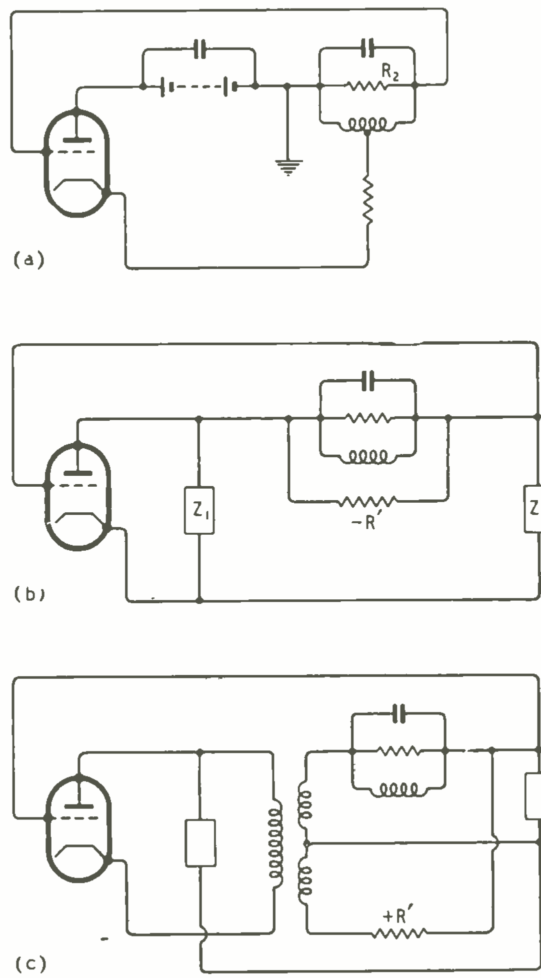


Fig. 6. The bottom of Fig. 5 looks like this as we calculate the cathode transformer.



Right: Fig. 7. Drawn as in (a) the circuit shows the bridged-T form. After the T-π transformation (b), and a further rearrangement (c), the circuit assumes a bridge form.

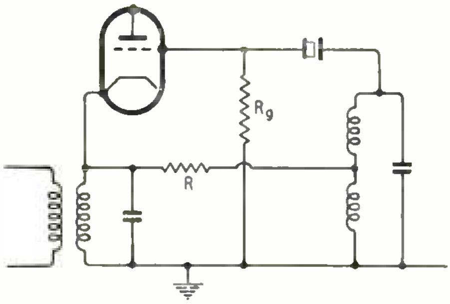


Fig. 8. You want to add a crystal? Just plug it in, and add a grid leak. The value of R needs to be reduced by a few per cent.

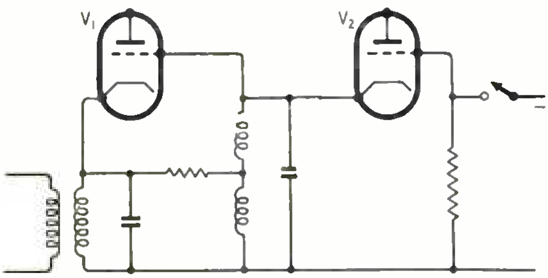


Fig. 9. The triode V_2 can be used to key the oscillator and provide the same starting phase to each pulse.

happens next, but by means of T—π transformation the network can be converted into the form of Fig. 7(b), with the shunt arm R transforming to a negative resistance —R′ this is the method used to obtain an infinite-Q rejection circuit, and it was described in *Wireless World* some years back[4]. A further operation gives us the equivalent circuit shown in Fig. 7(c), with a transformer providing a phase reversal on one side so that a positive R′ can be used.

Now we can see what is happening. The resistance R′ produces positive feedback from anode to grid, but this is offset by the negative feedback through the LCR circuit, except at the anti-resonant frequency of the LCR circuit. At this frequency the negative feedback through R_2 is not quite enough to prevent oscillation: at harmonic frequencies, of course, there is a lot of negative feedback, so that harmonics, and hum, too, are suppressed. Drawn in this way the circuit is obviously a bridge and has all the advantages of a bridge circuit. The reader may wonder why the oscillator does not include a thermistor for amplitude control, thus ensuring completely Class A operation. The answer is simple: thermistors with a suitable characteristic are hard to come by. For the example we have discussed the thermistor, which would replace the resistor R, would need to be about 12,000 ohms with an applied voltage of about 10 volts—a dissipation of the order of 10 mW. Furthermore, the resistance must rise with applied level. If this B-type characteristic were readily available it might be worth reconsidering the design to see if we could apply thermistors.

An interesting extension of the oscillator is to crystal control. It is not, I suppose, one of the very best crystal circuits, but it has a feature of extremely great value: the crystal current is predetermined quite accurately, so that there is no reason why the crystal should be overloaded. The necessary modification for crystal control is shown in Fig. 8. The circuit without the crystal is designed in the way already described, and is set up to give oscillations at the required frequency. The amplitude of oscillation is adjusted by trimming R. Suppose that this amplitude is 20 V, and that the recommended maximum crystal current is 25 μA. By choosing $Rg = 1\,M\Omega$, the crystal current cannot exceed 20 μA, because the grid swing, which is equal to the cathode swing, can only drive this current through the crystal and Rg in series. When the crystal is inserted, of course, the oscillator will probably not oscillate, because R will be just too high. A very small reduction of R will be needed to make up for the loss in the series resistance of the crystal. In this circuit the crystal is operating in its series mode, and I can see no reason why it should not be worked on an overtone, although I have not yet tried this.

One final variant is shown in Fig. 9. This is actually better known than the oscillator itself. It is a method of keying this oscillator to produce a very clean square wave-train which always starts with the same phase. When the key is down, V2 is completely backed off, and the oscillator functions quite normally. When the key is up, the grid of V2 goes to earth, V2 conducts and damps the tank circuit so heavily that the oscillations just stop. Each time the key is operated, therefore, the cathode of V2 drops sharply, brings the grid of V1 down with it, and the circuit is all set at a peak of the sinusoid, free to oscillate. This form is described in "Waveforms," referred to above.

The modified Hartley oscillator described in this article is an extremely simple and good circuit. As we have seen, it can be described as a bridge circuit; and it might also be well described as an over-balanced rejector circuit oscillator.

[4] June 1950, p. 223

Measuring Interference

DIFFICULTIES have for some time been experienced both in Germany and in this country in correlating the data on the measurement of interference from motor vehicles obtained in each country. Tests were, therefore, arranged through the Electrical Research Association and the Fernmeldetechnisches Zentralamt, with the co-operation of Joseph Lucas, Ltd. and the Bosch Co., in order to compare the behaviour of the British and German measuring equipment under identical conditions.

A comparison of the two types of equipment, as a result of tests which were carried out in January last year at the F.T.Z. at Darmstadt, is given in a report published by the E.R.A. This report (M/T123) entitled "Radio Interference from Motor Vehicles," by A. H. Ball and S. F. Pearce, shows that the British interference measuring equipment (Post Office measuring set RI2) will give indications of field strength from an ignition system approximately 20 db lower than that obtainable with the German set.

The results of the tests show why more elaborate suppression was required in Germany to meet the proposed limit of 120 μV/m than has usually been found necessary to conform to the British limit of 50 μV/m. Experience in Germany would be comparable with that in Great Britain if the proposed German limit were increased to 500 μV/m.

The report is obtainable from the British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorking Road, Leatherhead, Surrey, price 10s 9d by post.

By S. KELLY*

The Transistor in

DURING the five years since the introduction of transistors, considerable effort has been expended not only in the development of the transistors themselves but also in circuit techniques and associated components. The prime advantages of the transistor are the ability to work at very low power levels with high efficiency, small size and light weight. The disadvantages of currently available transistors are higher noise level than equivalent vacuum valves, rather bad temperature coefficient, and greater variability of characteristics than vacuum valves. So far as can be seen at present, the first and last of these criticisms are a question of manufacturing techniques and will be overcome as quantity mass production of transistors becomes fact. The question of temperature coefficient appears to be bound up in the nature of the beast and, for the time being at any rate, must be suffered. Variations in transistor characteristics and temperature coefficient can be compensated by circuit design, but are usually wasteful of gain, and with the present high cost of transistors cannot usually be justified on economic grounds for commercial applications.

It is important to appreciate that the transistor behaves almost as the dual of the familiar vacuum valve.[1] Additionally, there is considerable reaction between the input and output circuits coupled to the transistor, which is almost entirely absent in vacuum valve circuits at low frequencies, thus requiring an entirely different approach to circuit design. Unfortunately, junction transistors have not so far been generally available in this country, with the consequence that practical experience, which alone can give familiarity with any technological process, has been denied to the majority of designers.

Apart from specialist uses, such as for military requirements, computors, and the telephone industry, the main outlet for transistors in the domestic field in the next few years would appear to be in hearing aids and miniature "personal" radio receivers, where the high initial cost of the transistor is more than outweighed by the considerable saving in running costs. So far as can be seen, the transistors will all be of the junction type.

An output power of 2.5mW at 10 per cent distortion can be obtained from available junction transistors for a current consumption of 2mA at 3V, or an efficiency of 42 per cent. A modern hearing aid sub-miniature output pentode gives 0.95mW output at 10 per cent distortion for a total battery power consumption of 15.25mW with an efficiency of only 6 per cent. The significance of the transistor will be appreciated by those who have not already had experience of maintaining small battery-operated devices, when it is realized that the cost of "high-tension" power from batteries may cost as much as £5 per kilowatt hour as compared with, say, 1d from the national electricity supply grid.

Because of the low voltages and currents involved, the design of really sub-miniature components becomes a practical proposition, and the reader is referred to the article "Components for Transistors," by G. W. A. Dummer (*Wireless World*, May, 1953). These components, however, have been developed for the Services, and are not yet generally available.

Transistors can be used in various ways: (a) earthed base, (b) earthed emitter, and (c) earthed collector. Fig. 1 shows their approximate equivalent vacuum valve circuits.

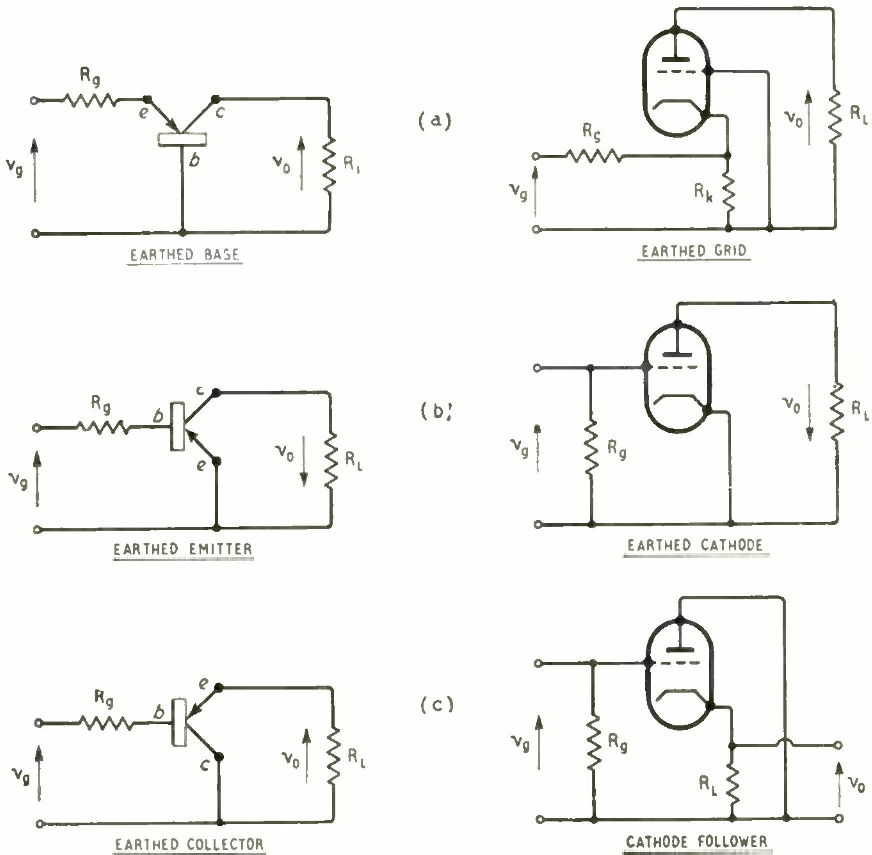
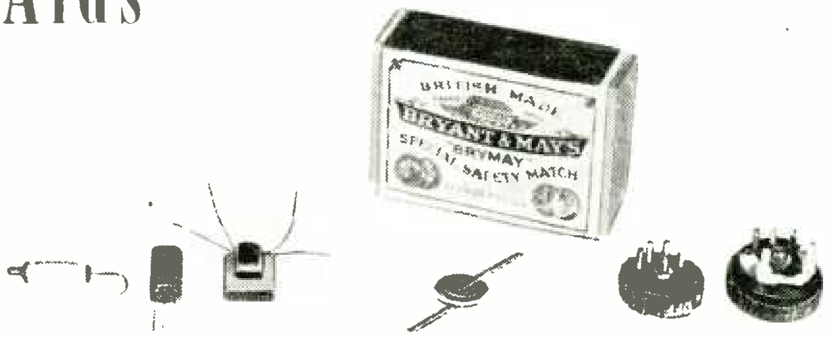


Fig. 1. Transistor circuits and their approximate valve duals.

* Cosmocord, Ltd.
[1] R. L. Wallace and G. Raisbeck. *B.S.T.J.* April, 1951

Hearing Aids

Its Impact on the Design of Components



Some typical transistor hearing aid components. (Left to right) 6μF electrolytic coupling capacitor, junction transistor, coupling transformer, bias cell, on-off switch and low-resistance logarithmic volume control.

It is emphasized that these are approximate only, but they are a good practical working guide. Application of feedback to the equivalent circuits can give an exact correlation,[2] but it is not justified in this dissertation.

When used as an earthed base amplifier, the input resistance lies between 40 and 100Ω and the output resistance between 100kΩ and 300kΩ; the power gain will vary from 10 to 20db for a variation in load impedance of 1,000 to 10,000Ω. As shown in Fig. 1 (a), this form of connection behaves very much the same as an earthed grid triode.

The earthed emitter gives the same general effect as a normally connected triode with the cathode at earth potential. The input resistance is 500 to 1,200Ω, the output 20kΩ to 100kΩ; the power gain is 20 to 30db for a source resistance of 800 to 1,200Ω, and a load resistance of 15kΩ to 25kΩ (Fig. 1 (b)).

When used as an earthed collector, Fig. 1 (c), the cathode follower configuration is approximated. The input resistance will vary from 10kΩ to 200kΩ when the load resistance is varied from 500 to 10,000Ω, the power gain being almost constant at about 10db for a variation in load resistance of 300 to 10,000Ω.

Circuit Design

From the above it is seen that there is considerable interaction between the input and output circuits, and the determination of the operating point, particularly when using a single power source (which is dictated by the ease of battery replacements, servicing, etc.), becomes a complicated affair. However, for the majority of audio-frequency applications, the earthed emitter configuration is used and the circuit designed backwards (i.e., decide power output, determine the best load resistance, then work towards the front end).

As we have seen, the input resistance of the average transistor working as an earthed emitter is of the order of 1,000Ω as against, say, 0.5 to 5MΩ for the grid resistance of a vacuum valve. The output impedance of the transistor will usually be of the order of 20,000Ω, and for maximum power gain the load resistance should approximate this value. In cascade circuits, some form of impedance transformer will therefore be required to couple the stages. Were transistors not so costly, it would be possible to use an earthed collector transistor as the impedance-transforming device between the earthed emitter units. Under present conditions it is more economic to use a transformer.

The transformer shown third from the left in the photograph measures 0.375in × 0.375in × 0.25in. The stack of 0.008in thick Mumetal laminations has a core cross-sectional area of 0.096in × 0.096in and the bobbin is 0.25in cube. The primary is wound with 3,500 turns of 49 s.w.g. and the secondary with 800 turns of the same gauge of wire. The insertion loss of the transformer at 3,000c/s is 2.7db under working conditions, the primary inductance being 6 henrys when measured with 0.1 volt a.c. across it.

The coupling condenser, which is of the electrolytic type, has a value of 5 to 10μF, in order to maintain the bass response with the low value of the load resistance. Compared with the remainder of the components, the electrolytic condenser is somewhat large, and some Continental manufacturers have replaced it with a modified form of bias cell (fourth from left in the photograph). This requires the circuit constants to be slightly rearranged so that a maximum potential difference of 1.2 volt across the cell terminals is not exceeded. Under these circumstances, the bias cell behaves as a capacitance of 30μF at 3,000c/s, the impedance being approximately constant with frequency and the leakage current negligible.

One of the severest headaches encountered to date has been the provision of sub-miniature volume controls with a low resistance value of 5,000Ω and a logarithmic track. These are now available in production quantities and when used between the first and second stages of the amplifier, the noise level is considerably less than that due to associated circuits.

Choice of Microphone

Valve-operated hearing aids almost invariably use piezo-electric microphones, the input resistance of the amplifier is usually of the order of 10 to 30 MΩ, and the design of the microphones is directed to obtain the highest practical open circuit voltage sensitivity. To this end, small crystals using series elements are used, resulting in an output of approximately 3 millivolts with a source capacity of 300 to 500pF. But the transistor has a low input impedance and must be thought of as a power-operated rather than a voltage-operated device.

Crystal microphones can be used successfully with transistors by using an appropriate matching trans-

[2] R. F. Shea, "Transistor Circuits" Chapter 15.

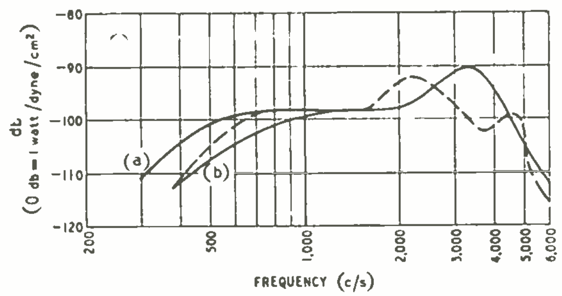


Fig. 2. Response of parallel-connected crystal with transformer working into 1,000-ohm load. Microphone capacitance (a) 4,000pF, (b) 2,000pF. A typical magnetic microphone response is shown dotted.

former. If a normal type of hearing aid microphone is used, the primary inductance of the transformer would need to be between 100 and 200H for adequate bass response. This high value of primary inductance can be reduced to approximately 20H or even less if certain elementary modifications are made to the crystal assembly. It can be shown that if a parallel combination of crystal elements instead of the usual series arrangement is used, the voltage is reduced by half, and the capacitance increased by four times—which, in terms of available *power*, is exactly the same as the first case. If the crystal is further subdivided, into a total of four elements, the capacitance is increased 16 times and the voltage output reduced to a quarter. (These two latter combinations giving between 2,000 and 4,000pF and 10,000 and 20,000pF respectively.)

Coupling Transformers

It thus becomes a practical proposition to design a sub-miniature matching transformer to couple the microphone to the transistor. In the case of the four-element crystal, the transformer previously described functions quite satisfactorily, but the crystal element is a rather costly proposition. The two-element parallel crystal can be used successfully if the primary inductance of the coupling transformer is approximately 20H. The absolute value is arranged to resonate with the microphone crystal capacitance at the low-frequency end of the spectrum (the −3db point). This has been taken as 750c/s for hearing aids, and without any secondary loading there will be a resonant rise in current at this frequency. The turns ratio is adjusted to give the maximum power transfer at 1,000c/s, resulting in a virtually aperiodic system, and a fall of 6db per octave below 750c/s. The actual transformer winding consists of 6,000 turns of 50 s.w.g tapped at 600 turns, and is used as an auto-transformer to conserve space.

The sensitivity of the microphone plus transformer is −100db referred to 1 watt per dyne per cm² at 1,000c/s and can be maintained easily to 6kc/s (Fig. 2). It should be noted that the high-frequency performance of these miniature transformers is extremely good, considering their simple construction, some units being only −1db at 20kc/s referred to the 1-kc/s level.

Magnetic-type microphones, which can be manufactured quite economically for low-impedance working, are quite a practical proposition, the coil being wound to give the correct source impedance for matching the input impedance of the transistor. The majority of present-day magnetic microphones are very similar in construction to the magnetic telephone receiver with the addition of an auxiliary diaphragm. The power sensitivity of these units is the same as the crystal microphone, being approximately −100db referred to 1 watt per dyne per cm.² With one or two notable exceptions, the high-frequency response is not good, there being a rapid cut-off above the main resonant frequency, which is usually about 2,500c/s.

The modern insert magnetic telephone receiver is characterized by high power sensitivity, good low-frequency response, and low distortion; but the high-frequency response could, with advantage, be improved. In most units the peak sensitivity is at about 2kc/s with a very rapid fall-off in sensitivity beyond 2.5 to 3kc/s. They can be wound to any required impedance between about 25 and 10,000Ω and can therefore be connected directly in the transistor collector feed circuit without an isolating transformer. Excellent impedance match can be obtained and they will give an output in excess of +120db referred to 0.0002 dyne per cm² (threshold level) for 2 milliwatts input power. This is usually adequate for most hearing aid and miniature receiver requirements.

Fig. 3 shows a complete hearing aid amplifier circuit which has performed satisfactorily with both American and British junction transistors.

Maximum power output, whilst keeping within the limiting values imposed by the transistor manufacturers, requires rather critical control of the base bias resistor, and it has usually been necessary to vary this resistance for optimum conditions, the value usually lying between 5kΩ and 30kΩ. Once the optimum value has been determined, it can be considered fixed for the life of the transistor, provided that the unit has not

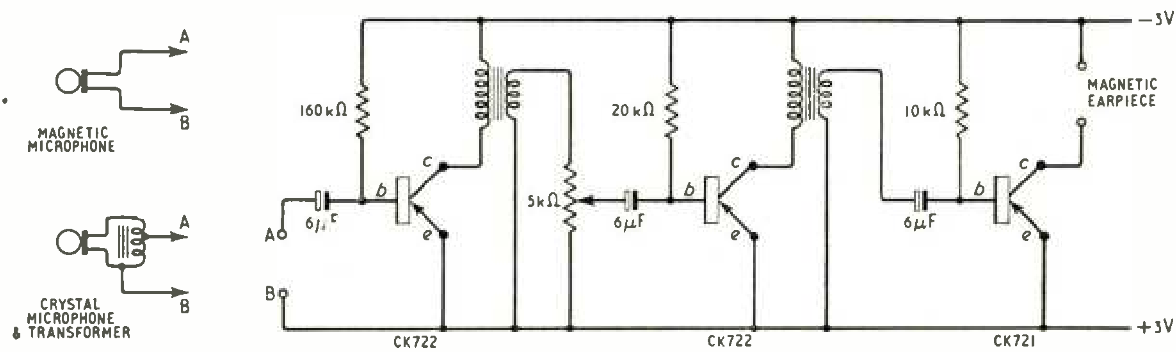


Fig. 3. Hearing aid circuit which gives good results with many makes of junction transistor.

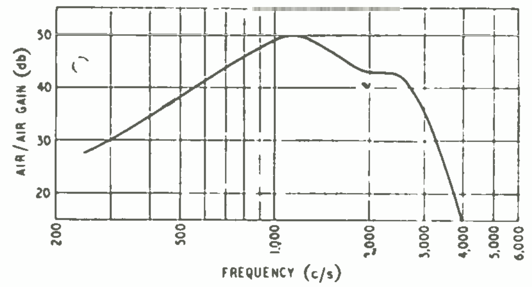


Fig. 4. "Air-to-air" overall gain of the hearing aid whose circuit is given in Fig. 3.

been exposed to temperatures in excess of about 60 deg C. It has been found easier to adjust the resistance until the collector current is of the order of 2 to 2.2mA, although for greater power output it can be adjusted for a maximum of about 4mA. This results in a reduction of the input impedance of the transistor and the coupling transformer turns ratio must be adjusted accordingly.

The second stage is not critical, but the adjustment of the base resistor can vary the overall gain quite considerably. Here, however 20kΩ has proved more satisfactory.

Noise Reduction

Either magnetic or crystal-cum-transformer microphones may be used, and the circuit is generally self-explanatory. There are, however, one or two points which need amplification. Usually the first transistor has to be carefully selected for noise and it has been found expedient to vary the base bias resistor for optimum results—about 160kΩ results in the best compromise between maximum gain and maximum signal-to-noise ratio.

The coupling transformers are the units previously described, and the maximum working gain is of the order of 80 to 85db. It is flat from about 500c/s to 15,000c/s. With care, the noise level can be dropped within 20db of Johnson noise. Transistor noise differs from other common types such as thermal and shot noise in that transistor noise per unit bandwidth varies approximately inversely with frequency,[3] (i.e., each octave of the frequency range contains the same noise power). The representative value of the collector open circuit noise voltage is 5 to 15 microvolts; the emitter open circuit voltage is usually 30 or 40db below this value. The total noise is, however, very dependent upon the operating point. The emitter noise is almost independent of the collector voltage whilst the collector noise depends strongly on it. In addition to this dependence on operating conditions, noise is also very dependent upon operating temperature, and, generally, the increase in noise is such as to detract considerably from the use of transistors in fairly low level circuits for use in temperatures in excess of 40 deg C. Additionally, the transistor parameters vary very considerably with temperature. For example, the collector resistance under a given set of conditions can vary from 100kΩ to 50kΩ over a temperature range of 20 deg to 70 deg C. The latter is considerably above normal ambient temperatures and will not usually be reached with transistors working under low power conditions, but this temperature can certainly be obtained if the transistor is called upon to deliver more than a few milliwatts of power.

Fig. 4 shows the air-to-air response of the complete hearing aid receiver, and before the high-fidelity enthusiasts raise their hands in pious horror, a word of explanation may be offered. The amplifier portion is quite flat in the high-frequency region, and the very rapid fall off with frequencies above the peak is due almost entirely to the insert telephone receiver. The low-frequency cut-off is deliberately engineered in the microphone circuit in order to provide the most desirable frequency response of +12db per octave which, according to the Medical Research Council Report No. 261, results in optimum articulation efficiency for deaf people. The overall performance is by no means ideal, but is comparable with the average two-valve and some of the three-valve hearing aid units being offered to the public today. The high-frequency response could be materially improved with a better high-frequency performance on the part of the telephone receiver. It may be thought possible to compensate for this lack of high-frequency response by altering the frequency characteristic of the amplifier or microphone, and this would be satisfaotory if the unit were not required to run at peak power over the whole frequency band. Obviously, if the output transistor is delivering peak output at 1,000c/s and a rise in frequency characteristic is built into the pre-amplifier, it will be grossly overloaded at these higher frequencies although, at lower levels, the measured frequency response may appear superior.

Much remains to be done in component development for use with transistors and, in this country at least, it can be said that generally transistor development is ahead of associated components. But, to revert to the introductory remarks, it is a pity that more transistors were not generally available earlier, because they are delightful little beasts and tend to grow upon one.

[3] H. C. Montgomery, *Bell Lab. Record* Sept., 1949.

PRODUCTION CONTROL

IN the report of the specialist team* on production planning and control which visited the United States in 1951, the use of radio as an aid to production control—in some quarters erroneously called radio control—is strongly recommended to British industry.

One of the first engineering concerns to employ radio communication to co-ordinate the movement of goods in its factories was Davey, Paxman and Company, of Colchester, Essex. Their installation, which includes five mobile units and a control station, was initially installed by Pye two years ago. Operating on 172.2 and 182.2 Mc/s, which are shared with (among others) a London taxi organization, the fixed station can readily be received at Harwich Quay, over 25 miles away. Its main use, however, is for the co-ordination of movement of heavy cranes and fork lifts within the main works and the conveyance of goods between the two factories which are about a mile-and-a-half apart.

With the proposed clearing of Band 3 to make room for an alternative television service, the position of such users is threatened and the recently formed Mobile Radio Users' Association is strongly contesting the users' case.

*Among the 12 members of the team were representatives of Plessey, B.T-H., E.M.I. and Automatic Telephone & Electric Co.

Measuring Non-Linearity

By D. C. PRESSEY. B.Sc. (Lond.)*

DISTORTION arises as a result of non-linearity in the input versus output characteristic of apparatus, and has been the subject of two recent articles in *Wireless World*[1,2]. This article has been written with the object of supplementing them with a method of measuring non-linearity that is simple, and has found numerous applications.

When the input is sinusoidal the output contains harmonics of the input frequency as well as the fundamental, and to measure or examine the distortion the fundamental must be somehow removed.

For the purpose of diagnosis, Wigan[1] has described a rather elaborate method for subtracting the fundamental; it requires both filters and phase-shifters. Tyler[2] uses a fairly simple valve filter to remove the fundamental.

The disadvantages of filters are that they may shift the phase of harmonics, and that they restrict the test frequency to that for which the filters were designed.

In the following method the substraction is carried out by a frequency-insensitive element, so that tests may be carried out from zero-frequency upwards and without the need, in general, of pure sine-wave test signals.

The basic principle is simply that if the apparatus is linear, and of gain A, the output may be cancelled by adding to it a voltage A times the input voltage, but in anti-phase to the output. If the apparatus is non-linear incomplete cancellation results, the difference being exactly equal to the amount of the non-linearity for every value of the input voltage.

This method was developed particularly to measure the non-linearity of d.c. computing amplifiers and other units having non-linearities of the order of 1% or less, but it is entirely suitable for less rigorous tests.

The process can be formulated mathematically as follows. The relationship between output and input can be written :—

$$v_o = av_i + bv_i^2 + cv_i^3 + \quad .. \quad .. \quad .. \qquad (1)$$

where the coefficient a defines the gain, and b, c, etc., are the coefficients of the non-linear terms. This relationship is depicted in Fig. 1, showing also that a is the slope of the tangent to the curve at the origin. If the apparatus were linear the output would be av_i, and adding $-av_i$ to equation (1) gives :

$$v_o - av_i = v_e = bv_i^2 + cv_i^2 + \quad .. \quad .. \qquad (2)$$

Strictly, the percentage non-linearity is given by :

$$N = (v_e/av_i) \times 100\% \quad .. \quad .. \quad .. \qquad (3)$$

* Southern Instruments Ltd., Camberley, Surrey.

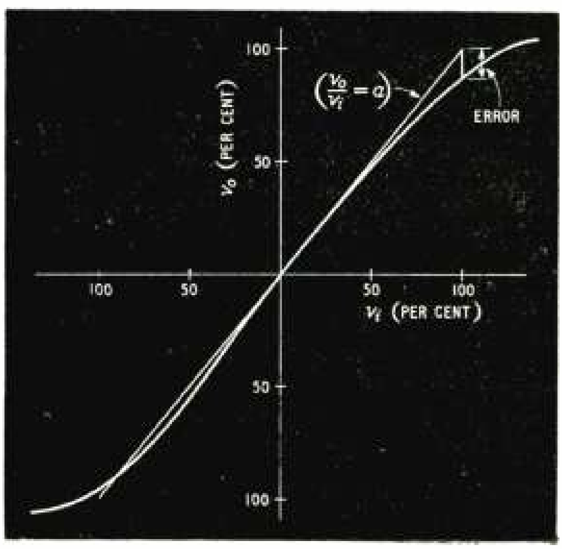


Fig. 1. Illustrative input/output characteristic.

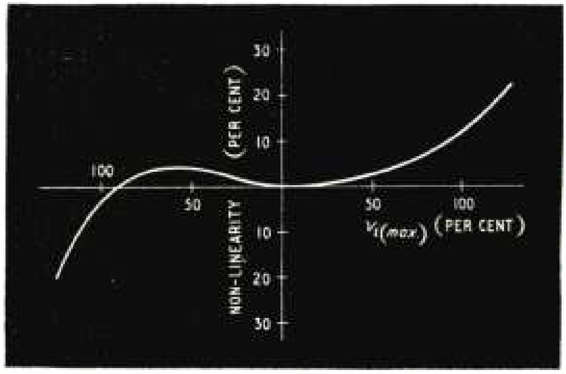


Fig. 2. Here, the non-linearity of the characteristic of Fig. 1 is plotted as a percentage of the nominal maximum output $av_{i(max)}$, against the input v_i. These two figures incidentally illustrate the difficulty of observing non-linearities of below 3% on c.r.t. displays corresponding to Fig. 1.

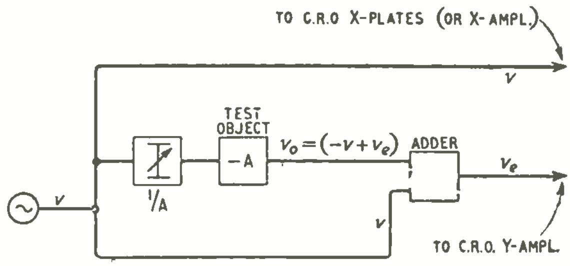


Fig. 3. Suitable experimental arrangement.

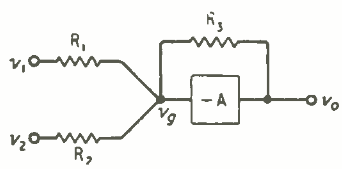


Fig. 4. Amplifier connections to provide an output proportional to the sum of two inputs. Typically $R_1 = R_2 = R_3 = 1M\Omega$.

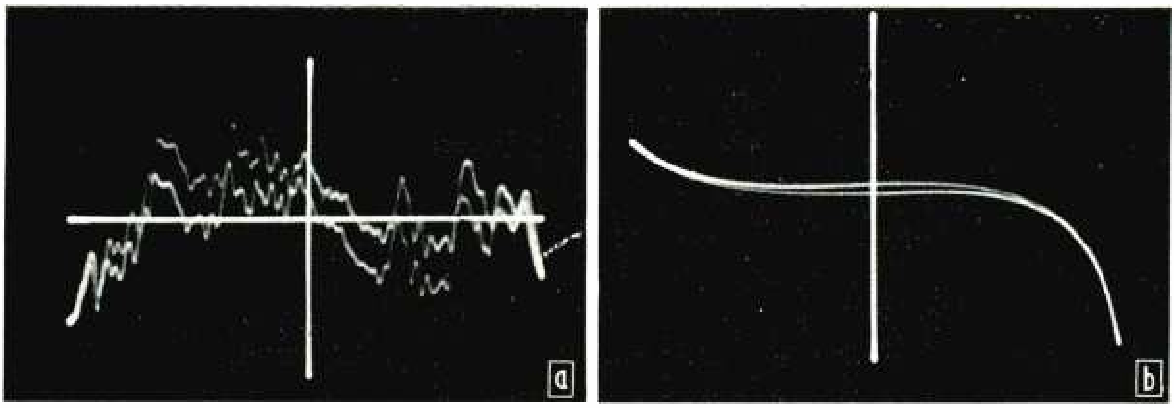


Fig. 5. The trace (a) shows the error in the output of an analogue multiplier. The irregularities are due to a scanned edge, and the separation of the traces is due to hum. The gain has been taken as the value which gives minimum peak-peak value to the error voltage. The amplitude of the calibration line is ± 0.5%. In (b) is shown the error of a paraphase amplifier adapted from the circuit of Fig. 6(a) by applying the input to R_1 and omitting R_2. In this case the error curve is horizontal at the origin. The amplitude of the calibration line is ± 1%.

but it is more convenient, and more usual, to calculate the non-linearity as a percentage of the nominal maximum output; i.e., $av_{i(max)}$ is used in place of the term av_i in equation (3). The non-linearity of the curve in Fig. 1, is plotted on this basis in Fig. 2.

This way of defining the gain leads to the simplest mathematics, and is correct for audio amplifiers and many others. For other applications (e.g., oscilloscope amplifiers) it is more convenient to define the gain as the slope of the best straight line, which, in this case, is that straight line drawn through the origin which gives minimum errors at all points throughout the working range.

In d.c. amplifiers for analogue computers the quantity v_e is frequently called the "error" due to the amplifier, leading to the name "error curve" for the curve of Fig. 2. As it shows the departure from true linearity of the apparatus this term is thought to be more descriptive than "difference diagram," as used by Wigan. Furthermore, the error of a meter is expressed in this way, $av_{i(max)}$ corresponding to full-scale deflection.

Experimental Arrangement. The simplest and most accurate arrangement for testing a phase-reversing amplifier by this method is shown in Fig. 3. If the attenuator is adjusted till the error curve is horizontal at the origin, or till the errors are minimal, depending on the application of the unit, the attenuation is then equal to 1/A, A being the gain of the test object. The value of *N* is found by calibrating the Y-amplifier by means of a suitable fraction of v. The adding unit is of the type used in analogue computers. For d.c. tests the oscilloscope X and Y amplifiers can be replaced by meters.

Fig. 5 shows some of the results obtained.

The adding unit is a negative-feedback amplifier connected as in Fig. 4. For $R_1 = R_2 = R_3$ and a sufficiently high gain the output approximates to the sum of the inputs, i.e.,

$$v_o \approx (v_1 + v_2) \quad \ldots \quad (4)$$

For example, for $A = 150$, $v_o \approx 0.98\ (v_1 + v_2)$, which is sufficiently accurate for many purposes. If required, perfect addition may be obtained by making

$$R_3 = R(A - 1)/(A + 2) \quad \ldots \quad (5)$$

where $R_1 = R_2 = R$

These formulæ are derived in Appendix 1.

A suitable circuit is shown in Fig. 6 (a). For a.c. use only, the simpler circuit of Fig. 6 (b) can be used.

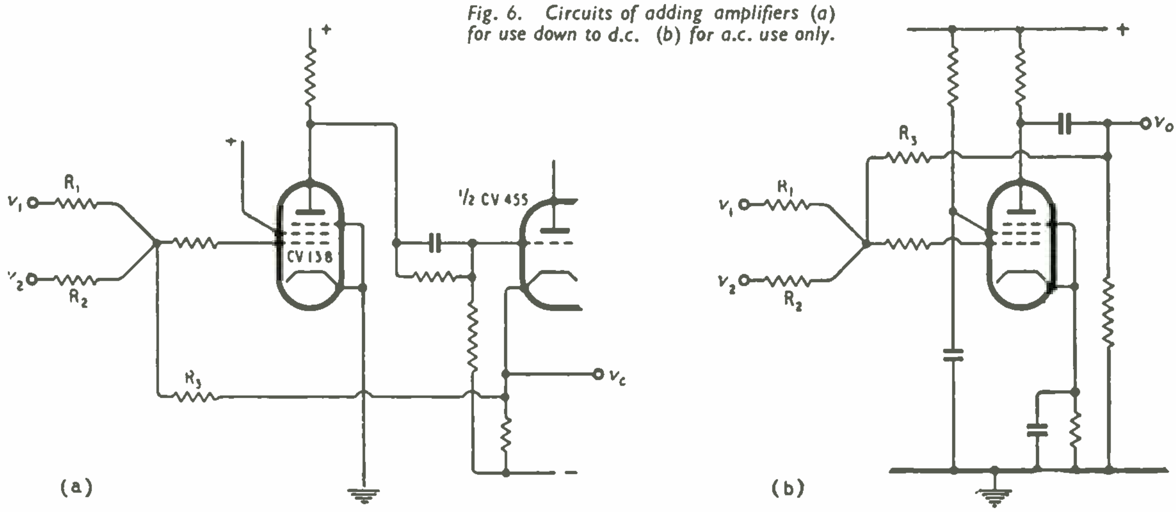


Fig. 6. Circuits of adding amplifiers (a) for use down to d.c. (b) for a.c. use only.

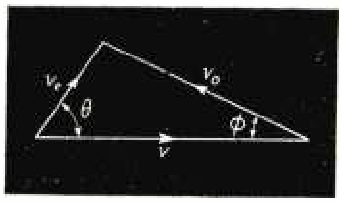


Fig. 7. Vector diagram for the equation $v_e = v + v_o$. The amplitudes and phase angles are shown. If v is taken as the reference phase, then conventionally, both v_o and ϕ are negative for the case shown.

In the computer field such arrangements are known as "adders," or "adding amplifiers."

For the a.c. tests of non-phase-reversing units the problem of phase-reversal is simply solved by the use of a centre-tapped transformer to supply test signals to the adder and the test object in antiphase. For d.c. tests a paraphase amplifier must be inserted between the attenuator and the unit under test, except when this has a gain of less than unity, when it is best to insert it in the lead to the adder, as it then has to handle smaller signals. The non-linearity of this unit has to be added to the measured error; its non-linearity being simply measured by first omitting the test object and attenuator.

The attenuator may be dispensed with when the gain of the unit under test does not differ greatly from unity by adjusting the ratio of (R_1/R_2).

Requirements of Test Apparatus and Precautions.—It is essential for the adder and Y-amplifier (and X-amplifier and attenuator if used) to be free from phase shift at the test frequency. At 50 c/s, or even 1,000 c/s, this presents little difficulty. When testing at mains frequency, it is advisable to observe the c.r.o. trace before applying the test signal to the adder and the test object in order to note any hum. If the test object introduces any phase-shift the error curve will take the form of a loop.

A saw-tooth test signal may be used (e.g., a c.r.o. time-base) *providing that* the frequency response of all units, including the one under test, is flat over the range of frequencies contained in the saw-tooth. This is quite a stringent requirement as harmonics up to twenty times that of the recurrence frequency will normally be present.

Accuracy.—The method is inherently very accurate provided that the adder is carefully adjusted to give no output for equal and opposite inputs. Subsequent errors in measurement of the error voltage are of secondary importance. Thus if a paraphase amplifier giving a nominal 50 volts out has a measured error voltage of 50 millivolts then the non-linearity is 0.1%, but if there is, say, a 10% high error in the measurement of the error voltage the true figure for the non-linearity is 0.09%. If the output had been measured directly, however, and the measuring instrument had given a 10% high figure (i.e., 55.05 volts) the figure for the non-linearity would have appeared to be 10.1% instead of 0.1%.

Measurement of Phase-Shift.—Phase-shift is usually accompanied by a change in the output level. To measure these it is necessary to use a pure sine-wave input and to decrease the input level until the test object is substantially linear. The c.r.o. display will then be elliptical if the phase shift is present. The amplitude and phase angle of the error voltage are then determined[3,4]. If these are v_e and θ then the amplitude error is given by $(v - v_o)$, which may be expressed as a percentage or as a number of decibels in the usual way, where v_o is given by:

$$v_o = \sqrt{(v^2 + v_e^2 - 2vv_e \cos\theta)} \quad .. \quad .. \quad (6)$$

and the phase angle is given by.

$$\phi = \cot^{-1}[(v/v_e) \operatorname{cosec}\theta - \cot\theta] \quad .. \quad (7)$$

The formulæ are derived in Appendix 2.

Further Applications.—It is possible to apply this technique of error measurement to the testing of servo-mechanisms providing that the input and output are, or can be converted into, voltages. It is thought that it may be possible to carry out what have been referred to as two-terminal tests[1] by the provision of a reference signal.

Acknowledgements.—The author wishes to record his indebtedness to his colleagues and to Mr. J. A. Colls for helpful discussions.

APPENDIX 1

The analysis of the circuit of Fig. 4 is as follows. Denoting the gain of the amplifier by $-$ A, we have

$$(v_o + v_g)R_3 = (v_1 - v_g)R_1 + (v_2 - v_g)/R_2 \quad (1)$$

and

$$v_g = -Av_o \quad (2)$$

From (1), putting $R_1 = R_2 = R$

$$v_o = [(v_1 + v_2)R_3/R] - v_g(1 + 2R_3/R) \quad .. \quad (3)$$

From (2) and (3)

$$v_o = (v_1 + v_2)(1 - 1/A - 2R_3/AR) \quad .. \quad .. \quad (4)$$

showing that the output is equal to the sum of the inputs multiplied by a constant factor. For $R_3 = R$, this reduces to

$$v_o = (v_1 + v_2)(1 - 3/A) \quad .. \quad .. \quad .. \quad (5)$$

which approaches unity as A approaches infinity. If required, perfect addition is obtained by making the factor exactly unity, and the condition for this is

$$R_3 = R(A - 1)(A + 2) \quad .. \quad .. \quad .. \quad (6)$$

APPENDIX 2

Relationships between error voltage and output voltage.

Fig. 7 shows the vector relationship of the voltages involved. For the case shown, if v is taken as positive, then v_o and ϕ are negative, ϕ being a phase lag.

Clearly, for v_o we have

$$v_o = \sqrt{(v^2 + v_e^2 - 2vv_e \cos\theta)} \quad .. \quad .. \quad (1)$$

Also $$v = v_e \cos\theta + v_o \cos\phi \quad .. \quad .. \quad (2)$$

and $$v_o/\sin\theta = v_e/\sin\phi \quad .. \quad .. \quad .. \quad (3)$$

therefore $$v_o = v_e \sin\theta/\sin\phi \quad .. \quad .. \quad .. \quad (4)$$

whence $$v = v_e \cos\theta + v_e \sin\theta \cot\phi \quad .. \quad .. \quad (5)$$

$\therefore$ $$\cot\phi = (v - v_e \cos\theta)/v_e \sin\theta \quad .. \quad (6)$$

or $$\phi = \cot^{-1}[(v/v_e) \operatorname{cosec}\theta - \cot\theta] \quad .. \quad (7)$$

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[2] Tyler, V. J., "Simple Distortion Meter," *Wireless World*, Vol. 59, p. 431, September 1953.
[3] Scroggie, M. G., "Radio Laboratory Handbook" (5th Edition), p. 247 (Iliffe & Sons Ltd.).
[4] Benson, F. A., "Phase Angle Measurements," *Wireless World*, Vol. 59, p. 157, April 1953.

Centimetre-wave Oscillograph

FREQUENCIES of the order of 9,500 Mc/s can be displayed on an experimental c.r. oscillograph which has recently been built at Manchester. Described in a letter to *Nature* (5th December, 1953) by B. Jackson, D. R. Hardy and R. Feinberg, it uses a special 6-in aluminized c.r. tube with a highly actinic blue phosphor screen. The vertical electrostatic deflection system is formed by a twin-wire transmission line passing through the tube at right angles to its axis. This reduces the transit time of the electron beam in the deflection field and permits correct matching to the signal source. The deflection sensitivity of the tube is about 0.006mm per volt. A single-sweep time base of 1.3 milli-microseconds duration is used, giving a sweep width of about 4cm, and with this the writing speed amounts to approximately 5×10^{10}cm per second. The tube is magnetically focused and its trace is about half a millimetre wide.

The D.C. Component in Television

Video-Stage to C.R. Tube Coupling

By W. T. COCKING, M.I.E.E.

IN a recent paper[1] D. C. Birkinshaw has stressed the importance of the d.c. component of the television signal to the correct reproduction of pictures and he illustrated his theme by a most convincing series of photographs. He pointed out that although considerable attention is paid to the maintenance of the proper level of the d.c. component in the B.B.C. transmissions it is considerably attenuated in many commercial receivers.

Out of 26 sets tested, only seven reproduced the d.c. component fully. Eight reproduced it with from 15% to 40% attenuation, six with 50%, three with 62% to 70% and two with 100%.

The d.c. component is, of course, the part of the picture signal which governs the mean brightness of the picture. Its absence or appreciable reduction means that the brightness control of the receiver will require re-adjustment whenever the mean brightness of the transmitted scene changes. If such re-adjustment is not carried out some pictures will be too dark, with a lack of detail in their darker parts, and others will not be dark enough and will have washy blacks and visible frame-flyback lines.

In view of this, it seems surprising that deliberate attenuation is often introduced in commercial receivers. As Birkinshaw states, however, it is often done with the aim of reducing aircraft flutter. It is, however, not essential to attenuate the d.c. component to do this; it is possible to reduce flutter in other ways,[2] the use of a.g.c. being probably the best method. In his paper, Birkinshaw did not consider how the d.c. component should be retained; he confined himself to showing the bad effect of attenuating it and he did this most convincingly. However, he did make one statement about circuit performance which is actually incorrect. He is hardly to be blamed for this, because most designers believe the circuit in question to be a satisfactory one and, until quite recently, the writer did also.

[1] "The Importance of the D.C. Component," *J. Televis. Soc.*, July-September 1953, Vol. 7, No. 3. p. 105.

[2] See "Television Interference by Aircraft," by A. H. Cooper. B.Sc. *Wireless World*, April 1949, Vol. 55, p. 142, for a discussion of the subject. Because of the input impedance of the c.r. tube the particular circuit and component values given in this article are unlikely to permit full retention of the d.c. component.

The reference is to the common circuit (Fig. 1) in which the cathode of the c.r. tube is fed from the anode of the video stage through a voltage divider. This is done to keep the heater–cathode voltage of the tube within its rating and it inevitably reduces the d.c. component of the signal below the value existing at the anode of the video valve. To overcome this, the d.c. component is equally over-amplified at the anode of the video valve, usually by a correct choice of value for the anode de-coupling resistor.

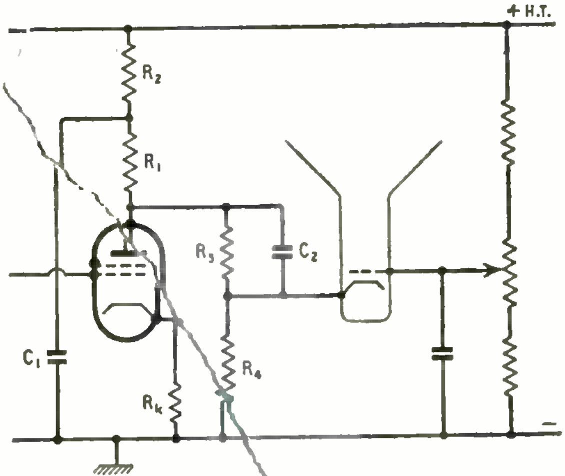


Fig. 1. A commonly-used video-stage to tube coupling. If the tube resistance is very high, the coupling is compensated and gives equal gain at all frequencies. The compensation is spoilt in practice by the input resistance of the tube.

What has been overlooked in the past, and what makes it impossible to obtain the correct level for the d.c. component with this circuit, is the fact that a c.r. tube which is fed at the cathode has a fairly low input resistance. Moreover, it has an input resistance which varies greatly with the signal voltage.

The circuit in question is the well-known one of Fig. 1. In an a.c./d.c. set, the heater of the tube must usually be at chassis potential and the maximum allowable difference of potential between heater and cathode is usually 150 V; in some of the older tubes it was considerably less. The anode potential of the valve may well be 150–200 V and the voltage divider brings the cathode potential to $R_4(R_3 + R_4)$ of this figure.

At all frequencies within the picture signal, the capacitors are large enough to be short-circuits. The load on the valve is then R_1 in parallel with R_4 and, since R_4 is large compared with R_1, it is virtually R_1 alone. At d.c. the capacitors form open-circuits and the load on the valve is $R_1 + R_2$. The amplification at d.c. is $1 + R_2/R_1$ times as great as at higher frequencies, but only $1/(1 + R_3/R_4)$ of it is passed on to the tube. The d.c. component is fully retained if $R_2/R_1 = R_3/R_4$. In addition, if C_1 and C_2 are related in a certain way the overall amplification is constant at all frequencies. However, by a proper choice of their values, the amplification can be made to fall off at very low frequencies near to d.c. and the circuit can then give proper representation to the d.c. component while also reducing aircraft flutter.

All this is in accordance with the usual circuit theory and supposes that the c.r. tube has an input resistance which is very large compared with R_3

and R_4 in parallel. Quite normal circuit values would be $R_1 = R_2 = 3.5$ kΩ and $R_3 = R_4 = 100$ kΩ.

Tube Input Impedance

Now a cathode-ray tube is exactly analogous to an ordinary valve as far as its electrical characteristics are concerned. Although figures for them are not usually quoted, it has a mutual conductance g_m and an anode a.c. resistance. It is well known that when a valve is used in a cathode input (earthed-grid) circuit it has a low input resistance of the order of $1/g_m$; it is commonly 100–500 Ω. A cathode-ray tube also has an input resistance of $1/g_m$ but, because the mutual conductance is small compared with that of a valve, the input resistance is correspondingly high. It is not often less than 50 kΩ.

The mechanism by which this comes about is quite simple. If the cathode voltage is changed by some small amount in a direction to increase the anode current (that is, cathode voltage changing negatively) this same voltage is operative between grid and cathode where it also acts to increase the anode current, but by μ times as much. The change of current is thus

$$i_a = \frac{e_k}{r_a}(1 + \mu)$$

where r_a and μ are the anode a.c. resistance and amplification factor of the tube. This current flows from the circuit which feeds the tube. An equivalent resistance R_{in} for the tube is one which, if connected to the driving circuit in place of the tube, would draw from it the same current. Therefore

$$R_{in} = \frac{e_k}{i_a} = \frac{r_a}{1+\mu} \approx \frac{1}{g_m}$$

It is possible to obtain figures for g_m from the ordinary tube maker's grid-volts-anode-current characteristics. At an operating voltage corresponding to peak white, the mutual conductance is usually about 0.02 mA/V, which makes $R_{in} = 50$ kΩ.

Like those of a valve, the tube characteristics are curved and the mutual conductance falls as the tube is biased back for reduced brightness, consequently the input resistance rises as the brightness decreases. Unlike a valve, however, a cathode-ray tube cannot be operated only over the straight part of its characteristic, for the beam current must be nearly, if not quite, cut off for picture black. As the signal varies the brightness between white and black, therefore, the input resistance must change from a minimum of the order of 50 kΩ to a high value approaching infinity.

In the circuit of Fig. 1, this tube resistance appears in shunt with R_4. At high frequencies, where the capacitors are short circuits, the load on the valve is R_1, R_4 and R_{in} all in parallel. If R_1 is 3.5 kΩ and R_4 is 100 kΩ, the load is $3.5 \times 100/103.5 = 3.38$ kΩ in the dark parts of the picture where R_{in} is very large. At peak white, if R_{in} is 50 kΩ the load falls to $3.38 \times 50/53.38 = 3.17$ kΩ. The gain near white is about 94% of that near black. The effect on the tone graduation of the picture is that changes near white are not quite as great as they should be.

The magnitude of the effect is very small, however, and is both smaller and in the opposite sense to that brought about by curvature of the tube characteristics. It is therefore negligible.

At d.c., however, matters are quite different, for the tube is fed from R_3 and R_4 which have values of the same order of magnitude as R_{in}. Near black level R_{in} is large and will have comparatively little effect upon the circuit so that the d.c. component will be present at the tube cathode at very nearly its proper level. At peak white, however, matters are very different. Suppose $R_1 = R_2 = 3.5$ kΩ, $R_3 = R_4 = 100$ kΩ and $R_{in} = 50$ kΩ. Then R_4 and R_{in} in shunt come to 33.33 kΩ, and the loading of the voltage divider on $R_1 + R_2$ (7 kΩ) is 133.33 kΩ. The load on the valve is $7 \times 133.33/140.33 = 6.65$ kΩ. At high frequencies the load is 3.17 kΩ, so the gain to the valve anode is at d.c. $6.65/3.17 = 2.1$ times the gain at high frequencies. The reduction factor to the tube cathode is $33.33/133.33 = 0.25$ and so the d.c. component is $2.1 \times 0.25 = 0.525$ of its proper level.

The result of using this circuit in practice is that if the brightness control is initially adjusted correctly on a rather dark picture, then when a picture of greater mean brightness comes along the brightness does not increase proportionately. The dark parts of the picture are too dark and the detail in them is lost. The brightness control has to be turned up for proper reproduction. Conversely, if the brightness control is initially adjusted on a bright picture then when a dark one is transmitted it will be reproduced too brightly; black will not be black, but dark grey, and the frame flyback lines will show. These effects are quite noticeable in practice.

It will now be clear that with the circuit of Fig. 1 a reduction of the d.c. component to 50% of its proper value is quite likely even when the designer has the intention of retaining it fully. Because of the variable nature of R_{in} it is not possible to compensate for it by any practicable change in the values of the components. Because the resistance is variable, its effect can be made negligible only by feeding the tube from a circuit having a resistance low compared with the lowest value of R_{in}. This is a condition which exists in Fig. 1 only at high frequencies and it is one which must be made to exist at d.c. also.

In the circuit of Fig. 1 this could be done if it were practicable to reduce R_3 and R_4 to about 10 kΩ only. They would then shunt R_1 and R_2 so much that these two resistors would have to be increased in value. The reduction of R_3 and R_4, coupled with the increase of R_1 and R_2, would require an increase of h.t. supply voltage to maintain proper operation of the valve. In an a.c./d.c. set this is usually impossible.

In commercial practice circuits of the form of Fig. 1 are often used but with values deliberately chosen to reduce the d.c. component. Quite often, for instance, R_2 is omitted. Even without the effect of the input resistance of the tube the d.c. component may then be reduced to 50% of its proper value; when the tube resistance is taken into account the reduction may be to 25% of the correct level. As already stated, this reduction is often deliberate and is introduced to alleviate aircraft flutter.

We are not concerned here with the question as to whether or not it is desirable to do this. There is no doubt that where aircraft flutter is not experienced it is desirable to retain the d.c. component fully. There is also very little doubt that it is desirable to remedy aircraft flutter, not by reducing the d.c. component, but by employing a.g.c. Whether or not it is commercially practicable to do so this is quite another matter.

For the present, therefore, we shall consider only how best to retain the d.c. component. It is clear that the use of the circuit of Fig. 1 is inadmissible. Two alternatives present themselves. The first is to utilize the circuit of Fig. 1 but to include a cathode follower between R_3R_4 and the tube. The second is to omit R_3R_4 and to join the cathode of the tube directly to the anode of the valve, adopting some other means of keeping the heater–cathode potential within bounds. The cathode follower is used in at least one commercial set, but mainly for other reasons. The second alternative is used in a good many sets and is applicable wherever it is possible to use a separate winding on a transformer to supply the heater of the tube. It is only in the case of the a.c./d.c. set, where the heater must be at chassis potential, that difficulty may arise with it.

Practical Cathode-Input Circuit

We shall not discuss here the cathode-follower circuit, because the design of the complete video stage plus cathode follower is quite an intricate matter. We shall deal only with the second circuit in detail. Before doing so, however, it may be as well to remark that if the video signal is fed to the grid of the tube instead of to the cathode all these difficulties disappear. A capacitance coupling with a d.c.-restoring diode can be used. Because the video signal must then be of opposite polarity, however, difficulties arise in the sync separator and an extra valve in this circuit would probably be needed to obtain a normal performance. The use of d.c. restoration with cathode input to the tube does not seem practicable because of the low input resistance of the tube. The use of capacitance coupling to the tube cathode with a pulse-operated black-level clamp might, however, be practicable but has not been investigated.

The form of circuit which we shall now consider in detail is shown in Fig. 2. At all but the lowest frequencies and d.c., that is, at what we shall for convenience term high frequencies, the capacitors are all short-circuits and the video stage gives an amplification of

$$A = \frac{g_m R_1}{1 + F_k} \quad \ldots \quad (1)$$

where g_m and g_T are respectively the mutual conductance of the valve connected as a pentode and as a triode and $F_k = g_T R_k$. At d.c. the internal resistance of the h.t. supply, shown as R_2, plays a part, for it is common to both screen and anode circuits. The voltage developed across it appears on the cathode of the tube and a fraction $R_5/(R_4+R_5)$ of it is also applied to the grid (via the brightness control) where it acts in opposition; only the fraction $R_4/(R_4+R_5)$ of the voltage across R_2 is, therefore, effective in operating the tube.

The voltage across R_2 and R_k, and also any across R_3, acts on the screen grid where it produces negative feedback tending to reduce the gain. On balance, R_2 tends to increase gain and R_3 to reduce it. It is possible, therefore, by a proper choice of R_3 to make the gain at d.c. the same as at higher frequencies.

It is not difficult to work out the d.c. gain. Between the grid of the valve and the cathode–grid circuit of the tube it is

$$A_{DC} = \frac{g_m R_1 + g_T R_2 \alpha}{1 + F_s + F_a + F_k} \quad \ldots \quad (2)$$

where

$$\alpha = \frac{R_1}{R_1 + R_5}$$

$$F_k = 1 + g_T R_k$$

$$F_s = \{g_T(R_2 + R_3 + R_k) - g_m R_3\}/\mu_{12}$$

$$F_a = \{(R_2 + R_k) g_T / g_m + R_1\}/r_a$$

r_a = anode a.c. resistance of the valve as a pentode.

μ_{12} = amplification factor of the valve between control and screen grids.

The gain at d.c. relative to that at high frequencies is

$$\frac{A_{dc}}{A} = \frac{1 + \dfrac{g_T R_2 \alpha}{g_m R_1}}{1 + \dfrac{F_s + F_a}{1 + F_k}} \quad \ldots \quad (3)$$

In a pentode r_a is normally very large and the term F_a can usually be neglected. If the gains at a.c. and d.c. are to be equal equation (3) must be unity. Neglecting F_a, the condition for this is

$$R_3 = \frac{\dfrac{g_T R_2 \mu_{12} \alpha (1 + g_T R_k)}{g_m R_1} - g_T(R_2 + R_k)}{g_T - g_m} \quad \ldots \quad (4)$$

As an example, suppose $R_1 = 3.5\ k\Omega$, $R_k = 220\ \Omega$, $R_2 = 500\ \Omega$, $\alpha = 0.6$, $g_m = 6.5$ mA/V, $g_T = 8.5$ mA/V, and $\mu_{12} = 75$. Inserting values, we get $R_3 = 9\ k\Omega$.

It may or may not be possible to use this value for R_3. It depends on the h.t. voltage and the required screen voltage. If R_3 is zero, the relative gain works

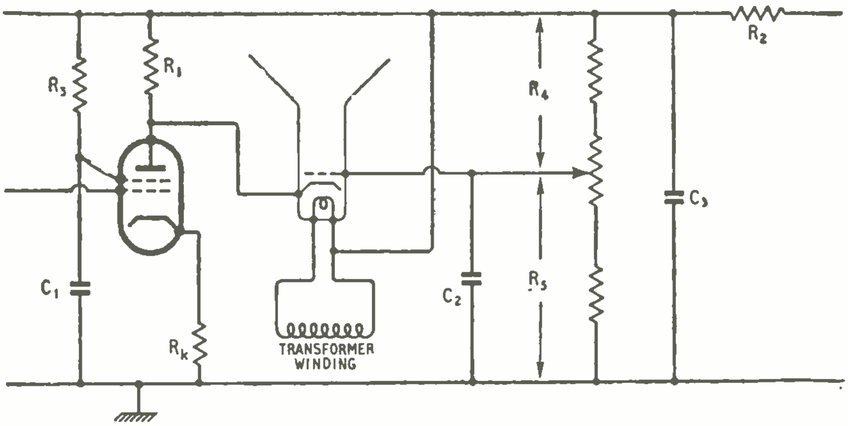


Fig. 2. This circuit can give nearly perfect reproduction of the d.c. component if R_3 is correctly chosen. It is, however, very good even without R_3. The resistance R_2 represents the resistance of the h.t. supply. Care must be taken over the tube-heater supply if the heater-cathode rating is not to be exceeded.

out at 1.08 to slide-rule accuracy. Without any attempt at compensation by choosing a particular value of R_3, therefore, the excess of d.c. component is only about 8%.

The basic tendency with this circuit is for the d.c. component to be slightly over-amplified. The excess, however, is not critically dependent on the values of components or the valve characteristics as long as the two right-hand terms in numerator and denominator of equation (3) are a good deal smaller than unity. Consequently, it is not necessary to employ close-tolerance components. In the circuit of Fig. 1, however, close tolerances, or at least closely matched components are necessary; with normal components errors of 40% in the d.c. component level are possible.

Taking into account both performance and cost, the circuit of Fig. 2 seems to be unquestionably the best one. Generally speaking, it seems to be an unnecessary refinement to choose R_3 in accordance with equation (4) and it is sufficient to choose it only to suit the screen voltage required by the valve. Often this will be the full voltage of the h.t. line and then both C_1 and R_3 can be omitted.

It must be emphasized that the practicability of the circuit of Fig. 2 is often restricted to receivers in which it is possible to supply the heater of the tube from its own private winding on a transformer. The heater can then be joined to any required point on the h.t. supply to minimize the heater–cathode potential difference. As shown in Fig. 2, this will often be positive h.t.

In an a.c./d.c. set, however, the tube heater must usually be at chassis potential. It is safe to use the circuit in such sets, therefore, only when the h.t. supply is of lower voltage than the heater–cathode rating of the tube.

In neither Fig. 1 nor Fig. 2 have the high-frequency compensating components been shown. They are irrelevant to the present discussion but, in practice, R_1 will usually have an inductance in series with it, or there may be one in series with the cathode lead of the tube; sometimes both are used. Then R_k quite often has a small capacitance in shunt with it. All these things have no effect at all at d.c. or at the lower picture frequencies; they play their part at frequencies over 2 Mc/s.

Ionosphere Review: 1953

Short-wave Propagation Changes : Approaching the Sunspot Minimum

By T. W. BENNINGTON*

IT is now nearly ten years since the last sunspot minimum—ten years during which the solar activity has passed through nearly all its changes and is now approaching a minimum again. It was in April, 1944, that the last sunspot minimum values were recorded, after which the activity rapidly increased to a maximum of almost unprecedented intensity in May, 1947. Almost unprecedented, that is, when compared with the intensities of the previous maxima shown in the records available, records which exist on a continuous basis for just over 200 years. In that time 19 sunspot maxima have been recorded, and only one of these was of greater intensity than that of 1947—a fact which may or may not be of significance. Who can say, for what is 200 years in the life of the sun?

Since 1947 the average sunspot activity has been declining towards another minimum and it might be thought, observing that the mean duration of the cycles is about 11.1 years, that the coming minimum is a year away. But there is no certainty about this; the length of the sunspot cycles varies very considerably, ranging for the 17 cycles for which we have complete records from about 9.1 to about 13.6 years. Thus the time of the occurrence of an approaching minimum cannot be foretold on the mere basis of the lapse of time since the preceding minimum, or indeed of that since the last maximum. It is, in fact, impossible to forecast its occurrence with accuracy on any known basis, though, as we shall see later, indications of some value on this point may be obtained from a study of the past cycles. There are also some of greater value directly provided by the sun itself.

Fig. 1 shows the twelve-month running average of the sunspot number for each monthly epoch from Jan./Feb., 1947, to June/July, 1953; the twelve-month running average of the noon critical frequency of the ionospheric F_2 layer and the twelve-month running average of the midnight critical frequency of the layer, for the same periods. The sunspot number is obtained from the observations made at a number of astronomical observatories (or, in the case of the last 12 values, at the Royal Greenwich Observatory alone) and is a measure of the sunspot activity on the sun's visible disc. The critical frequency of the F_2 layer is the highest frequency returned from the layer (which is the principal transmission medium in short-wave communication) when the measuring waves are sent vertically upwards. The two curves are compiled from the measurements made at the Slough station of the D.S.I.R. The

* British Broadcasting Corporation.

object of presenting the curves in the form of twelve-month running averages is that by smoothing out the month-by-month variations in sunspot number and the regular seasonal variations in critical frequency enables the long-period changes in both sunspot number and critical frequency to be more clearly seen. The last available number given by this method is, of course, that for a period six months back from the time of the last observation; *i.e.*, in the present case six months back from December, 1953, to the epoch June/July, 1953. The dotted portion of the curve which carries it forward into 1954 will be referred to later.

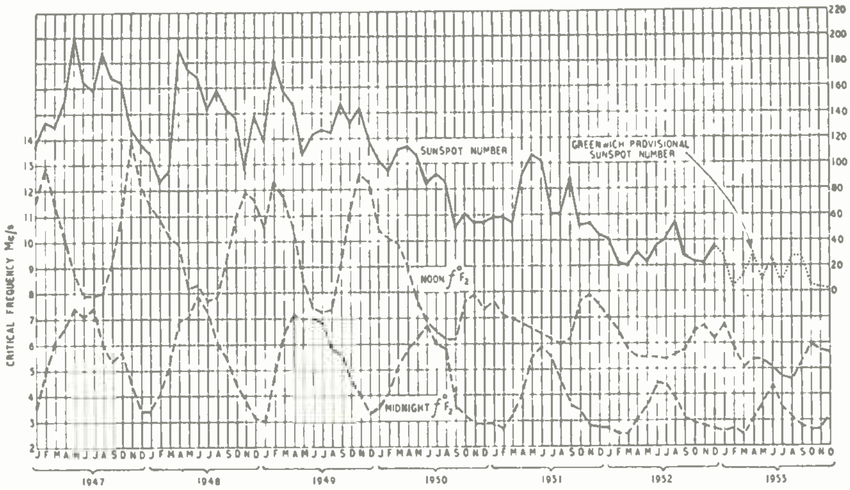


Fig. 1. Twelve-month running averages of sunspot numbers and noon and midnight F_2 critical frequencies since the last sunspot maximum, with possible future values of sunspot number (dotted extension).

It is seen that since the sunspot maximum in 1947 the sunspot number has fallen from about 150 to one of somewhat less than 20, though during the last twelve months it fell only by about 15. During all this time the critical frequency curves have followed the decreasing sunspot activity in a very faithful fashion, decreasing, in the case of the noon curve, from about 10.4 Mc/s to about 5.5 Mc/s and in the case of the midnight curve from about 5.7 Mc/s to about 3.1 Mc/s. It was pointed out, at the end of 1952, that the critical frequency had already attained "quasi minimum" values, and indications were that the noon critical frequency would fall by about 1 Mc/s only between then and the sunspot minimum. As can be seen, during the past year the fall in noon critical frequency is of the order of 0.5 Mc/s only, whilst that in the midnight value was correspondingly smaller. It appears, therefore, that the critical frequencies are likely to undergo only a very small further decrease between now and sunspot minimum.

All of which means, of course, that there is not likely to be much change, due to the sunspot cycle, in the frequencies at present of use for short-wave communication until after the coming minimum. These have decreased very considerably since the 1947 sunspot maximum, and, whilst the actual decrease varies widely for different circuits, with the seasons and with time of day, some idea of the order of things can be obtained from the figures given here. The decrease in noon critical frequency implies that the mean noon m.u.f. for transmission over the longest possible one-hop trajectory, with the ionosphere over Slough as its apex, has decreased since sunspot maximum by about 15 Mc/s, whilst the midnight figures indicate that the mean midnight m.u.f. has fallen by about 8 Mc/s. These large decreases have necessitated drastic alterations in the conduct of all kinds of long-distance services, which are now generally confined to the lowest short-wave frequencies, having regard to season and time of day. But, as has been said, no further appreciable reduction in their working frequencies is likely to be necessary.

For those who may be interested in more details of the changes which have occurred over the past few years the curves of Fig. 2 are given. These show the monthly means of the sunspot number and of the

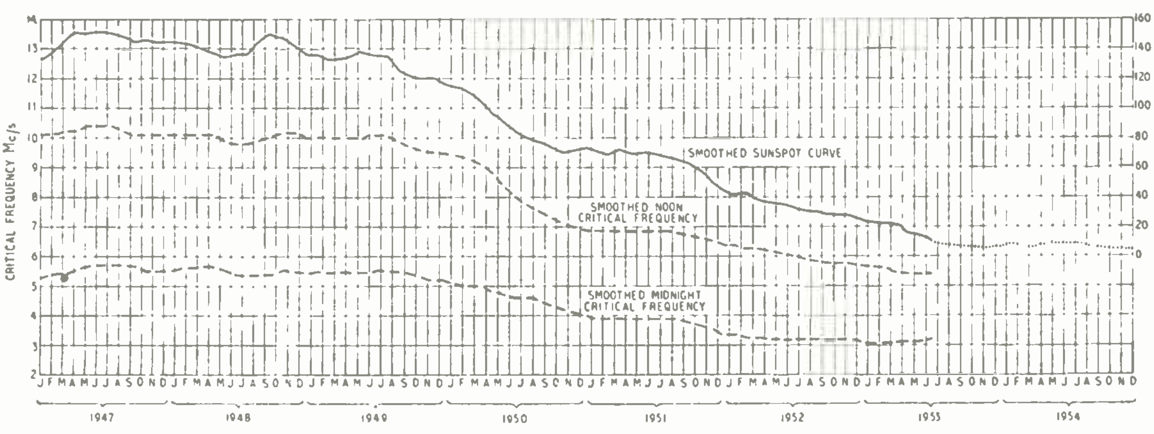


Fig 2. Monthly mean sunspot numbers and noon and midnight F_2 critical frequencies since the last sunspot maximum.

F_2 critical frequencies as measured at Slough. Some of the variations in the latter are rather interesting. For instance the noon critical frequency, which reaches its lowest values during the summer months, and its highest about mid-winter, is seen to have decreased by a very much greater amount since the sunspot maximum during the winter than during the summer. In fact it has decreased by about 8 Mc/s for winter and by about 3 Mc/s for the summer. On the other hand the midnight critical frequency decreased by about 1 Mc/s for the winter and by about 3 Mc/s for the summer. These differences may be ascribed to the differing effects of the sun upon the layer, either in kind or degree, at different times of the day and the year, but the net result on the usable short-wave frequencies is clear. They must vary over the sunspot cycle to the greatest extent during the winter day, to a lesser extent during the summer day and night, and least of all during the winter night. Of course these variations are much modified by the behaviour of the ionosphere in different terrestrial regions, and by the varying conditions over a long transmission path. But broadly speaking the variations in usable frequencies over the sunspot cycle are of the kind described.

Transferring our attention to Fig. 1 again and remembering our conclusion that it is unlikely there will be much further variation in critical frequencies or maximum usable frequencies until after the coming sunspot minimum, we are naturally concerned to know when that event will occur. But, as has already been stated, there is no way of telling this with any real accuracy. However, a classification of the sunspot cycles of which we have record would appear to indicate that the present one belongs to the class with high maximum and medium long duration. By matching it to a "representative" cycle of this class—which is the mean of all previous cycles of the same class—one can extrapolate it towards the minimum, and the result of this is shown in the dotted extension of the curve. This indicates possible future valves of the 12-month running average sunspot number and places the sunspot minimum at November/December, 1954. The curve should, of course, be accepted with reserve.

Signs of the New Cycle

However, some additional and stronger evidence that sunspot minimum may occur within a year or so has now been obtained from observations of the sun itself. Towards the end of a sunspot cycle the sunspots belonging to that cycle all appear in positions relatively near to the solar equator, but when the new cycle commences the spots appear in relatively high solar latitudes. Furthermore the spots of the new cycle have opposite magnetic polarity to those of the old one. These high latitude sunspots (belonging to a new sunspot cycle) usually begin to appear some considerable time before those of the old cycle have ceased, and, in fact, about a year before the sunspot minimum is reached.

According to a report from America† there was observed on August 13th, 1953, a very small sunspot in solar latitude 52° N by members of the staff of the McNath-Hulbert Observatory, Michigan, which it would seem may have been the first spot of the new cycle. It is also reported that magnetic observations of the sun made in Pasadena increase the probability that this sunspot belongs to the new cycle. If this is so the observations would indicate that, on the basis of similar observations made towards the end of past cycles, the sunspot minimum might be expected between about March, 1954, and April, 1955. Therefore, whilst it still is not possible to be precise about the time of the minimum, the implications of the observations do not appear to conflict very much with the dotted part of the curve of Fig. 1.

The frequencies at present of most use for communication over various circuits—such as 17, 15 and 11 Mc/s for daytime broadcasting, 9 Mc/s for summer night-time and 7 and 6 Mc/s for winter night-time use—are thus likely to remain so during 1954. And even after sunspot minimum does occur it would seem unlikely that the sunspot activity will begin rapidly to increase for several months, or perhaps for a year. So it looks as if the present "rock bottom" conditions are likely to remain for a considerable time yet and perhaps, to hazard a guess, till towards the end of 1955.

† *Publications of the Astronomical Society of the Pacific*, Oct., 1953, Vol. 65, No. 386, p. 256.

Transistor and Valve Circuitry

BECAUSE there is a good deal of functional similarity between the transistor and the thermionic valve, people have been tending to think of the process of "transistorization" as little more than pulling out valves and inserting transistors in their place, after making very slight circuit modifications. This impression has been greatly strengthened by various theories about the duality between valves and transistors and how it can be utilized in the design of transistor circuitry. Engineers are now beginning to realize, however, that this duality idea is not a good thing to follow slavishly, as it tends to restrict what can be done with the transistor. The valve automatically becomes the yardstick, and by comparison the transistor sometimes appears as rather a poor substitute. It would be more profitable to take the transistor for what it is, and build an entirely new type of circuit technique around it. For example, it has been suggested that since the transistor operates very efficiently in pulse and trigger circuits we should attempt to transform our existing linear circuits into this type of operation—rather as we can use a.c. techniques for amplifying d.c. fluctuations after making the d.c. discontinuous.

This new outlook was implicit, if not stated in so many words, in a recent I.E.E. discussion meeting "Will Transistors Oust Receiving Valves?" opened by E. H. Cooke Yarborough. One example which was mentioned of a departure from established valve-circuit technique was a new transistor digital computor at Manchester University. As a result of the new approach there were actually fewer transistors in this computor than there would be valves in an equivalent "thermionic" computor doing the same job. It was also pointed out by several speakers that greater flexibility should be possible in transistor circuits because of the reversible functions of the collector and emitter—a feature not possessed by the equivalent electrodes of thermionic valves.

At the same time, of course, the transistor must emulate the valve in some respects and be able to bear comparison with it. The limit on operating frequency is one problem here (resulting from the lower electron transit time in semiconductor materials) and to get comparable results the electrode spacing has to be very much smaller. However, one speaker at the meeting mentioned that an experimental transistor had been made to operate at 80 Mc/s, and there were hints from others that the limit could be pushed to well over 100 Mc/s. The restriction on power output was another difficulty, although it was mentioned that transistors dissipating as much as 20 W were being produced in the U.S.A.

LETTERS TO THE EDITOR

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

Ignition Interference in U.S.A.

HAVING read the letter from Mr. Morse on ignition interference with TV in this country (your October issue) and your subsequent editorial comments, coupled with those of my friend "Diallist," I feel driven to enter the controversy, if only to keep the record straight.

As an English immigrant to the U.S.A. of less than two years standing, I can claim to have seen TV on both sides of the ocean, and, quite impersonally, would like to make these comments.

There is no doubt that interference does exist in fringe areas, but it is a growing problem to find a fringe area, as new transmitters going into service are a frequent occurrence on the u.h.f. band. Mr. Morse probably speaks as he finds things. In nearly two years of TV, I have yet to see visual interference on my screen derived from auto ignition. Up to two months ago, I lived on an eight-lane super highway, with autos passing four abreast in each direction at the usual thirty-foot intervals, and never had reason to complain of interference. My experience when visiting with friends or in various cities across this country has been the same; no visual signs of ignition interference. As several million TV sets are in constant use, I feel sure, knowing the Americans, that if auto interference was a problem something would be done about it, and we would know.

My feeling is that it must be standard practice for all interference-forming machines to be adequately suppressed by the maker before sale. My car, a cheap one, was suppressed as delivered from the factory. So was my vacuum-cleaner, my washing machine, the clothes drier, the dish-washer, the refrigerator and all the small kitchen power tools. I have heard auto interference myself, particularly when following a pre-war car along open highways, showing as a superimposed crackle on the car radio. However, this has never been heard when following post-war automobiles.

I am not prepared to argue American v. British design, as I have a foot in both camps, but I will back Mr. Morse fully when he says he has never seen auto TV interference, I never have either, nor have any of my friends. So shall we put the matter to bed by saying electrical appliance makers suppress their products adequately before sale, here in the U.S.A.?

Ferguson, Mo., U.S.A. R. LINCOLN OSTER.

Skin Effect

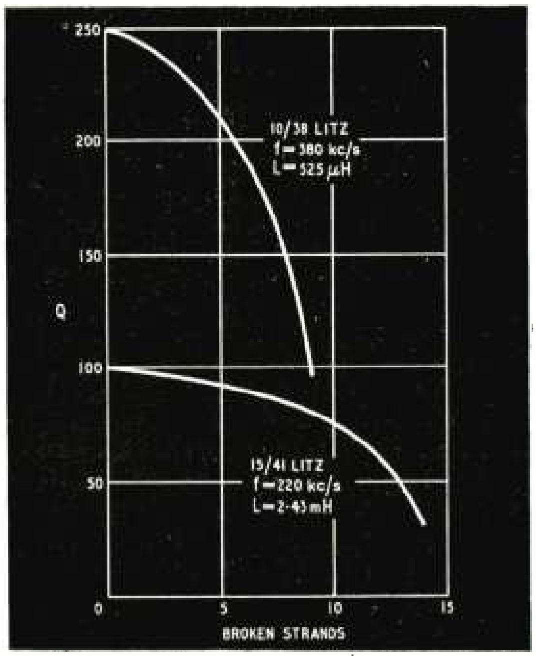
IN the final paragraph of his article "Skin Effect" (*Wireless World*, November, 1953), "Cathode Ray" observes that the effective resistance of litz wire rises appreciably when some of the strands are broken. While actual values are not stated, the reader is given the impression the resistance will increase in proportion to, or even exceed, the increase in d.c. resistance.

This popular misconception seems to appear periodically in the literature. Theory, however, does not substantiate this argument: in fact, there is ample evidence which disproves it.[1, 2]

The accompanying curves show the effect of broken strands in a universal type coil wound with 10/38 litz, and in a single-layer solenoid wound with 15/41 litz. The frequency in each case was sufficiently low to ensure efficient use of the litz wire.

[1] Hund and De Groot, *Bur. Stds. Tech. Paper* 298, Vol. 19, p. 651, 1925.

[2] Morecroft, J. H., "Principles of Radio Communication," 3rd Ed., p.195.



Curves showing effect of broken strands of litz wire in two different types of coil.

From the curves it is evident that the broken strands are not completely divorced from the circuit. Some current remains in the broken strands owing to the tight coupling between strands.

It is interesting to note the curves are somewhat similar when compared on a percentage basis.

Fairlawn, N.J., U.S.A. R. E. LAFFERTY.

[*"Cathode Ray" writes:* I am much obliged to Mr. Lafferty for correcting me in the matter of the rise in resistance when strands of "litz" wire are broken. It would be interesting to know what was the basis for the common belief that a few broken strands cause a disproportionate increase in r.f. resistance. I have been unable to trace it.—ED.]

Why No Prices?

WHY are so many of your advertisers so cagey about the prices of the goods they are trying to sell? One can, perhaps, understand it where a maker of resistors or condensers offers hundreds of different sizes, types and capacitances and is only interested in attracting makers of radio or electronic equipment; but there are many makers of other types of gear—testing sets, amplifiers, loudspeakers, recording tape, new types of valves and so on, who omit from their advertisements any suggestion of the price. Even the women's magazines now give one an idea of the prices of the creations advertised, "This dinky little model chapeau in *fer blanc*, about nine-and-a-half-guineas," but there isn't even that suggestion in many of your advertisements.

Surely the AVO people, Vortexion, Marconi Instruments and Trix don't expect to sell their products whole-sale by the gross—or do they? Even if they did, an indication that the retail price is so-and-so would be of interest to many readers, and would still not debar the large user from negotiating other terms.

Cambridge. G. W. IRWIN.

Crystal-Transistor Link?

IT is difficult to disagree with anything that Dr. Armstrong, the distinguished pioneer of regeneration, super-regeneration and the superheterodyne principle, says in his letter published in your January issue. "Major" Armstrong (as he will always be to me) helps to get the perspective right. The valve made little impact on the radio art until the introduction of regeneration, which turned it into a receiving device of hitherto undreamed-of sensitivity. The regenerative triode detector was the heart of the radio receiver for many years, and was not finally displaced until the short-lived neutralized triode (which quickly gave way to the screened-grid tetrode) provided us with effective r.f. amplification.

But is Dr. Armstrong right in implying (his penultimate paragraph) that the originators of the transistor obtained no inspiration from the crystal detector? I am inclined to submit that if they did not, there was little excuse for their failure. The oscillating zincite crystal, which aroused some interest in the early 1920s (I cannot confirm the date*) surely served, or should have served, as a fairly obvious connecting link between the humble crystal detector and the transistor.

"RADIOPHARE."

* *Editorial footnote.*—Several articles on oscillating crystals, including one from the Russian originator Lossev, appeared in *Wireless World* during 1924.

Historical Relic

MAY I correct "Free Grid's" dates? The German-made coherer unit which he illustrates on his page in your January issue was certainly on sale in either 1911 or 1912. I became the proud owner of one, with its accompanying spark-coil transmitter, about two years before the outbreak of the first World War. These sets were sold, I believe, by more than one shop dealing in electrical novelties for schoolboys.

The relay fitted to the receiver unit was for actuating the de-coherer, which at the same time rang a bell and so gave a clearly audible signal. I think "Free Grid" is wrong about the morse inker, which was not used with my set.

With careful adjustment of relay and de-coherer, a range of 20 or 30 yards was obtainable.

Manchester.

A. M. FISHER.

INTERNATIONAL MARINE V.H.F.

AT the Atlantic City Conference of the International Telecommunication Union in 1947, frequency modulation was made compulsory for marine v.h.f. communication on certain frequencies in Region 2 (the Americas), but not in Regions 1 (Europe) and 3 (Far East). Subsequently, in 1949, it was announced by the Post Office that it had been decided to specify amplitude modulation for all v.h.f. maritime services of the United Kingdom using the international simplex channels (156.8 and 156.6 and 156.3 Mc/s), or the proposed international two-frequency public correspondence channel (157.4 Mc/s mobile and 161.9 Mc/s fixed) and associated national two-frequency public correspondence channels (157.5, 157.6, 157.7 and 157.8 Mc/s mobile and 161.5, 161.6, 161.7 and 161.8 Mc/s fixed), or the group of two-frequency channels reserved in this country for the use of harbour docking and pilotage authorities (158.6 to 159.4 Mc/s mobile and 163.6 to 164.4 Mc/s fixed).

Not only was a.m. adopted by this country, but it was widely recommended by the U.K. to other countries in Regions 1 and 3.

According to facts given in a report issued by Rees Mace Marine these opposing decisions have resulted in a position where some 40 base stations and 330 mobile stations in North America (mostly on the Great Lakes) have been equipped with f.m. gear while over three times as many stations in the rest of the world have been fitted with a.m. equipment.

The Assistant Postmaster-General recently stated in the House, in reply to a question, that "The shipping industry and the radio industry (with the exception of one manufacturer) have agreed that it would be in the national interests to resume discussions internationally with a proposal in favour of standardization on frequency modulation, and there is at last some prospect of reaching agreement and of removing the uncertainty."

The Rees Mace report summarizes the present position and formulates a plan for the solution of the impasse. A truly international decision on a unified system of modulation cannot be arrived at until the next meeting of the I.T.U. which, at the earliest, will not be held until 1957. The view is, therefore, expressed that it would be wrong for changes to be introduced in the interim as these would not be internationally binding; on the other hand, it is pointed out that it would be quite unthinkable to stop fitting v.h.f. gear during this period. There must, therefore, be some co-ordinated interim plan, but, as pointed out by the General Council of British Shipping, such a plan must not only permit the continued growth of the use of v.h.f. but must ensure that any eventual change can be made with a minimum of inconvenience. It is, therefore, suggested that the problem can be solved by the production of dual-modulation equipment. During the interim period it will be necessary for only a small proportion of British ships to install dual-purpose equipment, in fact only those sailing to Region 2.

The report lists some of the problems which have to be solved before international standardization can possibly be achieved. They include (a) frequency allocation (at present only three channels have been internationally allocated); (b) simplex or duplex working; (c) a standardized selective calling system, and (d) transmitter and receiver specifications. Rees Mace consider that it would cause less disruption to British manufacturers to market dual equipment for a.m. and f.m. than it would to adopt American standards. "It is, therefore, at least as important to find out American views on international standards as it is to find out their views on modulation."

It is claimed that the Admiralty will support any plan which will permit British merchant ships to continue fitting v.h.f. and will facilitate v.h.f. inter-communication with ships throughout the world. The plan formulated in the report also leaves the door open for the integration of v.h.f. services for air/sea rescue purposes.

PUBLICATION DATE

In future *Wireless World* will be published on the last Monday (instead of the last Tuesday) of the month preceding that for which it is dated.

RUSSIAN TELEVISION

Some Notes from the U.S.S.R. on Equipment

LITTLE has been published in this country on the development of Soviet television, and it was, therefore, refreshing to find a delegate to this country during the recent British-Soviet Friendship Month who was able to give some factual information.

It is, of course, general knowledge that the U.S.S.R. is employing the "European" standard of 625 lines, 50 frames per second and f.m. sound, but using a bandwidth of 8 Mc/s. Transmissions are horizontally polarized.

It would appear that while there are a considerable number of communal receivers installed in the service areas of each of the four stations (Moscow [2], Leningrad and Kiev) there is a growing demand for domestic receivers. The large majority of sets are for direct viewing, but some projection models are available and both forward and back projection is employed.

In addition to the two transmitting stations, Moscow now has a television theatre which regularly shows the transmitted programmes on a big screen.

Each of the present stations originates its own programmes, but can be linked with other transmitters by radio and cable. Undoubtedly one of the biggest and most important problems for the Soviet broadcasting authorities is the relaying of television programmes in such a vast country. The shortest distance between any two of the present three centres is 500 miles. The same applies to the new stations being constructed in Stalingrad and Sverdlovsk.

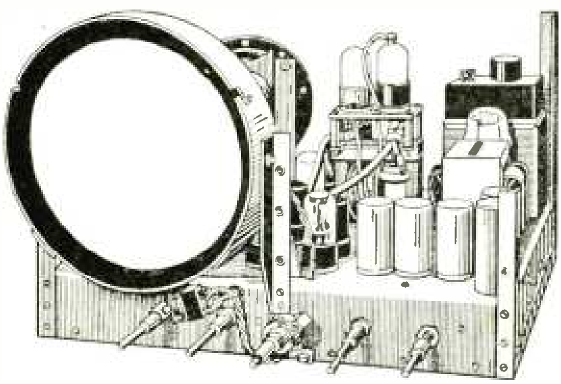
Russian television sets give a certain impression of the earlier American practice. The screens are fairly small—9in being about the average size—and are often made to look even smaller by the large loudspeaker grilles which appear alongside them on the fronts of the cabinets. There are usually four, five or six controls brought out for the viewer to adjust, and apart from the usual brightness, focus and sound volume these often include such things as contrast, frame-hold, wave-change and tone control. Modern sets are still being built with mains transformers and there is no evidence of the a.c./d.c. transformerless technique.

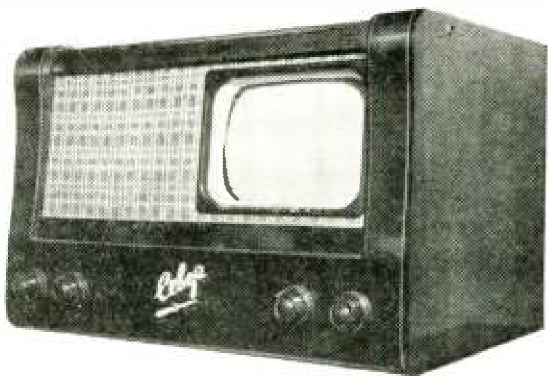
While most of the receivers are superhets, a good many straight sets are still being made for short-range reception. These usually have about ten valves to the superhets' 20. Some models have provision for receiving a.m. and f.m. sound broadcasts as well as the f.m. television sound transmissions. Few, if any, extra valves are needed for this, as some of the sound-channel stages are used for double purposes. One recent prize-winning design, for example, has a valve which acts as a limiter on the f.m. signals and as a diode detector for the a.m. sound broadcasts.

Blocking oscillators are popular for both frame and line time-bases and scanning coils are often directly fed from the anodes of their appropriate output valves. An unusual feature of one fairly typical receiver is the use of an efficiency diode to recover energy, not for the scanning system, but to energize the focus coil. It seems there is no difficulty in getting enough scanning power for the deflector coils since the cathode ray tubes are fairly small with narrow deflection angles.

American-type metal valves with octal bases are widely used in receivers and the 6.3-V heater appears to be standard. Some of the valves have well-known American type numbers and equally familiar characteristics, while others have numbers which are not recognizable but are obviously based on the same system. There are no signs of any miniature valves. Components generally have much the same appearance as ours.

With horizontally polarized transmissions the receiving aerials are naturally T-shaped, as in America. A good many people, however, make use of indoor aerials which are disguised to look something like electric bowl fires. The bowl reflectors are actually used to give a directional effect, so that the aerials can be adjusted to find the best angle for





On the left is a sketch of a recent prize-winning Russian receiver, reproduced from the Soviet journal "Radio," and on the right is a fairly typical table model in its cabinet.

reception. Naturally the directivity is not very great because the reflectors are relatively small compared with the wavelength. In blocks of flats communal aerial systems are used, as the authorities have the same objections to forests of dipoles on the roofs as they have in this country.

Colour television will be starting up soon, apparently on the frame-sequential system, and adaptors with rotating colour filters are being made for use with existing black-and-white receivers.

One type of interference which is not experienced by town dwellers in the U.S.S.R. is flutter caused by aircraft; flying is prohibited over built-up areas.

Gregory Alexandrov, our informant, who was leader of the delegation from the U.S.S.R., is a professor at the Central Film Institute, Moscow, and has directed a large number of Soviet films. He told us, incidentally, that they have experimented with the use of electronics in the production of films, but have abandoned the project.

Television Society's Exhibition

New Circuitry and Devices

HELD in London on 7th-9th January, the annual exhibition of The Television Society included 39 exhibitors. As in previous years, it was noteworthy for the number of demonstrations of an experimental and educational nature.

One of particular interest to sufferers from ignition interference was the "grey spotter" circuit of G.E.C. The circuit is shown in Fig. 1; V_1 is the video stage coupled in the usual way to the cathode of the c.r. tube. The signal from V_1 is also applied to the cathode of V_2 and appears at the anode in the same phase, whence it is passed to the grid of the tube. If the complete signal were passed it would, of course, cancel the cathode signal, but the limiting action of V_2 and V_3 makes the grid signal one of interference only. V_2 is biased to be non-conductive during the video signal proper and to conduct only during noise pulses of amplitude greater than peak white. It then conducts and amplifies and if it were not for the diode V_3 it would be a "black spotter" for, because of the amplification in V_2, the noise pulse applied to the grid of the tube would be greater than that applied to the cathode. V_3, however, is biased to act as a second limiter, this time of the noise pulse amplitude applied to the grid. The result is that the effective level of noise on the tube is held at a level corresponding to grey in the picture and as this is the average level of illumination the contrast between the noise and the picture brightness is reduced. In a demonstration the circuit appeared very effective.

A circuit which enables a direct visual comparison to be made between two aerials was demonstrated by Belling & Lee. It enables the top half of a normal television picture to be reproduced from a signal received on one aerial while the bottom half is provided by a signal received on a second aerial. It has the great merit of enabling a direct comparison of two aerials, particularly as to their susceptibility to interference, to be made under proper viewing conditions.

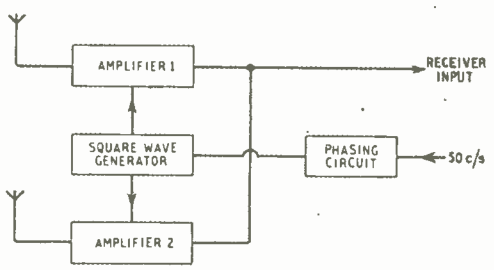
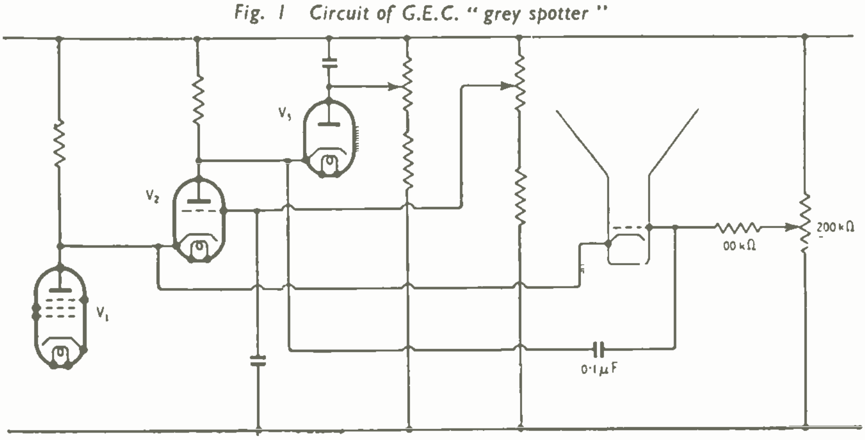


Fig. 2 Belling-Lee electronic switch for aerial comparison.

The arrangement is sketched in Fig. 2. Each aerial feeds an r.f. amplifier the outputs of which are commoned and taken to the input of any television receiver. The two amplifiers are rendered alternatively inoperative by a biasing pulse. A 50-c/s square-wave generator is used for this and is locked at 50 c/s through a phasing circuit which enables the change-over to be adjusted to the required point. One change-over occurs during the frame fly-back, the other half-way through the picture. In the demonstration an artificial source of interference was impressed on the input signal to one amplifier, the input to the other being free of interference. This gave a good idea of the capabilities of the method, which appears to be a valuable one for assessing the practical value of television aerials whenever it is possible to have the two to be compared erected simultaneously.

Apart from ignition interference, aircraft flutter is probably a major cause of interference, especially in certain districts. A circuit to reduce its effect on the picture was demonstrated by G.E.C. Under the somewhat artificial conditions of the demonstration, where the signal fluctuations were provided by an input attenuator which was varied regularly at a

Fig. 1 Circuit of G.E.C. "grey spotter"



slow rate, the circuit made an enormous improvement to the picture. although it did not completely eliminate the effects of the flutter,

The circuit is shown in Fig. 3 and is extremely simple. The video signal is fed back through an RC network comprising a cascade of integrator and differentiator type circuits which form a frequency-selective circuit. Neither picture-frequency signals nor d.c. is passed. Slow variations of the signal in the region of 10 c/s are passed, however, and vary the bias, and hence the gain of the i.f. amplifier, so that as the output increases the gain decreases and vice versa. It is a form of a.g.c.

The care that is needed in television receiver production is brought home by the elaborate apparatus shown by Bush for r.f. amplitude and phase characteristic tests. A combination of step and pulse methods is used. This same firm also showed an experimental recording wobbulator which enables a permanent record of the response curve of a television receiver to be made by means of a pen recorder. A variable-frequency oscillator is used to produce the signal and there are several crystal-controlled marker frequencies.

Bush showed a receiver using a direct-drive line-scanning circuit to show the simplicity resulting from this arrangement and G.E.C. demonstrated a set using an experimental 12-in c.r. tube with a 90° deflection angle. Small external magnets are used to correct for pincushion distortion.

The possible advent of new television stations in Band 3 was reflected at the show by a 12-channel tuner (Cyldon) covering the frequency range 50-220 Mc/s, and two new Mullard valves specifically designed for use in such circuits. These valves were the PCC84 double triode and the PCF80 triode-pentode, both on the B9A base. The PCC84 is intended for use as a cascode low-noise r.f. amplifier with an h.t. voltage of 180V. In the cascode circuit the two triodes are connected in series across the h.t. supply so they get only 90V each, but in spite of this low operating voltage each triode has a slope of 6mA/V and an amplification factor of 24, permitting a gain of about 12 db from the circuit. A difficulty of the cascode circuit is that a high voltage is placed across the heater-cathode insulation of the top earthed-grid valve. This has been catered for in the PCC84, which has a heater-cathode voltage rating of −250V and +90V.

The PCF80 triode-pentode is intended for use as a frequency changer following the PCC84, and in a typical circuit it is claimed to give a conversion gain of 20 db working with an input frequency of 200 Mc/s. The triode and pentode sections are placed side by side instead of one above the other as in earlier Mullard valves.

This combination of PCC84 cascode r.f. amplifier and PCF80 frequency changer is actually used in the Cyldon tuner. The unit is based on the American type of turret tuner and has a rotating drum carrying 12 aerial and 12 r.f. coupling and oscillator coils. These coils are mounted on low-loss Bakelite contact strips which are clipped on to the turret, and rotating the turret brings the desired set into circuit, leaving the others isolated.

Mullard were showing how the difficult and complicated processes of frequency-changer design can be simplified and made more exact by an interesting type of "three-dimensional" display which presents a large number of characteristics of a mixer valve (actually the PCF80) in their correct relationship on a single chart. It is called the "contour line method"

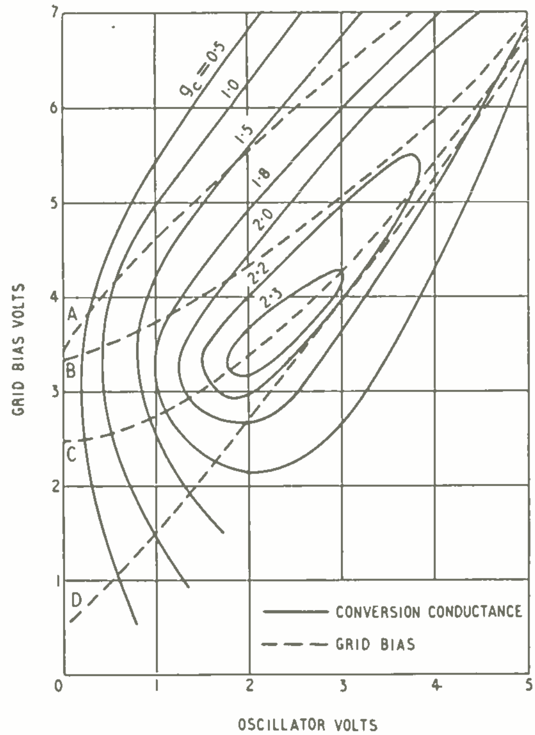
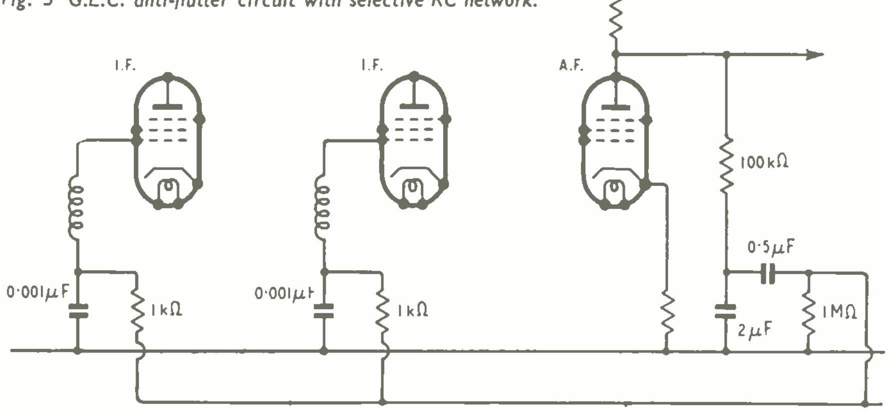


Fig. 4 "Three-dimensional" display of PCF80 characteristics. Control-grid bias of pentode section for different values of cathode resistor and grid resistor (A, B, C, D), plotted against oscillator volts, with superimposed "contour" lines of constant conversion conductance.

because on an ordinary two-dimensional graph are superimposed lines joining points of equal conversion conductance. Looking at Fig. 4 one can, in fact, imagine it as a bird's eye view of a relief map, with a "hill" rising to its summit in the middle at a conversion-conductance "height" of just over 2.3 mA/V. The dotted lines A, B, C, D represent different values of grid leak and cathode resistor. While the maximum conversion conductance lies on curve C, at an oscillator voltage of 2.3 V and a control-grid bias of −3.6 V, its value is affected considerably by changes in oscillator voltage. Optimum conditions are given by curve B, which runs almost parallel to the contours (along the side of the "hill" instead of straight up and down the slope) and is reasonably near the maximum conversion conductance.

Fig. 3 G.E.C. anti-flutter circuit with selective RC network.



Radar in Airliners

Is it a Practicable Aid to Extra Safety in the Air?

THE use of airborne radar as an aid towards safer air travel has recently attracted some attention in the daily Press; but it has been under consideration by the airlines ever since the end of the war, and a lot of work has been done towards developing a suitable set. In general terms, the requirement is to extend the "range of vision" from the aircraft, and to indicate clearly the presence of obstructions to flight. With increasing speeds of transport aircraft—up to 500 m.p.h.—the need for a lot of clear airspace is apparent, because transport aircraft, and their loads, are not normally subjected to violent manœuvres.

The routes which airliners follow are, of course, selected to avoid all dangerous ground, or else to fly over it at a height which provides a large margin of safety against a possibility of partial loss of power. Flying between mountain peaks is not airline business, and following an established route is an everyday exercise in air navigation, presenting neither novelty nor difficulty in normal circumstances. In fact, it is doubtful whether the use of aircraft radar as a form of map-painter will be any advantage, because the information on the radar screen is not detailed and the navigation systems available, such as for instance the Decca system, give precise information about position. In case of doubt, though, radar information can be used as confirmation of orthodox navigation, but it would be rather like using a watch to confirm the Rugby time signals.

Dangerous Cloud Formations

However, there is one particular application which can only be met in a satisfactory way by using radar, and this application is being followed up, with trials taking place at present by the Royal Canadian Air Force in a Comet. This application is the avoidance of obstacles which occur seasonally, and which are not stationary—dangerous clouds.

In and near the tropics at certain seasons the weather conditions produce a type of thundercloud (cumulo-nimbus) which has a core with a high percentage of water in it, and where the vertical currents are very severe, up to 60-80 feet per second. These clouds are avoided by aircraft, because of the very disturbed air around the cloud, which would cause a very rough ride. The interference increases as the aeroplane speeds are raised, and with high-speed jet aircraft it could become very troublesome.

As long as these clouds can be seen, they may readily be avoided, but at night they may be so severe as to cause flying to be suspended. Experiments with radar have shown that the dangerous clouds produce strong echoes on the radar screen (and so do some non-dangerous clouds); so by fitting radar, aircraft may be able to fly by night in areas where "stuffed clouds" are likely to be, with sufficient warning of the presence and locality of the hazards to allow the aircraft to avoid them. This is an appreciable advantage.

A radar set has been developed in England, by Ekco* working with the Ministry of Supply, and it has been extensively tested as it has been developed. It has a maximum range of 40 miles, and has detected clouds, presumed to be dangerous, at maximum range. The equipment needs about 650 VA of power, and its output is 10 kW peak, on a wavelength of 3 cm, with 700 pulses per second, each of 1-microsecond duration.

The strength of the echo from clouds depends on the size of the water drops in the cloud, and on the wavelength of the radar. Experimenters in U.S.A. have found that in some cases a wavelength of about 6 cm produces a much stronger echo than does the 3-cm radar, and they have built an aircraft set to use these longer waves. It has rather more range, for the same power, than the 3-cm radar, but has the great disadvantage that the aerial assembly is so very much bigger. This will make the equipment difficult to accommodate in an airliner, for a very large section of the nose would not only become useless as stowage space, but would have to be encased in Perspex or something similar.

Economic Problems

Space and weight are at a premium on every aeroplane, and the British equipment weighs about 200 lb, installed. This is about the same as the weight of a passenger, so it is clear that even to carry the radar implies a substantial cost to an airline; it must only be carried where it can serve a useful purpose. This would be equivalent to reducing the payload in some localities to cater for weather hazards, as is done in ships which are less deeply laden for winter in the North Atlantic than elsewhere.

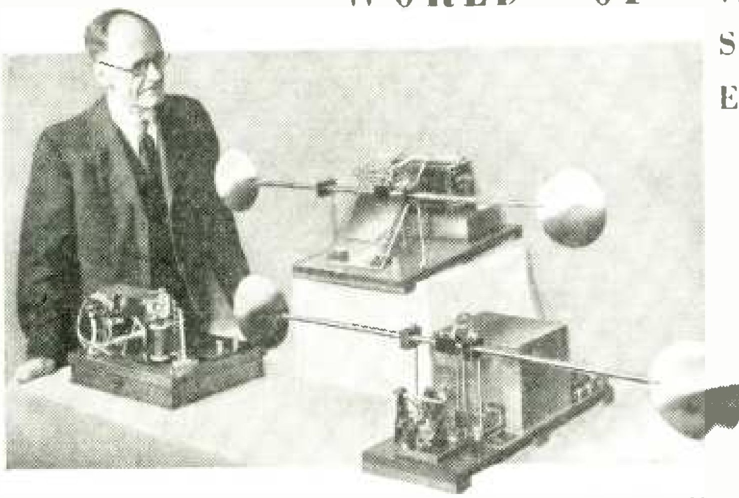
Aircraft radar has occasionally been suggested as a valuable preventer of collisions between aircraft, but the information displayed is not specific enough for collision prevention. However, collision between aircraft is not a serious hazard; there are few localities where air traffic is dense enough to create collision risks, and in all these localities there is an effective and rigid system of air traffic control, using ground radar as one of its principal tools. By means of two-way radio telephony, aircraft are given instructions on route and height, and the only danger would arise from an intrusion by an aircraft without two-way radio telephony. Such an intrusion is forbidden, but is has happened, though radar on aircraft would be of little value in such a case.

I have tried to show that there is a case for aircraft radar, which can be a useful aid in certain circumstances. This is far from recommending that all airliners should be fitted with radar as a permanent fixture, or from suggesting that without radar any operations carried out at present are less safe than they might be. The contrary is the case, and certainly radar will be used where its use is justified. The provision of a suitable equipment is actively being pursued, but the total costs will be so high that the article will have to be very good. J. M.

* "Radar Cloud Detector" *Wireless World*, December 1950

WORLD OF WIRELESS

Show News • Record Radio Exports • V.H.F. Report • TV Pioneer Honoured



MUSEUM-PIECE V.H.F. — A working model of the apparatus used by Marconi in his early experiments has recently been presented by the Marconi Company to the Science Museum, South Kensington, where its operation is being demonstrated to visitors. The apparatus, seen here with its maker, R. W. Piper, of the Marconi Marine Company, comprises a spark transmitter (top) and a coherer receiver (right). Operating frequency is 85 Mc/s

Instruments and Components

ANNUAL London exhibitions of the Radio and Electronic Component Manufacturers' Federation and the Physical Society will overlap by only one day this year. The R.E.C.M.F. components show will be held at Grosvenor House, Park Lane, W.1, from April 6th to 8th. Some 130 exhibitors will be participating in the exhibition. Admission is by invitation, limited to those interested in the industrial, scientific or trade aspect of components. The show will be open on each of the three days at 10.0 and will close at 6.0, 9.0 and 5.0 respectively. Tickets are obtainable from the Federation at 22, Surrey Street, Strand, London, W.C.2.

Tickets for the 38th Physical Society exhibition of scientific instruments and apparatus, which will be held at the Imperial College of Science and Technology, Imperial Institute Road, S.W.7, from April 8th to 13th, will be available from the Society from the beginning of March. As in previous years, tickets will be valid for specific sessions and days. The exhibition will open daily at 10.0 and will close at 8.0 on the 8th, 9th and 12th and at 5.0 on the 10th and 13th. On the opening day admission will be limited to Fellows and the Press from 10.0 until 2.0. The handbook covering the exhibition will be available on March 1st, from the Society, 1, Lowther Gardens, Prince Consort Road, London, S.W.7, price 6s, postage 1s 3d.

V.H.F. Broadcasting

THE LONG-AWAITED report of the Television Advisory Committee on v.h.f. broadcasting has, it is understood, been received by the Postmaster General. It is not known whether the findings of the Committee will be published, as, of course, the report has been prepared solely for the guidance of the Government and is not in itself a statement of Government policy. It is, however, known that the Committee recommends, as was anticipated, the use of frequency modulation, although there is an adverse minority report.

New Zealand Television

BRITISH 405-LINE TELEVISION standards having been recommended by a Government departmental committee for adoption in New Zealand, Pye recently shipped to Wellington complete transmitting equipment and a number of receivers to provide demonstration transmissions during the Wellington Show and Industrial Fair (January 7th-27th).

The Minister in Charge of Broadcasting has, however, stressed that there is no likelihood of the Government taking immediate action to establish a television service.

Radio Exports

ACCOUNTS for November recently issued by the Board of Trade show that the total value of radio exports during the month was £2,677,912, which, for the second successive month, broke previous records. The figure for the eleven months of 1953 (£23,328,347) is within £1.2m of the total for the whole of 1952.

The November figure and the eleven-month total (in £m) for each of the four sections of the industry are:

Transmitting and radio navigational gear	1.245	9.866
Components and sound reproducing equipment ..	0.955	8.222
Domestic receivers	0.276	3.225
Valves and c.r tubes	0.202	2.015

Faraday Medallist

ISAAC SHOENBERG is to receive the 32nd award of the Faraday Medal of the I.E.E. "for his distinguished work in electrical engineering, in particular the outstanding contributions which he has made to the development of high-definition television in this country."

Mr. Shoenberg, who is director of research of Electric and Musical Industries, led the team (including A. D. Blumlein, C. O. Browne, G. E. Condliffe and J. D. McGee), which was responsible for the development of the 405-line television system and ancillary equipment adopted by the B.B.C. in 1936.

Born in Russia in 1880, Mr. Shoenberg was chief engineer of the Russian Wireless Telegraph and Telephone Company, Leningrad, from 1905 until he came to this country in 1914 as consulting engineer to the Marconi Company of which he became joint general manager. He has held his present position since the formation of E.M.I. in 1931 through the amalgamation of the Gramophone Company and the Colombia Graphophone Company of which he had been joint managing director for three years.

European Broadcasting Problems

DURING the meeting of the Technical Committee of the European Broadcasting Union at Monte Carlo in November, E L. E. Pawley (B.B.C.) chairman of the

Committee, presented a report on the studies of a working party concerned with v.h.f. broadcasting, especially in relation to the Stockholm Plans. In its future studies this working party will consider the problems regarding the securing of the 216-223 Mc/s channel for television (this will extend Band 3 by 7 Mc/s) and the co-ordination of investigations into the use of Bands 4 and 5.

Three new working parties, were set up during the meeting. One will deal with the operational use of magnetic-tape recording, including its applications in television; another with the expansion of the television network in Europe, with special reference to the location and responsibility for standards-converters for international relays; and the third will be responsible for collaboration between the E.B.U. and the C.I.S.P.R.

The report of the Brussels Technical Centre given at the meeting included references to the standard of musical pitch, the choice of i.f.s for television sets, stereophony and the compilation of a bilingual technical glossary.

"*W.W.*" *Index*

COPIES of the index to the 1953 volume of *Wireless World* are now available from our Publishers price 1s (postage 2d). Cloth binding cases are also obtainable with index, price 6s 5d by post. The binding of readers' own issues can be undertaken by our Publishers, the cost, including binding case and index, being 17s 6d plus 1s 4d postage on the bound volume.

NEW YEAR HONOURS

Dr. W. G. Radley, C.B.E., Post Office engineer-in-chief, received a Knighthood in the New Year Honours. He joined the Post Office in 1920, was for five years controller of research and was appointed E.-in-C. in 1951. He is chairman of the Technical Sub-Committee set up by the Television Advisory Committee.

Norman C. Robertson, M.B.E., who recently concluded his two-year term of office as director-general of electronics production at the Ministry of Supply and returned to E. K. Cole, Ltd., where he has been deputy managing director since 1945, has been appointed a Companion of the Order of St. Michael and St. George (C.M.G.).

Rear-Admiral (L) C. P. Clarke, C.B., D.S.O., R.N.(ret.), and **Cdr. S. S. C. Mitchell,** C.B., O.B.E., R.N.(ret.), are created Knights Commanders of the Order of the British Empire (K.C.B.). Commander Mitchell has been controller of guided weapons and electronics (M.o.S.) since 1951 and has been in charge of all research, development and production of guided weapons in this country.

G. J. S. Little, G.M., an assistant engineer-in-chief, Post Office, and **G. Darnley Smith,** managing director of Bush Radio and Cinema Television, are among the new Commanders of the British Empire (C.B.E.). Mr. Darnley Smith is chairman of the Radio Industry Council and is one of the two representatives of the industry on the Television Advisory Committee.

Among the new Officers of the Order of the British Empire (O.B.E.) are **T. H. Baines,** deputy director radio equipment (production), Admiralty, **A. S. Mitson,** assistant director electronics production. M.o.S., and **M. J. L. Pulling,** senior superintendent engineer (television), B.B.C. Mr. Pulling has been in his present position since 1949 and was previously superintendent engineer (recording) for eight years. He recently visited the United States and gave his impressions of American television in our January issue.

New M.B.E.s include **O. H. Barron,** engineer, Planning and Installation Department, B.B.C., **D. J. Bowman,** B.B.C. Monitoring Service, **F. Clark,** Marconi Radio Officer in m.v. *Isipingo*, **W. H. F. Griffiths,** chief engineer, H. W. Sullivan, Ltd., who has contributed articles on standard measuring equipment to both *Wireless World* and *Wireless Engineer*, **H. J. Harbour,** test controller, Radio Division, E. K. Cole, Ltd., and **G. Houghton,** chief technical instructor, Radar Section, Technical Training College, Indian Air Force, Jalahalli.

Recipients of the British Empire Medal include **W. McLaren,** leading technical officer, P.O. Radio Station, Cupar, and **G. Wilkins,** experimental mechanician, McMichael Radio.

PERSONALITIES

Ernest Leete has been elected an Honorary Member of the I.E.E. "for his services as Honorary Treasurer . . . and also for his work on behalf of the Benevolent Fund of the Institution." Mr. Leete joined the London Electric Wire Company and Smiths, Ltd., in 1904 and subsequently became managing director.

H. Faulkner, C.M.G., B.Sc., M.I.E.E., has retired after forty years' service in the Post Office where he has been deputy engineer-in-chief since 1948. He was a member of the team responsible for the design of the Rugby Station and was its first officer-in-charge (1925). Mr. Faulkner was chairman of the recent London meeting of the C.C.I.R. and is a member of the Technical Sub-Committee of the Television Advisory Committee. He has accepted the office of director of the Telecommunication Engineering and Manufacturing Association (see opposite page).

A. H. Mumford, O.B.E., B.Sc.(Eng.), M.I.E.E., succeeds Mr. Faulkner as deputy E.-in-C. at the Post Office, having been an assistant E.-in-C. since 1951. He joined the Post Office Engineering Dept. as a probationary assistant engineer in 1924, and after a short period at Headquarters went to the Dollis Hill laboratory. He took charge of the Radio Branch in 1928. Mr. Mumford is succeeded as assistant E.-in-C. by **C. F. Booth,** O.B.E., who has been deputy director, External Telecommunications Executive, for the past eighteen months. Both Mr. Mumford and Mr. Booth have been chairmen of the I.E.E. Radio Section. (Portrait opposite.)

Rudolph Kompfner, the originator of the travelling-wave valve which he described in the November, 1946, issue of *Wireless World*, is now at the Bell Telephone Laboratories, Murray Hill, New Jersey, U.S.A., where he is working on microwave valves and has recently contributed an article on backward-wave valves in the *Proceedings of the I.R.E.* He came to England from Austria in 1934 and joined the Admiralty as a temporary experimental officer in 1941, undertaking research in the Physics Department of Birmingham University. From 1944 until 1952 he was in the Clarendon Laboratory of Oxford University.

RECIPIENTS OF NEW YEAR HONOURS

DR. W. G. RADLEY
(Knighthood)

NORMAN C. ROBERTSON
(C.M.G.)

M. J. L. PULLING
(O.B.E.)

W. H. F. GRIFFITHS
(M.B.E.)

W. R. Nash, M.Inst.R.E.(Aust.), who has been London manager of Amalgamated Wireless (Australasia), Ltd., for the past seven years, has returned to Sydney as an assistant to the managing director of A.W.A. He is succeeded by **D. Craig,** who joined A.W.A. in 1936 after five years with Raycophone, Ltd. From 1937 to 1946 he was in the company's research laboratory where he was concerned with development work on crystal manufacturing machinery, aircraft equipment and mobile f.m. gear. For the past seven years he has been in the Technical Services Section.

A. H. MUMFORD

D. CRAIG

A. I. Bray, B.Sc.(Eng.), A.C.G.I., A.M.I.E.E., who joined the engineering staff of the B.B.C. in 1935 and was attached to the London Outside Broadcasts Section, has been appointed engineer-in-charge Television Outside Broadcasts (London). During the war he served in the R.A.F., attaining the rank of Squadron Leader, and returned to Television O.B.s in 1946.

L. Evans has been appointed engineer-in-charge of the Isle of Man television transmitter. He joined the B.B.C. in 1941 and has served at a number of the Corporation's sound and television stations, including Sutton Coldfield and Wenvoe.

OUR AUTHORS

S. Kelly, chief engineer of Cosmocord's electro-acoustic division, who writes on components for transistors in this issue, was on radar research at R.A.E., T.R.E. and at the Massachusetts Institute of Technology for the major part of his wartime service in the R.A.F. He was subsequently senior radar officer, Transport Command Development Unit. Before the war Mr. Kelly was in the development laboratories of Standard Telephones & Cables and Philco.

D. C. Pressey, author of the article on page 60, is at present developing analogue computing devices at Southern Instruments, which he joined in 1950. He commenced his radio career in 1944 at R.R.D.E. (now Radar Research Establishment), Malvern, where most of his work was concerned with the radio proximity fuse. Two years later he went to the Nuffield Department of Anæsthetics, Oxford University, where he undertook research on the application of electronics to medical problems, as a result of which an instrument for the recording of respiration rates and volume was developed.

T. W. Bennington, whose annual survey of the ionosphere appears in this issue, was from 1939 until recently in charge of the ionospheric and short-wave propagation work of the Overseas and Engineering Information Department of the B.B.C. He is now engaged on similar work in the Corporation's research department. He helped in 1930 to inaugurate the first long-distance ship-shore radio-telephone service and was in charge of the radio-telephone service in R.M.S. *Majestic.* Mr. Bennington, who joined the B.B.C. in 1934 after a period in the radio industry, is author of the book "Short-wave Radio and the Ionosphere."

H. S. Jewitt, contributor of the article on wideband i.f. amplifiers on page 86, worked on anti-aircraft radar while in the army from 1939 until invalided out in 1942. He then undertook research work on v.h.f. and a.f. until September, 1945, when he went to Queen Mary College, London University. He graduated in 1949 as B.Sc.(Eng.) and joined Ferranti's as development engineer working on pulse circuitry. Since mid-1952 Mr. Jewitt, who is now 31, has been with Decca Radar where he is senior engineer in charge of the receiver design group at the radar research laboratory, Tolworth, Surrey.

IN BRIEF

Receiving Licences.—During November the number of television licences in Great Britain and Northern Ireland increased by 119,157, bringing the total to 2,846,227. The total number of broadcast receiving licences, including sound, vision and 202,676 for car radio, was 13,216,644 at the end of the month.

East Anglian Transmitter.—A new low-power transmitter at Hempstead, near Cromer, was brought into service by the B.B.C. at the end of December. The 2-kW station, which operates on 434 metres (692 kc/s), has been provided with a directional aerial system designed to give a good service in Sheringham, Cromer, North Walsham and Aylsham without affecting reception of the Moorside Edge transmissions in north-west Norfolk and along the Lincolnshire coast.

Farnborough 1954.—The annual flying display and exhibition of the Society of British Aircraft Constructors at Farnborough, which is fast becoming the focal point for aeronautical radio, will this year be held from September 7th to 12th.

The **Daventry Third Programme Transmitter** (647 kc/s), the aerial of which had been undergoing repair for some time, resumed transmission on full power at the end of the year. Further adjustments to the aerial system are being made to reduce the fading which is experienced after dark in the more remote areas.

The Physical Society is organizing a conference on the **Physics of the Ionosphere,** to be held at the Cavendish Laboratory, Cambridge, from September 6th to 9th. Details of the Conference, which will be devoted to discussions on the lowest ionosphere, irregularities and movements in the ionosphere, the F2 layer and the mathematics of wave propagation, may be obtained from J. A. Ratcliffe, F.R.S., Cavendish Laboratory, Cambridge.

T.E.M.A.—The Telecommunication Engineering and Manufacturing Association, of which H. Faulkner has been appointed director (see "Personalities"), is concerned mainly with general policy matters in the telecommunication industry. Among the members of the association, which was formed in 1943, are A. T. & E., Creed, Ericsson, G.E.C., Plessey, S.T.C., Siemens and T.M.C. The address of T.E.M.A. is Stafford House, 40-43, Norfolk Street, London, W.C.2.

Magnetic Tape Standards.—A revised British Standard (BS1568:1953) has been issued on "Magnetic Tape Sound Recording and Reproduction for Programme Interchange." Dimensions are now included of an adaptor to permit the use of American N.A.B. spool hubs on machines designed primarily for European standard spools. Copies, price 2s 6d, are obtainable from the British Standards Institution, 2, Park Street, London, W.1.

Amateur Colour Television pictures have been transmitted over a closed circuit by C. G. Dixon, of Ross-on-Wye. The home-built equipment works on the frame-sequential system with rotating colour discs in front of the camera and c.r.t. monitor, and the scanning rate is 100 colour frames per second or 33⅓ complete pictures per second of 150 lines (non-interlaced) each.

Richmond Readers interested in the "technical aspects of the reproduction of music" might like to know that a group of music enthusiasts in the district is holding monthly meetings. Details may be had from B. J. Davis, 18, West Park Avenue, Kew Gardens, Richmond, Surrey.

As already announced, the fourth **Mechanical Handling Exhibition and Convention,** organized by *Mechanical Handling,* will be held at Olympia, London, W.14, from June 9th to 19th.

A booklet on the benefits of **V.H.F. Mobile Radio-telephones** in business and public services has been prepared by the Radio Communication and Electronic Engineering Association. It includes a list of the members of the Association supplying mobile radio equipment.

Amateur Call Book.—The winter edition of the R.S.G.B. Amateur Radio Call Book, which contains the calls, names and addresses of some 7,500 amateurs in the British Isles and Eire, is now available by post from the Society, price 2s 9d.

A new **Mullard Film** dealing with the technicalities of valve design and manufacture is now available for showing to clubs, colleges and schools. The "Manufacture of Radio Valves" as it is called, can be borrowed from Mullard's, Technical Publications Department, Century House, Shaftesbury Avenue, London, W.C.2.

Details of specialized **Higher Technological Courses** in a variety of subjects including electronics, high vacuum techniques, semi-conductors and transistors, which are available at 26 establishments in London and the Home Counties, are given in a Bulletin issued by the Regional Advisory Council, Tavistock House South, Tavistock Square, London, W.C.1. The price is 1s 6d.

INDUSTRIAL NEWS

Belling & Lee are arranging to give talks to the trade on the reception problems associated with the proposed introduction of an alternative television programme. They will be given in areas in which it is intended to erect transmitters and will cover aerial adaptors, feeders, input arrangements, etc.

Marconi Marine Company has appointed as manager of its Grimsby Depot, J. W. Dalton, who commenced his service with the company as a sea-going operator in 1928. He was manager of the Cape Town Depot of Marconi (South Africa), Ltd., from 1946 to 1953.

An order valued at over £100,000 has been placed with **E.M.I. Factories** by the French Air Ministry for 100 airborne Rebecca Mark IV sets with spares and associated test gear.

A complete **Pye** duplex multi-carrier radio-telephone system has been installed in South Turkey for the police. The installation consists of a 15-watt control station at Adana which controls two 50-watt repeaters installed at points where maximum coverage can be obtained. A further fixed station at the port of Mersin is linked by radio with the police headquarters at Adana 75 km away

A further three complete **Emitron** mobile television microwave radio links have been ordered by the Swiss Post Office from E.M.I.

Ediswan's Glasgow district office is now at 167, St. Vincent Street, Glasgow (Tel.: Central 0687). The cathode-ray tube service depot is at the same address, but its new telephone number is Central 2206 The company has also opened a c.r.t. service depot at 39-41, Jacksons Row, Manchester, 3 (Tel.: Blackfriars 2969).

Wharfedale Wireless Works, of Bradford, Yorks, celebrated in December the 21st anniversary of its formation.

MEETINGS

Institution of Electrical Engineers

London.—Faraday Lecture "Electro-Heat and Prosperity" by O. W. Humphreys, B.Sc., at 6.0 on February 16th at Central Hall, Westminster, S.W.1. (Admission by ticket obtainable from Savoy Place, W.C.2.)

"The Manchester Kirk o'Shotts Television Radio Relay System" by G. Dawson, B.Sc., L. L. Hall, K. G. Hodgson, B.A., R. A. Meers, O.B.E., T.D., and J. H. H. Merriman, on February 4th.

Radio Section.—"Basic Ground-Wave Propagation Characteristics in the 50-800 Mc/s Band" by J. A. Saxton, B.Sc., Ph.D., and "Ground-Wave Field Strength Surveys at 100 and 600 Mc/s" by J. A. Saxton, B.Sc., Ph.D., and B. N. Harden, M.Sc., on February 10th.

Discussion on "Acceptable Standards of Quality in Sound Broadcast Transmission and Reception"; opener, J. K. Webb, M.Sc. (Eng.), B.Sc.Tech.

The above meetings will be held at 5.30 at Savoy Place, London, W.C.2.

Cambridge Radio Group.—"The Use of Radio in the Ascent of Everest" by G. C. Band, at 6.30 on February 16th at the Cambridgeshire Technical College.

North-Eastern Radio Group.—"Technical Arrangements for the Sound and Television Broadcasts of the Coronation Ceremonies" by W. S. Proctor, M. J. L. Pulling, M.A., and F. Williams, B.Sc., at 6.15, on February 15th, at King's College, Newcastle-upon-Tyne.

North Midland Centre.—"Special Effects for Television Studio Productions" by A. M. Spooner, B.Sc.(Eng.), and T. Worswick, M.Sc., at 6.30, on February 9th at the British Electricity Authority, 1, Whitehall Road, Leeds.

"Ignition Interference with Television Reception" by A. H. Ball and W. Nethercot at 7.15 on February 25th at the Yorkshire Electricity Board, Ferensway, Hull.

North-Western Radio Group.—"The Reproduction of Signals Recorded on Magnetic Tape" by E. D. Daniel, M.A., and P. E. Axon, M.Sc., Ph.D., at 6.30, on February 17th, at the Engineers' Club, Albert Square, Manchester.

South Midland Radio Group.—"What is an Amplifier?" by D. A. Bell, M.A., Ph.D., at 6.0, on February 22nd, at the James Watt Memorial Institute, Great Charles Street, Birmingham.

Rugby Sub-Centre.—"Technical Arrangements for the Sound and Television Broadcasts of the Coronation Ceremonies" by W. S. Proctor, M. J. L. Pulling, M.A., and F. Williams, B.Sc., at 6.30, on February 3rd, at the Rugby College of Technology and Arts.

Southern Centre.—Faraday Lecture "Electro-Heat and Prosperity" by O. W. Humphreys, B.Sc., at 6.30, on February 18th, at the Guild Hall, Southampton.

"Technical Arrangements for the Sound and Television Broadcasts of the Coronation Ceremonies" by W. S. Proctor, M. J. L. Pulling, M.A., and F. Williams, B.Sc., at 7.30, on February 24th, at the R.A.E. Technical College, Farnborough.

Western Centre.—Faraday Lecture "Electro-Heat and Prosperity" by O. W. Humphreys, B.Sc., 6.30, on February 1st, at Sofia Gardens Pavilion, Cardiff.

"Technical Arrangements for the Sound and Television Broadcasts of the Coronation Ceremonies" by W. S. Proctor, M. J. L. Pulling, M.A., and F. Williams, B.Sc., at 6.0, on February 8th, at the South Wales Institute of Engineers, Park Place, Cardiff.

South-Western Sub-Centre.—"Printed and Potted Electronic Circuits" by G. W. A. Dummer and D. L. Johnston, B.Sc.(Eng.), at 4.30, on February 11th, at Dowlish Ford Mills, Ilminster, Somerset.

British Institution of Radio Engineers

London Section.—"Electronics in Film Making" by W. D. Kemp and B. R. Greenhead (High Definition Films), at 6.30 on February 17th at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1.

Scottish Section.—"Electronics in Film Making" by W. D. Kemp and B. R. Greenhead (High Definition Films), at 7.0 on February 4th at the Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2.

North-Western Section.—"Police Radio, Its Past, Present, and Future Possibilities" by I. Auchterlonie (Manchester City Police) at 7.0 on February 4th at the Reynold's Hall, College of Technology, Manchester.

North-Eastern Section.—"Some Aspects of Micro-Wave Aerial Design" by J. Bilbrough (Microwave Instruments), at 6.0 on February 10th at the Neville Hall, Westgate Road, Newcastle-upon-Tyne.

Merseyside Section.—"Micro-Wave Test Gear" by J. Bilbrough (Microwave Instruments), at 7.0 on February 4th at the Electricity Service Centre, Whitechapel, Liverpool, 1.

West Midlands Section.—"Applications of Electronic Techniques to the Testing of Magnetic Materials" by J. MacFarlane (Guest, Keen & Nettlefold), at 7.15 on February 23rd at the Wolverhampton & Staffordshire Technical College, Wulfruna Street, Wolverhampton.

British Sound Recording Association

London.—"Stereophonic Sound Reproduction" by J. Moir, at 7.0 on February 19th at the Royal Society of Arts, John Adam Street, London, W.C.2.

Manchester Centre.—"The Problems of Hearing" by J. E. J. John (Manchester University), at 7.30 on February 15th at the Engineers' Club, Albert Square. Manchester.

Television Society

London.—Fleming Memorial Lecture on "Colour Television" by G. G. Gouriet, B.Sc., at 7.0 on February 10th and 24th at the Royal Institution, Albemarle Street, London, W.1.

Leicester Centre.—"Modified Murphy Receiver Using 24-in G.E. Tube" by H. Fairhurst (Murphy Radio), at 7.0 on February 28th at the College of Art and Technology, The Newarkes, Leicester.

Institute of Navigation

"The Requirements for Marine Pilotage" by Commander L. W. Akerman and R. F. Hansford, at 5.0 on February 19th at the Royal Geographical Society, 1, Kensington Gore, London, S.W.7.

Institution of Production Engineers

Wolverhampton.—"Electronics in Production Engineering" by D. R. Whatley, B.Sc. (Eng.), at 7.15 on February 3rd at the Wolverhampton and Staffordshire Technical College, Wulfruna Street, Wolverhampton.

Edinburgh.—"Electronics in Industry" by G. Horsfall, at 7.30 on February 17th at the North British Station Hotel, Edinburgh.

Radar Association

"Some Unsolved Radar Problems" by K. E. Harris (Cossor) at 7.30 on February 10th in the Anatomy Theatre, University College, Gower Street, London, W.1.

Institute of Practical Radio Engineers

Midlands Section.—"Ultra Television Receivers" by H. G. Trapp (Ultra), at 7.30 on February 1st at the Crown Hotel, Broad Street, Birmingham.

Radio Society of Great Britain

London.—"Practical Aspects of Tape Recording" by S. A. Lacey (Murphy Radio), at 6.30 on February 26th at the I.E.E., Savoy Place, London, W.C.2.

Electron Optics

By "CATHODE RAY"

How Electron Paths are Controlled by Electric Fields

WHAT is electron optics? Well, for one thing it is a contradiction in terms. My dictionary says that "optics" is derived from a Greek word meaning "pertaining to sight; visible." Now one of the most obvious things about electrons is that they are *not* visible. You may perhaps have read somewhere that the fluorescent screen in a cathode-ray tube is for rendering the electron stream visible, but of course that is not literally true; it is the effect of their impact that is visible, not the electrons themselves. But "electron optics" does not even mean the technique of rendering effects visible. It is often very closely connected with such technique, notably in the cathode-ray tube, but it is really quite a distinct science. Roughly it could be defined as doing with electrons much the same kinds of things as can be done with light. Such things as focusing and deflecting rays. But I would like to make it clear from the start that "optics" only comes into the title on the strength of an analogy, and what is called electron optics could quite well be practised if there were no such thing as optics or even light. The analogy between optics and electron optics is by no means perfect and can actually mislead. One might almost as well call the subject of ordinary current electricity "electron hydraulics" because there is an analogy between electric currents and water. As we shall see, optics is not the only analogy that can be used in explaining "electron optics." However, that is the name it is known by, for good or ill, so we shall just have to use it.

I suppose we had better begin by establishing the resemblance between electron optics and optics, or electron rays and light rays; and the customary starting place is the Maltese-cross experiment, described by Sir William Crookes (as he later became) in 1879. This experiment, as you probably well know, was performed with a glass vacuum tube (Fig. 1) in which "cathode rays" were produced by applying a high voltage between two electrodes. The glass of the tube fluoresced under the impact of the rays, except where it was protected from them by the anode, which cast a shadow. The anode was in the form of a Maltese cross, but as far as I can see there is no special merit in that shape; it could just as well be a silhouette of Marilyn Monroe, and in fact that would probably ensure closer attention to the demonstration; though, in that comparatively unsophisticated age, the cross seems to have made such a hit that a less picturesque demonstration of the same phenomenon no less than ten years earlier by a man named Hittorf was quite overshadowed. However it did show strikingly that what was coming from the cathode bore some resemblance to light, notably in normally travelling in straight lines and in being stopped by metal. There was, even in 1879, a strong suspicion that these rays consisted of negatively charged particles, which were later (after the suspicion had been confirmed) named electrons.

The study of light had shown that its rays can be bent ("refracted" is the scientific term) by various means, such as lenses; and when it was found that similar things could be done with electron rays (though not by the same means) there was enough of an analogy for people to begin to talk about "electron optics," "electron lenses," and so forth. The tie-up with light was made practically unbreakable by the arrival of the electron microscope, which does the same sort of thing as a light microscope only more so. Some of the vast existing store of knowledge about optics has been used to develop electron optics, but it needs a good deal of adaptation, and much of it cannot be applied at all.

We shall probably be doing well enough if we confine this first view of electron optics to its use in cathode-ray tubes, for that is what interests most of us. In their raw state, the cathode rays would just make a splodge of light on the screen, which would be no use for anything (beyond the childish pastime of throwing electronic shadows). A prime necessity is to focus the rays to a fine point—the very words emphasize the analogy with the "burning glass." But the

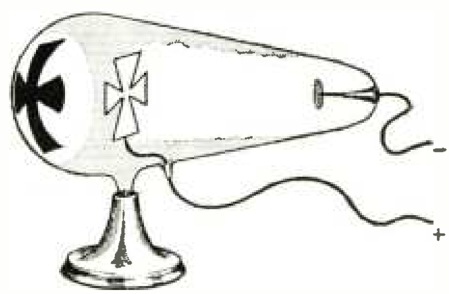


Fig. 1. The celebrated Maltese-cross experiment, by which Crookes demonstrated that cathode rays resemble light in travelling in straight lines and being stopped by metal. The cross casts a shadow on the fluorescent glow caused by the rays.

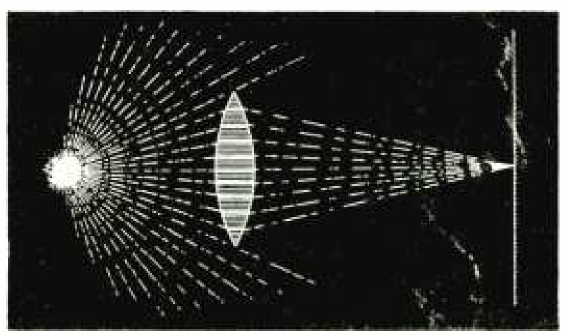


Fig. 2. Light rays can be focused on a screen by means of a glass lens, which bends the rays. Any device that does the same thing for cathode rays is called an electron lens.

resemblance is more in the results than in the means for achieving them. So I think it would be a mistake to spend a lot of time studying optics as a preliminary to electron optics, much though I would enjoy illustrating it in terms of the effects of local boggy ground on the movements of columns of troops. But I don't want to be classed with the lecturer on electricity whose students complained that they learnt a great deal from him about water in pipes but not very much about electricity. All we need, I think, is a passing glance at the probably very familiar diagram, Fig. 2, which shows a lens focusing a diffuse beam of light by bending its rays so that they all converge on the same point. The corresponding kind of electron lens is one that makes electrons do the same thing, and that is the kind we are going to consider.

Bending Electron Paths

The principle used in an optical lens for bending the rays of light is the change in speed of light when it passes from one medium to another, such as from air into glass. How are the paths of electrons bent? There are two means—electric fields and magnetic fields. So here once more we find ourselves confronted with these twin fantasies that seem so elusive and unreal and yet are the basis of everything electrical —and in fact of the whole universe. Our understanding of things electrical—including emphatically electron optics—can be no better than our understanding of fields. Unfortunately, being basic, there is nothing more basic that can be used for describing them, and in the attempt to "unscrew the inscrutable" one is almost bound to make use of imaginary things shown as lines drawn on paper. It must be remembered all the time that such things are no more than artificial aids towards apprehending something whose ultimate nature may be beyond our grasp but about whose behaviour there is no doubt.

However, let's get down to it. Most electrical people have a more or less clear picture of the workings of Ohm's law. And even though it is nearly always applied to circuit elements such as wires, where one does not have to bother much about the sideways distribution of current but only the length, it ought not to be too difficult to visualize what happens in wide conductors. (There is no need to fear another departure into "skin effect"; we shall be considering d.c. only!) Suppose we were to coat a rectangular sheet of plastic with a perfectly uniform layer of carbon, and connect a 100-V battery to opposite ends, using strips of copper to make sure that the whole width was at the same potential (Fig. 3). Then if we were to reckon the lower edge as zero potential, the top edge would be at +100 V, and the potentials in between would be proportional to the height up the strip. If we had a voltmeter that took no current at all we could quite easily check this by applying point probes to the carbon surface. We could, in fact, map out the surface with "equipotential lines," as shown dotted. But in this simple case we can easily fix their positions theoretically by Ohm's law.

We might also draw another kind of dotted line to show the directions in which the current would flow as a result of this potential pattern. The current, of course, consists of free electrons in the carbon, and they take the shortest route towards a more positive potential. Or, more correctly, what appears at the moment to be the shortest route. Like J. H. Newman, they say "I do not ask to see the distant scene; one step enough for me." And what appears to the short-sighted electron to be the shortest route *is always at right angles to the equipotential lines.* Fig. 4 is an enlarged view of a bit of Fig. 3, and it must be obvious that a stationary electron at A will take the shortest route to the higher potential, viz., along AB, and, of course, that shortest route is at right angles to the dotted lines. Any other route would necessitate sideways movement, and that could not take place without a sideways attraction, and if there were any sideways attraction, the potential pattern could not be as shown.

With such a simple set-up as Fig. 3 one could hardly go wrong. The equipotential lines and the lines of electric force (for that is what the electron paths are called) together make a sort of squared-paper pattern. But what happens when the short view and the long view disagree; that is to say, when the equipotential lines are not parallel to one another. Suppose the carbon sheet had the shape shown in Fig 5. A zero-potential electron at A, if it were far-sighted, would see that the nearest maximum-potential point was B and would make straight for it along the chain-dotted line. But this would mean that during the first stage of the journey it would *not* be taking the shortest route between 0 V and +10 V. The electron can only respond to the direction of the attractive force where it actually happens to be at the moment, and that force is beckoning not from the +100-V line, nor the +10-V equipotential line (which is visibly out of parallel with the 0-V "starting grid"), nor even the +1-V line, but from a line so close in front as to be practically parallel to the 0-V line; and so the electron moves off at right angles to that line. But as it progresses the increasing inclination of the equipotentials bends its path around, so that when complete it is the curve leading to B′.

Potential Gradients

Does that mean that there will be just as much current flowing along the outer edge of this wide track as along the shorter inner path? Certainly not, if Ohm's law is true, for the total voltage is the same for every path, whereas the resistance is proportional to the length of the path. So the current density is greatest on the inside and decreases towards the outer edge in the same proportion as the distance increases. (The current density along a surface is the amount of current per small unit of width.) Another way of putting it is to say that the current density increases with the closeness of the equipotential lines. One advantage of this way is that if one knows anything at all about contour maps a very pretty analogy fairly leaps to the mind. Contour lines, of course, are lines

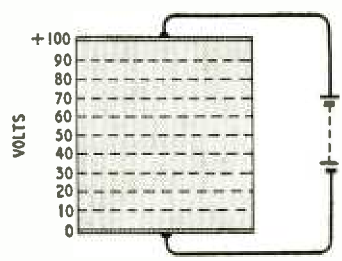


Fig. 3. Equipotential lines (dotted) of electric field along a uniformly conducting strip having a difference of potential between the ends.

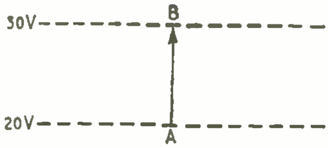


Fig. 4. An electron starting from rest at A tends to take the shortest path to a more positive potential, and in doing so always moves along the line of force and at right angles to the equipotential line passing through its position.

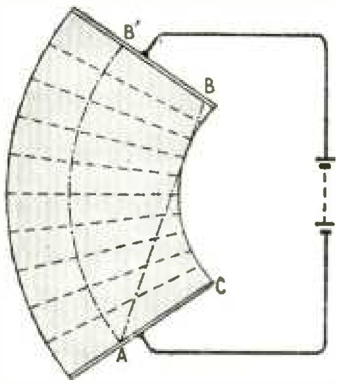


Fig. 5. When the equipotential lines are, as here, not parallel to one another, the electron does not take the shortest route (AB) to the highest potential. It still tends to keep at right angles to its own equipotential line, which means a curved path (AB′).

joining all points at the same height above sea level, so they might be called equi-height lines; and since electrical potential is often likened to height the analogy is obvious. A steep gradient is revealed on the map by the contour lines being close together. The steeper the gradient the stronger the pull of gravity along the surface. That pull always acts at right angles to the contour lines; one might say that the lines of gravitational force are at right angles to the equi-height lines. Fig. 5 can now be regarded as a plan diagram of a spiral stairway, except that instead of steps we must imagine a smooth slope, to correspond with the smoothly continuous change of electrical potential along the carbon strip. If the slope is downwards from A, a marble released there does not roll straight to B; it cannot see, so it does not know anything about B, all it knows about is the slope where it actually is, at A, and that slope is at right angles to CA, so it starts off on the AB′ curve, just like the electron in the carbon strip. Will it then, like the electron, follow that line all the way to B′?

You have only to try it—or perhaps even imagine it—to realize that it will not. Because the slope is smooth, the marble gains speed, and the direction of its movement is then determined not only by the direction of the slope but also by the direction in which it was moving when it reached that slope. The marble always tends to go straight on, and cannot respond immediately and fully to a change in direction of slope. The faster it is going the less readily it responds.

The electron in the carbon conductor can be likened to a marble rolling down a slope thickly studded with pins, rather like a Corinthian bagatelle board but with no permanent stops. Every time it hits a pin its journey is interrupted and it has to start afresh, so its speed is no greater at the end than at the beginning. Its average speed is so low that its movement is controlled almost entirely by the slope, and when the slope stops the marble stops. Similarly the electron in the carbon is constantly bumping into carbon molecules, and so is kept down to a constant average speed, which as we saw last month is very low. It continues to move only so long as it is on a potential slope. If the strip in Fig. 3 were extended beyond the 100-V terminal into a sort of blind alley, would they go on into it? Not they!

Introducing Free Electrons

But what we are supposed to be studying is the movement of electrons that are *not* hindered by resistance. So our carbon conductor, although it may serve as an introduction to electric field and equipotential lines, is actually a complication. If we throw it out of Fig. 3, leaving only the battery and copper electrodes, the potential pattern remains. The space between the electrodes is still occupied by an electric field, and any free electrons there are attracted along nearly the same lines of force as before. The trouble is that there aren't any free electrons there. So we have to introduce some. A convenient way of doing this is to coat the negative electrode (i.e., the cathode) with a suitable material such as barium oxide, and heat it. Electrons then boil off, but their space trip is complicated by encounters with air molecules, so to give them a clear run it is necessary to put the electrodes in a glass bulb and pump the air out. Then, at last, the electrons can really display their own simple nature, which is (as Newton saw long before electrons were thought of) to remain in a state of rest or uniform motion in a straight line unless acted upon by external forces, and to accelerate in proportion to any acting force. The particular force we are concerned with just now is the electric field.

In the carbon or any other resistance the electron speed is very limited because it gives rise to a kind of frictional force that neutralizes the force of the electric field, and directly it is fast enough to do so exactly there is no net force and the electron continues uniformly at that speed, in accordance with Newton's first law. But in the clear vacuum it continues to gain speed, like the marble, as long as it is falling down a potential gradient.* As we saw last month, the speed it gets up depends only on the voltage it "falls" through, and if that voltage is denoted by V the speed reached from a standing start is $593\sqrt{V}$ kilometres per second, which is $368\sqrt{V}$ miles per second. The analogy with marbles rolling down frictionless slopes holds good, for the speed they acquire in losing height to the extent of h feet is $8\sqrt{h}$ feet per second. regardless of whether the slope is gradual or precipitous; and when they have acquired it they continue at that speed indefinitely on the level. But whereas in practice friction always interferes with rolling balls (otherwise the game of bowls would be unplayable) our electrons in a vacuum really do keep on accelerating so long as the voltage is rising, and in a constant-potential region they keep up the speed and direction with which they entered it. (They are

* It may be necessary to remind ourselves that because an electron is negative a downward gradient to it is one that becomes increasingly positive. Any confusion in the fact that a "rising" potential is (from the electron's point of view) a downward slope is the fault of whoever persuaded everybody to call the electron-attracting end "positive."

so light that the force of gravity on them can be neglected.) The only restriction on their speed is that when they have accelerated through about 10,000 volts (to 59,300 kilometres per second) their increase of mass due to "relativity" begins to become appreciable, and this makes the speed curve flatten off to an absolute limit of 299,792 km/sec, which would be reached if the voltage were infinite. But even in modern high-voltage cathode-ray tubes the relativity correction is quite small, so we shall not bother about it here.

Steering the Electrons

We can sum up our knowledge of electron optics so far by saying that we know how many volts we need to accelerate electrons to any desired speed (up to about 40,000 miles/sec, anyway!), and having got them up to speed can keep them going in a straight line at that speed, simply by arranging for their route to be at a constant potential. Presumably also we can retard them as desired, using a negative voltage; for retardation is just negative acceleration. But all that is not enough to gain us an electron-driver's licence. We must now tackle the much more difficult problem of steering. Unlike electrons in wires, those in space are not "vehicles steered by their own tracks." Nor is it enough to lay down lines of electric force in the required directions (though that may seem difficult enough, seeing they are imaginary!) because there can be no lines of force without change of potential, and change of potential causes change of speed, and the quickness of response to changes in direction of the lines of force depends on the speed. It is no more use expecting a high-speed electron to follow a sharp bend in a line of force than it is to expect a car to get round a sharp corner at 80 m.p.h.

But let us get back to our marbles. Suppose we release a gentle cascade of them from the top of a long straight ridge, AB in Fig. 6. If the contour lines of the slope were parallel to AB all the way down, the lines of gravitational force would run at right angles to AB and parallel to one another, and the cascade of marbles, though gaining speed, would continue to spread thinly over the whole width. But hollowing the slope out, as shown by the curving inwards of the contour lines CD etc., would make the lines of force converge. If the marbles followed these lines exactly (as they would were it not for their momentum) they would take the paths at right angles to the contour lines as shown, and converge into a raging torrent of marbles at P. Note that it would not be necessary to continue the slope all the way to P; provided that the marbles were going in the right directions by the time they reached the line KL the ground from there on could be perfectly flat.

Near the start, before the marbles had time to get up much speed, their actual paths would follow the lines of force fairly closely; but as they gained momentum they would respond less and less to the inward curvature of the slope. So it would seem to be a good idea to do the focusing as near the start as possible; partly because least curvature would be needed, and partly because the marble tracks could be predicted the most accurately from the lines of gravitational force, which can be plotted by means of a simple slope-indicating device or arrived at from the contour lines. But of course one would not really care to leave the matter quite so vague as this; what exactly is the principle determining the actual paths taken by the marbles?

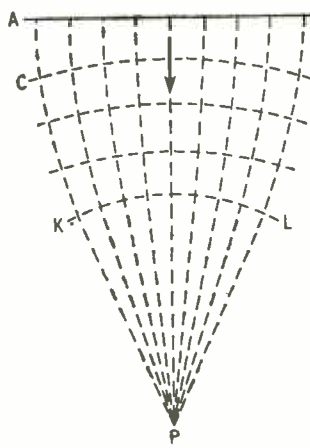


Fig. 6. Contour lines (CD, etc., to KL) of a hollow downward slope that would make marbles released along AB converge towards P. If their directions are correct by the time they reach KL the rest of the run can be flat, as shown by absence of further contour lines.

Well, this is really a matter of mechanics, and if that is a totally unknown subject it is a little late to give a full course on it here and now. But I suppose most *Wireless World* readers are sufficiently knowledgeable to need only an outline, at most. Suppose then that A in Fig. 7 is the position of a marble—or electron—which is travelling with a known velocity in the direction AB. If there were no other influence it would arrive at B after a certain interval of time. But suppose that a certain gravitational—or electric—field is acting in the direction AC. This force can be resolved in the usual way into one force acting along AB and another at right angles to it, along DC. The marble—or electron—is therefore accelerated in both of these directions in proportion to the separate forces. If the length AC represents the combined force the component forces are represented by AD and DC. The acceleration in any direction is equal to the mass of the marble—or electron—multiplied by the force acting in that direction. So the effect of the force here is to increase the velocity along AB so that the position in that direction after the interval of time is not B but E, and the right-angles acceleration has meanwhile carried it a distance EF, so the actual position is F. By plotting the position after different intervals of time, its track can be found—the dotted curve. All this may sound rather complicated, but such tracks are familiar from our earliest youth, for a ball thrown into the air is a body with an initial velocity in an arbitrary direction, combined with a steady acceleration (downwards). The faster the ball is thrown horizontally, the less is its curvature downwards and the longer it takes to come into line with the gravitational lines of force.

Designing the Electrodes

Given a field pattern, the foregoing principles can be used to calculate the track of an electron from any point in it. But that is not quite the problem; usually one is given the desired electron tracks and wants to find the arrangement of electrodes and voltages that will provide the field pattern that will produce those tracks. And that is quite a different matter. It is usually solved by a combination of calculation, intelligent guesswork, and experiment.

The first stage is to find the field patterns between various electrodes. For a few specified configurations they can be calculated mathematically; some fairly easily, others not so easily. Usually the easier they are to calculate the less likely they are to be directly useful in practical c.r. tube design. It is not very helpful, for example, to have to accept a proviso that the electrodes are infinitely large, or that there is nowhere for connecting the sources of p.d. Even a pair of parallel plates does not provide a simple rectangular field pattern, unless the plates are infinitely large; with finite plates the lines barrel out at the edges, something like Fig. 8. We can easily guess, however, that one way to obtain a converging or diverging pattern is to make one electrode smaller than the other, as in Fig. 9. Note that the potential changes more rapidly where the lines of force are close together. This is what one would expect by analogy with the carbon sheet; if the lower electrode in Fig. 3 were made smaller than the upper, the greater current density near it would cause a greater voltage drop per inch there than near the wider electrode. As we have already noted, one could actually use a uniform carbon sheet to plot field patterns experimentally, by placing electrodes on it—preferably lead, so that they could easily be bent into different shapes—and plotting the potentials with a pointed probe and "infinite-input-impedance" voltmeter; but to simulate infinite space the sheet would have to be much larger than the inter-electrode space. Another and better method is to use a tank of liquid instead of the carbon.

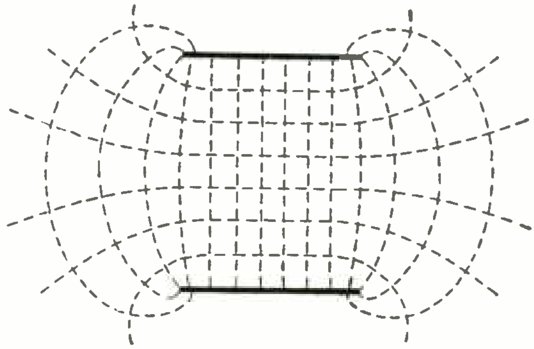


Fig. 8. Pattern of lines of electric force and equipotential lines between and around a pair of parallel charged plates.

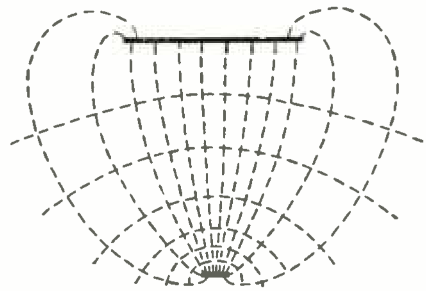


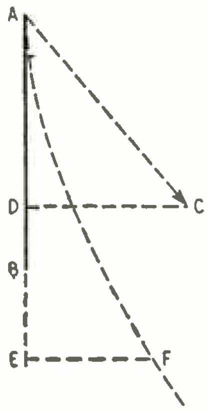
Fig. 9. The pattern when one plate is relatively small.

Final Adjustments

Having found the field pattern around the electrodes being studied, one can make a slope model with contour lines coinciding with the equipotentials, and try rolling marbles down it, or, better still, ball-bearing balls. This shows the tracks of electrons, and gives some idea of how the electrodes should be modified to get nearer the desired result. Alternatively, there are graphical methods of plotting the electron tracks on the field patterns, and even more or less automatic apparatus for plotting them direct from the electrolytic tank.

Fortunately a good focus does not depend on the electrode system having been manufactured dead right in the first place. Electron lenses are, so to speak, flexible, like the little optical lenses forming the fronts of our eyeballs, which change shape without conscious effort when changing our distance of looking. The focus of electric lenses can be varied within considerable limits by adjusting the voltages applied to the electrodes.

Fig. 7. How to find the net result of constant speed along AB and constant acceleration along AC.



Obviously the plate kind of electrode we have been thinking about is not likely to be much good in an electron lens, however useful it may be in a valve; nor is the grid kind, because it stops some of the electrons altogether and on those that get through it imprints a pattern of its mesh. Most of the electrodes forming lenses in electrostatically focused c.r. tubes are hollow cylinders, rings, or disks with holes in the middle.

Rolling-Ball Analogy

Time is just about up, and we have not yet looked at any examples of electric lenses, still less the more difficult subject of magnetic focusing. They will have to wait till next month.

In the meantime, to stop anybody writing in to complain that I am deluding the proletariat by giving the impression that the analogy between rolling balls and flying electrons is perfect, I would mention that whereas the electric force on an electron is inversely proportional to the distance between equipotential lines, the gravitational force on a ball is inversely proportional to the distance *along the slope* between the contours, not the horizontal distance shown on the contour plan. But provided the gradient does not exceed 1 in 7 the difference is less than 1%. There is also a discrepancy due to the fact that rolling balls roll and thereby acquire some rotational energy, but this also makes little difference.*

* "Determination of Electron Motion in Two-Dimensional Electrostatic Fields," F. H. J. A. Kleynen, *Philips Technical Review*, 1937, p. 338.

Magnetic Tape Recording

Problems of Standardization : Accidental Printing Phenomena

EXCELLENT as are the results obtained with magnetic tape as a medium for high-quality reproduction of sound, it is nevertheless liable to irregularities and inconsistencies which assume importance when attempts are made to measure and standardize a recording characteristic—which is necessary when tapes have to be exchanged between broadcasting organizations.

A systematic study has been undertaken by the B.B.C. and an outline of some of the results was given in a recent lecture to the British Sound Recording Association, "Problems of Magnetic Tape Reproduction," by P. E. Axon, M.Sc., Ph.D. One of the main difficulties is that the surface intensity of magnetization on the tape can be measured only indirectly, and that the flux is modified by association with the reluctance of the magnetic core used in the normal type of pick-up head. This manifests itself in discrepancies between the slopes of curves taken with short and long gaps—even after allowance has been made for variations of eddy-current losses with frequency.

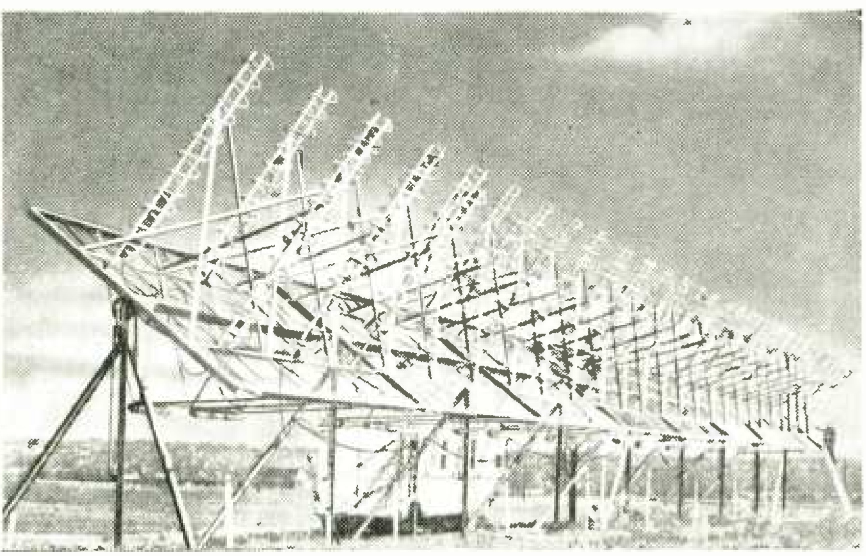
Better agreement is found when a non-magnetic single-turn head is used for calibration. This consists of a thin strip of copper foil between ebonite clamps mounted edge-on to the tape and supplied with thicker soldered leads at the ends. A series of minima appear when the thickness of the conductor equals an integral number of wavelengths, but unlike the magnetic head the "effective" gap is equal to the physical thickness of the conductor, and the frequencies of the minima are all harmonically related.

The virtue of the single-turn head is that with it a tape can be recorded and calibrated with a surface induction rising exactly at the theoretical rate of 6 db/octave, and this standard tape can be used subsequently to calibrate existing iron-cored heads.

Intimate contact between tape and head is of great importance in all calibration work, and both the tape and the head in the region of the gap must have a smooth surface finish if consistent measurements are to be made. It has been calculated that the loss due to separation is about 55 db per wavelength (λ) of the recorded frequency. At $7\frac{1}{2}$in/sec and 7.5 kc/s, $\lambda =$ 0.001 in, and a separation between tape and head of only a tenth of this distance gives a drop in signal strength of nearly 6 db. Under normal recording conditions such irregularities manifest themselves as amplitude modulation noise.

Mr. Axon also discussed the phenomenon of accidental printing, and showed that the print level between adjacent layers could increase nearly 10 db after a rise of temperature of 10 C lasting only 5 minutes. Other factors known to affect printing are external magnetic fields and the physical tension of the tape during spooling.

Fortunately, accidental prints, made without h.f. bias, were less stable than the master signal and showed a tendency to decrease rapidly over a period of minutes from the instant of separation. The stability of the print increases with the duration of contact before separation, and all effects which tend to increase the printing level also increase its stability. Provided that the accidental print is not too deeply established, successful differential erasure between the wanted and unwanted signals is possible, using a weak h.f. field in the erasing head. This may even force the print below the noise level of the system, without reducing the main recording more than a few db. It is always worth while to re-spool immediately before replaying and at intervals during the storage life of the tape.



RADIO TELESCOPE

THIS broadside array of 48 helical beam aerials mounted on a pivoted earth screen has been built by the Ohio State University, U.S.A., for studying celestial radio sources. It has a beam width of only 1.2 degrees at 250 Mc/s. Each helix has 10 turns and is 10ft long by 15in in diameter. Receiving equipment is in the van underneath.

(Photo: Courtesy Electronics)

Megawatt Transmitter

Dependable World-wide Communication on Very Low Frequency

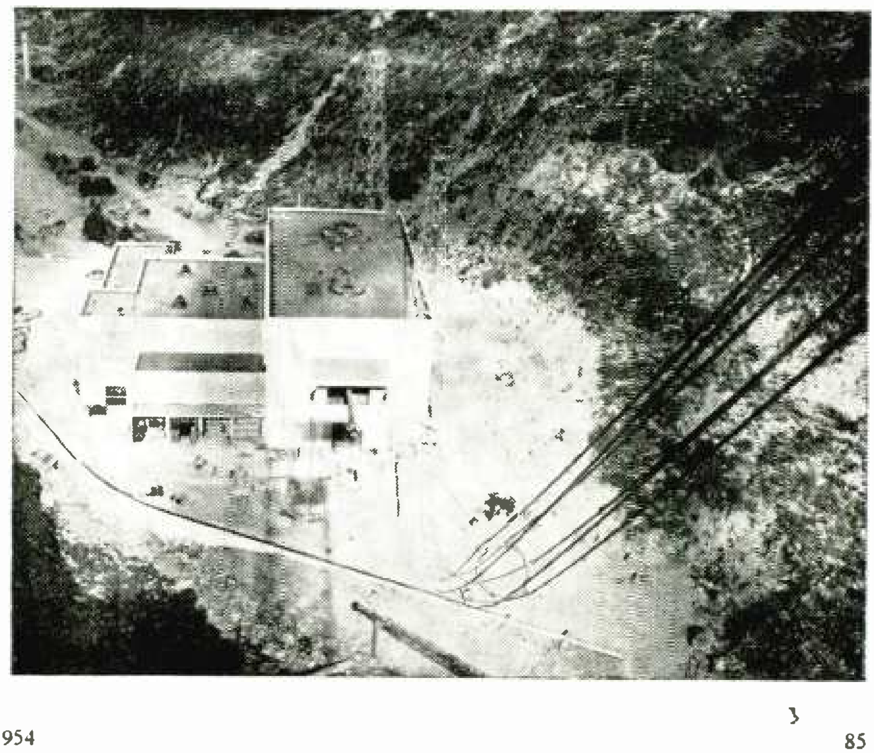
A GIANT radio transmitter which has taken six years to build was recently handed over by the Radio Corporation of America to the United States Navy. It was conceived with the idea of providing dependable communication with U.S. Fleet units in any part of the world at any time of the day or night and under all atmospheric conditions.

This requirement is best fulfilled by a powerful, very low frequency transmitter, as such frequencies are far less dependent on changeable wave propagation conditions than any of the frequencies normally used for long-range communications. If the power is great enough and the wavelength long enough signals will penetrate to arctic and tropical outposts and to submerged submarines, despite magnetic storms and ionospheric disturbances of the worst kind.

Special Valve

This transmitter is designed for operation on frequencies between 14.5 and 35 kc/s and is capable of a maximum power output of 1,200 kW. It consists of two nominal 500-kW units operating in parallel and arranged so that each can be used independently if required. The transmitters were designed around the special RCA Type 5831 high-vacuum transmitting triode. Each of the two r.f. amplifier units employs three of these valves, two in a push-pull circuit with the third as spare. The valves measure 10 in in diameter and 38¾ in high, weigh 135 lb and are water cooled. The six-volt filament structure of thoriated tungsten requires 13 kW. Each valve needs 500 watts of grid driving power for 285 watts output at 80% anode efficiency with an anode voltage of 11.5 kV.

The design and erection of the aerial system constituted a gigantic task. The site chosen was the Jim Creek Valley, situated in rough country some 55 miles north east of Seattle. The station lies in a valley at the foot of twin 3,000-ft mountain peaks from which is suspended an impressive aerial system.



Bird's eye view through steel framework of 200-ft summit ridge tower shows transmitter building in a valley between 3,000-ft mountain peaks.

Prior to the erection of the aerial thousands of trees were felled on the valley slopes to facilitate rigging work and eliminate possibilities of forest fires. Most important of all, however, was the necessity to improve the transmitter efficiency as trees tend to absorb large amounts of r.f. energy radiated by nearby aerials.

The actual aerial consists of ten trans-valley spans each over a mile in length and forming a zig-zag pattern high above the floor of the valley. Twelve 200-ft steel towers erected along the crests of the twin mountains support the aerial. Owing to the tapering nature of the valley the spans are of unequal length; the longest measures 8,700 ft and the shortest 5,640 ft.

Like the transmitter, the aerial system is divided into two parts, each independent of, and isolated from, the other. This arrangement makes it possible to operate one-half of the transmitter and one-half of the aerial system in the event of repairs being required to the other halves.

With an aerial at such a great height there is a marked tendency to pick up static electricity from the air and if left unearthed for any time voltages can build up to a point where sparks a foot or so long will jump gaps in the system. As a safety measure the system is kept securely earthed when not employed for transmission. More than 200 miles of copper wires, cables and screens are buried in an intricate pattern across the valley floor to provide an efficient "earth."

Wide-Band I.F. Amplifiers

By H. S. JEWITT,* B.Sc. (Eng.)

Design Technique Using Negative Feedback

IN many electronic systems using pulses the trend at present is towards the use of shorter pulses, and pulse lengths of 0.1 microsecond and less are now common in the radar field. This development has necessitated the design of intermediate frequency amplifiers of large bandwidths, so that the reproduction of such short pulses will not be degraded. Bandwidths (to the − 3db points on the response curve) for amplifiers are now commonly greater than 10 Mc/s, and the problem of achieving wide bandwidth and higher gain, yet producing an amplifier which is an economic possibility to manufacture, is very real and pressing. On the one hand the designer must use a large number of valves and tuned circuits to obtain the required gain and bandwidth; on the other, he is pressed to design his amplifier in such a way that it is easy to manufacture and maintain in service.

There are two methods of obtaining wide bandwidths in common use, one utilizing transformers as the tuned elements and the other frequency-staggered circuits. Both of these give satisfactory results as far as obtaining the necessary gain and bandwidth is concerned, but both tend to give difficulty in manufacture and service. These difficulties arise from one major cause, which is the tolerances to be expected on the parameters of the valves used. The difficulty is that an i.f. amplifier may be aligned with a given set of valves before it leaves the laboratory or factory to be put into service: if a valve fails in service and has to be replaced it is only too probable that the alignment process will then have to be repeated to restore the original bandwidth, as the capacitances of the new valve will differ from those of the old one. Alignment in the field is not easy on wide-band amplifiers: in the transformer-coupled case the difficulty of adjusting the inductances of the two windings and the coupling factor between them is considerable; in the staggered amplifier the frequencies of individual circuits and their damping resistors need adjustment.

In assessing the value of any particular circuit configuration the desirability of "pre-plumbing" must not be overlooked. By this term is meant the manufacture of the amplifier from components of reasonable tolerance without provision for any aligning: the amplifier when fitted with valves from stock should then give the required performance within the permissible limits. Clearly, if this can be achieved valve-changing in service will no longer be a problem.

A means of obtaining wide bandwidths in i.f. amplifiers which has been known for a considerable time, but which appears to have been somewhat neglected in comparison with those noted above, is the application of negative feedback. That the use

* Decca Radar.

TABLE I: COMPONENT VALUES FOR FEEDBACK PAIRS

B = − 3 db bandwidth of response curve
C = Total capacitance = $C_{in} + C_{out} + C_{strays}$
g_m = Valve mutual conductance
from which $R_T = \frac{1}{2\pi CB}$ = effective damping required
and $G = g_m R_T$ = approximate gain per stage
K = Shape coefficient

	FIGURE 1		FIGURE 2	
	$R_1 (= R_3)$	R_2	$R_4 (= R_6)$	R_5
General Case $2 > K > -2$	$\frac{4GR_T}{2(\sqrt{2} + K)G - (2 - K)}$	$\frac{4GR_T}{2 - K}$	$\frac{4GR_T}{2 - K + 2(\sqrt{2} + K)G}$	$\frac{4GR_T(2 - K)}{4G^2(2 + K) - (2 - K)^2}$
Special Cases $K = 0$ (flat pair)	$\frac{2GR_T}{\sqrt{2}G - 1}$	$2GR_T$	$\frac{2GR_T}{1 + \sqrt{2}G}$	$\frac{2GR_T}{2G^2 - 1}$
$K = -1$ (pair in flat triple)	$\frac{4GR_T}{2G - 3}$	$\frac{4GR_T}{3}$	$\frac{4GR_T}{3 + 2G}$	$\frac{12GR_T}{4G^2 - 9}$
$K = +\sqrt{2}$ (pairs in flat quadruple)	$\frac{4GR_T}{3.7G - 0.58}$	$6.9GR_T$	$\frac{4GR_T}{0.58 - 3.7G}$	$\frac{2.32\ GR_T}{13.7G^2 - 0.335}$
$K = -\sqrt{2}$	$\frac{4GR_T}{1.52G - 3.42}$	$1.17GR_T$	$\frac{4GR_T}{3.42 + 1.52G}$	$\frac{13.7GR_T}{2.32G^2 - 11.6}$

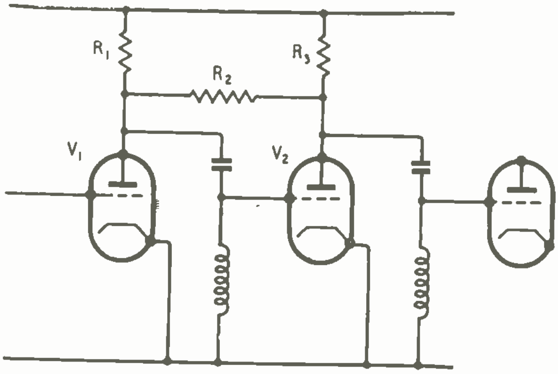


Fig. 1. Simple negative feedback amplifier with feedback applied through R_2.

of negative feedback will broaden the response curve of an amplifier is immediately apparent from consideration of the effect of the feedback. If all stages of the amplifier are tuned to the same frequency (the centre i.f.), then the feedback will be strongest at this frequency. Provided that the feedback circuit is not frequency-sensitive, the feedback will decrease on each side of centre frequency, thus increasing the response at off-centre frequencies. The shape of the resultant response curve depends upon the degree of feedback used: for small amounts of feedback the curve will exhibit one peak at centre-frequency, but as the feedback is increased the curve will become first flat-topped and then double-humped, with humps spaced equally about the centre frequency.

The original conception of this method appears to have been a chain of amplifier stages, over each of which the feedback was applied, but this has been simplified to the application of feedback over alternate stages. Thus the amplifier is divided up into a series of pairs of valves, the first valve of each pair operating without, the second valve with, feedback. It will be seen, then, that this type of amplifier will produce the flat-topped response curve usually associated with the staggered pair or transformer-coupled amplifier. It will be shown that the flatter, steeper-sided curves given by staggered triples, quadruples and so on can also be produced.

The feedback amplifier has been analysed mathematically,† and Table I, which is a simplification of the results of this analysis, gives the required component values for the circuit with a minimum of computation. The expressions are accurate enough for normal design processes. It should be particularly noted that the shape and width of the response curve and the gain of the amplifier are governed solely by the relative values of the resistors whose values are given. In comparison with the two other methods mentioned above, the use of single-tuned circuits eliminates the difficulties of the i.f. transformer, and since these circuits are all tuned to the centre i.f. there are no problems of accurate maintaining of stagger frequencies or different Q-factors in individual circuits.

The simple feedback pair of Fig. 1 shows how the feedback is applied. V_1 and V_2 are the valves forming the pair, R_1 and R_3 being their respective anode loads. The resistor R_2 is for applying feedback across V_2. From the practical point of view this circuit has dis-

† "Vacuum Tube Amplifiers" by Valley and Wallman, Chapter 6. (M.I.T. Radiation Laboratory Series, Vol. 18), McGraw Hill.

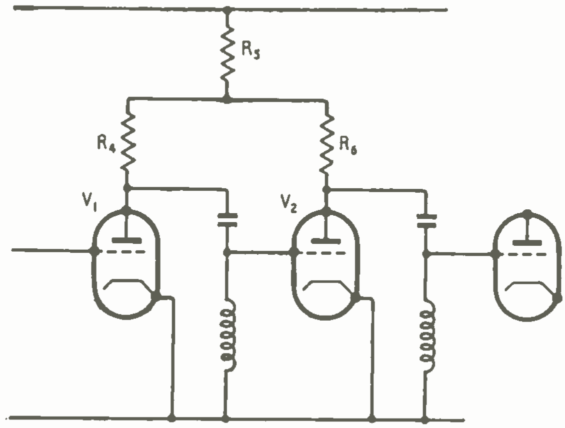


Fig. 2. Modified version of Fig. 1, giving more symmetrical response curve.

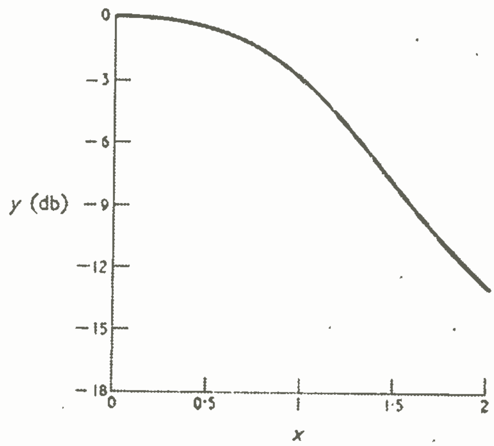


Fig. 3. Flat pair response curve. Only one half is shown as the curve is symmetrical about x = 0.

advantages, however. It was noted above that the feedback circuit should not be frequency-sensitive; if this condition does not hold the feedback will be greater on one side of centre frequency than on the other, and the resultant response curve will be tilted instead of being symmetrical about the i.f. Returning to Fig. 1, the resistor R_2 possesses self-capacitance (of the order 0.5 pF) which causes such a tilt; in addition the anode-grid capacitance of V_2 is in parallel with the feedback resistor, which increases the tilt.

The resistor network R_1, R_2, R_3 of Fig. 1 may be replaced by its T-equivalent, producing the circuit of Fig. 2. In this circuit the feedback is produced by the voltage drop across R_5 due to anode current in V_2, R_5 being common to the anode circuits of both valves. Now the effect of capacitance across R_5 will be to reduce its apparent value, and hence the feedback, at higher frequencies, so that the output of the amplifier will increase above centre frequency. The effect of the anode-grid capacitance of V_2 is to reduce the feedback at lower frequencies and increase the response below centre frequency. Thus the effects of these unavoidable but unwanted capacitances tend to cancel each other. Cancellation may be made complete by

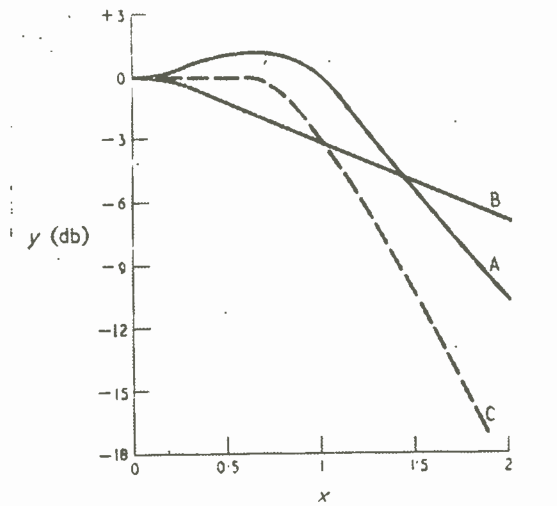


Fig. 4. Synthesis of flat-topped curve (C) associated with staggered or feedback triples.

increasing one or the other capacitance as indicated by the response curve tilt, and a symmetrical response curve may thus be obtained.

It was stated above that a wide variety of response curves can be produced according to the relative values of the resistors. One such curve is the flat-topped curve usually associated with the staggered pair, the mathematical expression of which is

$$y = \frac{1}{\sqrt{1 + x^4}}$$

where x represents frequency difference from centre frequency and y is the relative amplitude at the frequency considered (x). Clearly, $y = 1$ at centre frequency ($x = 0$), and where $x = \pm 1$, $y = \frac{1}{\sqrt{2}}$. In other words, $x = \pm 1$ gives the $-$ 3db points on the response curve and hence the bandwidth. This curve is shown on Fig. 3. The feedback pair to produce it has been found to be very non-critical and may be easily pre-plumbed. Slight staggering of the tuned circuit frequencies (due, for instance, to valve capacitance variation) has little effect on the response curve beyond broadening it.

To produce other curves of the flat-topped form a process of synthesis must be used, as is done with staggered circuits. The difference between the two types of circuit in this respect lies in the fact that a feedback pair, correctly designed, will generate a double-humped response curve with its circuits all tuned to the same frequency, whereas in the staggered system one circuit must be tuned to each side of centre frequency and appropriately damped to produce such a curve. The idea of synthesizing a flat-topped curve from two curves which are not flat-topped may be better understood from Fig. 4. This diagram illustrates the synthesis of the flat-topped curve associated with staggered triples or feedback triples. Three circuits are used (hence "triple"): two, in a feedback pair, give curve A, while the other circuit on its own gives curve B. These circuits are cascaded, and the resultant overall response may therefore be obtained by adding the two curves (a decibel scale being used for relative amplitudes). Curve A is slightly double-humped, the rise each side of centre frequency boosting the falling response of curve B. The result of the addition is the flat-topped curve C, which, if compared with the flat pair curve of Fig. 3, shows flatness over a wider range together with steeper sides. The first characteristic, flatness, is generally the desired one in this application, as several such circuits may have to be cascaded to obtain the necessary overall gain. Each additional circuit added will narrow the overall bandwidth, but the bandwidth narrowing will be less for the curve with the wider flat top. The mathematical expression for the triple curve is

$$y = \frac{1}{\sqrt{1 + x^6}}$$

and $x = \pm 1$ again gives the $-$ 3db bandwidth.

In general, any curve of the form

$$y = \frac{1}{\sqrt{1 + x^{2n}}}$$

may be synthesized, and n indicates the number of stages required in the synthesis. The general expression for the response curve of a feedback pair is

$$y = \frac{1}{\sqrt{1 + Kx^2 + x^4}}$$

in which x and y have significance as before. The constant K, which may be called the "shape coefficient," determines the form of the response curve obtained. One case already discussed, that of the flat pair, is seen to correspond to $K = 0$ when the above expression reduces to that for the flat pair curve. Other values of K will give different forms of response curve: K can lie between $+ 2$ and $- 2$. The value $K = 2$ corresponds to no feedback. Such a pair is identical with two single-tuned stages on the same frequency and should give the same response curve. Mathematically, this may be checked by substituting $+ 2$ for K and observing that

$$\frac{1}{\sqrt{1 + 2x^2 + x^4}} = \frac{1}{\sqrt{1 + x^2}\,\sqrt{1 + x^2}}$$

and that $y = \frac{1}{\sqrt{1 + x^2}}$ is the equation describing the single-tuned circuit response curve. Negative values of K give a double-humped curve: positive values give a single-peaked response. The value of shape coefficient for the synthesis of other flat-topped curves may be easily found. The expression for the desired flat-topped curve is first set down, for example

$$y = \frac{1}{\sqrt{1 + x^8}} \text{ for a flat quadruple.}$$

Now, the general expression, with shape coefficients K_1, K_2, etc., may be used to build up the desired equation:

$$\frac{1}{\sqrt{1 + x^8}} = \frac{1}{\sqrt{1 + K_1x^2 + x^4}} \times \frac{1}{\sqrt{1 + K_2x^2 + x^4}}$$

In this case only two pairs are needed because the final term of the right side of the equation is x^8, as required on the left side. By multiplying the terms on the right side together, we obtain:

$$1 + x^8 = 1 + (K_1 + K_2)x^2 + (2 + K_1K_2)x^4 + (K_1 + K_2)x^6 + x^8$$

The left side contains no terms in x^2, x^4 and x^6, so that the coefficients of these terms must be zero, and hence

$$K_1 + K_2 = 0$$
$$2 + K_1K_2 = 0$$

and from these equations $K_1 = +\sqrt{2}$, and $K_2 = -\sqrt{2}$. Therefore a flat-topped quadruple curve will be produced if two pairs are cascaded, one having shape coefficient $+\sqrt{2}$, the other $-\sqrt{2}$. Fig. 5 shows these two curves and the resultant curve. Similarly, curve C of Fig. 4, the curve of a triple, is generated by putting the equation of the triple curve

$$y = \frac{1}{\sqrt{1+x^6}} = \frac{1}{\sqrt{1+K_1x^2+x^4}} \times \frac{1}{\sqrt{1+x^2}}$$

and, following the same process, finding that $K_1 = -1$ so that the triple is built up from a pair with shape coefficient -1 and a single-tuned stage of the desired bandwidth.

Table I gives component values for certain commonly used values of shape coefficient, and enables flat feedback pairs, triples or quadruples to be quickly designed. For other curve shapes, the first line gives the general values of the components in terms of the shape coefficient K. As an example of the use of this table, the design of a typical amplifier may be carried out thus:

Bandwidth (to $-$ 3db) required (B) = 10 Mc/s.

Total parallel capacitance present = $C_{in}(V_2) + C_{out}(V_1) + C_{strays}$ (C) = 15pF.

Valve mutual conductance (g_m) = 7 mA/V.

Curve shape decided to be flat quadruple form, using circuit of Fig. 2.

From the above

$$R_T = \frac{1}{2\pi CB} = \frac{10^6}{2\pi \times 15 \times 10} \text{ ohms}$$
$$= 1060 \text{ ohms}$$

and $G = g_mR_T = 7 \times 1.06 = 7.4 = 17\text{dB}$

Since the curve is to be of flat quadruple shape, $K_1 = +\sqrt{2}$, $K_2 = -\sqrt{2}$.

First Pair ($K_1 = +\sqrt{2}$)

$$R_4 = R_6 = \frac{4GR_T}{0.58 + 3.7G} = 1120 \text{ ohms}$$

$$R_5 = \frac{2.32GR_T}{13.7G^2 - 0.335} = 24 \text{ ohms}$$

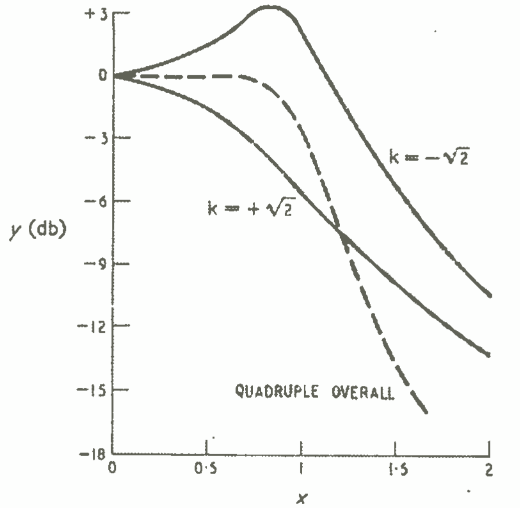


Fig. 5. Synthesis of flat-topped curve from two curves with different shape coefficients.

Second Pair ($K_2 = -\sqrt{2}$)

$$R_4 = R_6 = \frac{4GR_T}{3.42 + 1.526} = 2140 \text{ ohms}$$

$$R_5 = \frac{13.7GR_T}{2.32G^2 - 11.6} = 930 \text{ ohms}$$

and the two pairs are so designed. In practice the nearest standard values of resistors in the 5% range would be used. The complete circuit would be as shown in Fig. 6; the inductors (L) of Fig. 6 would be wound to resonate with 15pF at the chosen centre frequency. The overall gain will be approximately 68db (4 × 17db). If gain control is desired, it must be applied to V_1 or V_3 or both.

As is to be expected, the use of negative feedback is accompanied by a loss of gain. Except for extremely wide bandwidths, this loss is very small indeed and is usually within the normal uncertainties of gain computation. The feedback has a slight effect in stabilizing the gain of the amplifier, an effect which increases as bandwidth increases, but this stabilization

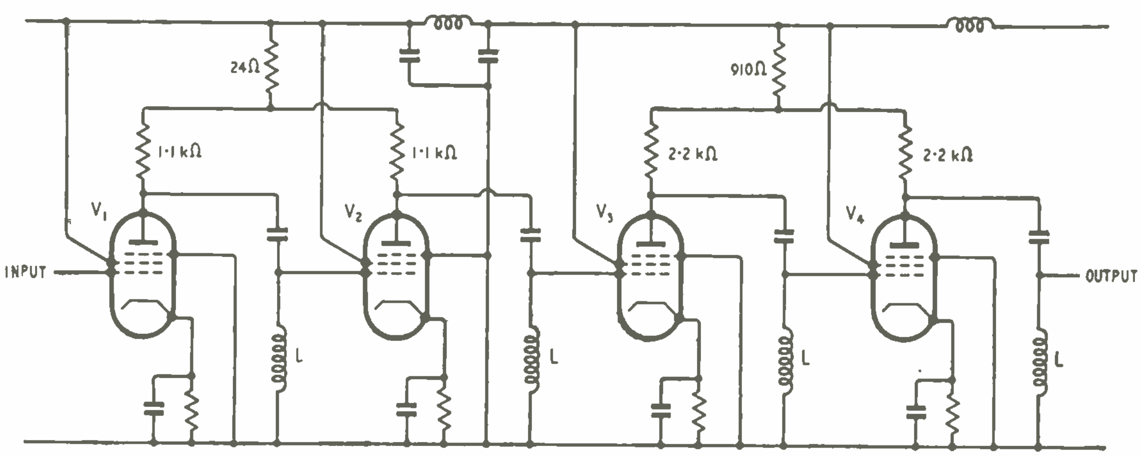


Fig. 6. Complete circuit of an amplifier designed to give a flat quadruple response curve with a bandwidth of 10 Mc/s.

is not enough to compensate for changes of mutual conductance in the valves. An additional disadvantage is that gain control can only be applied to those stages to which feedback is not applied. This is not normally serious as amplifiers of the type for which such circuits are used commonly have many stages, and control of two or three alternate valves gives an adequate gain control range. Application of bias to the feedback stages may, however, be used as a bandwidth control. The use of feedback pairs often results in a saving of decoupling components as stages may be decoupled in pairs. All amplifiers so far built have been found to be exceptionally stable, compared with amplifiers of similar characteristics using other methods of obtaining wide bandwidths.

The original setting-up procedure is very simple. The amplifier is built with resistor values chosen as detailed above. The feedback is removed (short circuiting R_5 in Fig. 2) from each pair in turn and the tuning coils within each pair are adjusted to tune to the centre i.f. In practice, it is found that adjustment of one coil is sufficient, all others then being wound to be identical with the correct coil. If feedback-resistor capacitance or valve anode-grid capacitance effects produce an objectionable tilt in the response curve a small capacitor is added (usually on one or two pairs only) across the appropriate points, and is adjusted until the curve is flat. If the feedback resistor capacitance is the controlling factor in curve tilt, the response is greater on the high frequency side of the centre i.f., as previously stated, and compensation is applied by adding a small capacitance between the anodes of V_1 and V_2 (Fig. 2) to reinforce the anode-grid capacitance of V_2. Similarly, if the inter-electrode capacitance of V_2 is the controlling factor and the tilt is from low- to high-frequency, then capacitance must be added in parallel with the feedback resistor R_5.

A number of amplifiers of various bandwidths have been constructed using this system, and all have been satisfactory. After a long alignment process needed for the previously-used staggered amplifier, the time and effort saved by adopting the feedback system has been most noticeable, as have the excellent response curves obtained. Amplifiers have been built with centre frequencies of 30, 45 and 60 Mc/s, with bandwidths ranging from 5 to over 20 Mc/s. In one particular instance the i.f. amplifier, of twelve stages, had a bandwidth of 20 Mc/s to − 1db at a frequency of 60 Mc/s and used a quadruple curve. The overall gain at i.f. was about 90db. In order to find out whether change of valves affected this amplifier, all twelve valves were changed *en bloc*. Twelve valves of a different make were inserted and the response curve was measured again. This was done for six sets of valves, the final set being a mixture of valves produced by various English and American manufacturers. The worst response curve change was a rise of 1db on one side of centre frequency. When a duplicate amplifier was built, the only adjustment needed was in the tilt-compensating capacitance, a small 5-pF trimmer. In most instances Mullard EF95 valves have been used, but some amplifiers have been built using the EF91.

EDUCATION AND TRAINING

WE are all prone to be insular and this is particularly noticeable in many Londoners, who tend to think of the metropolis as England. It was, therefore, refreshing for *Wireless World*, which so often attends discussions and meetings in London, to hear educationists in the Provinces discuss the question of "Education and Training in the Radio and Electronics Industry." The meeting, which was convened by the Merseyside Section of the British Institution of Radio Engineers, was addressed by representatives of Liverpool's University and Technical College, the Post Office, the Radio and Television Retailers' Association and the Automatic Telephone and Electric Company. There followed a lively discussion during which it was obvious that the speakers had their feet on the ground. It is also true that the speakers did not "pull their punches"; we doubt if we would hear a London graduate forcefully criticize the training scheme of the firm in which he was a student apprentice during a meeting attended by the company's training and education officer.

Both the introductory speakers and those taking part in the general discussion interpreted the title as including education both for and in the industry. We were particularly pleased to see the stress laid upon the need for a pass in English as an essential for apprentices. Technicians should be able to lucidly convey in writing their findings to others.

J. Durnford (Liverpool University) concluded his introductory remarks with these questions: (a) Are the Universities in fact giving the right sort of training? (b) Are there enough graduates being turned out? (c) Does industry in general know how to use its graduates to the best advantage? and (d) Should there be a period of practical training before as well as after a University course?

Some felt that the training was not sufficiently specialized, and to this end students should be encouraged to take part-time vocational training in industry, possibly between the "inter" and degree courses.

The question of technical qualifications, which is now being debated in our correspondence columns, and the confusion which exists regarding professional status in the industry was discussed. In this connection it may not be generally known that the Burnham Committee, which decides teachers' salaries, accepted some time ago associate membership of the Brit.I.R.E. (with certain provisos) as a degree equivalent for teachers in further education establishments.

CLUB NEWS

Cambridge.—The February meetings of the Cambridge University Wireless Society (G6UW), which will be held at St. John's College, include lectures on electron microscopy (1st), electronic organs (8th) and miniaturization (15th). The club plans to visit the Pye radio works on February 17th. Sec.: R. C. Marshall, St. John's College, Cambridge.

Cleckheaton.—At the meeting of the Spen Valley and District Radio and Television Society on February 10th, D. Skirrow (G3GFD) will speak on "Principles of Radar 1945-52." Meetings are held on alternate Wednesdays at 7.30 at the Temperance Hall, Cleckheaton. Sec.: N. Pride, 100, Raikes Lane, Birstall, Nr. Leeds.

Southend.—J. Missen, of the G.E.C. Research Laboratories, who recently described in *Wireless World* a circuit for a push-pull transistor amplifier, is to speak on transistors at the meeting of the Southend and District Radio Society on February 5th. At the meeting on February 19th, H. T. Stott (Bulgin) will speak on "Time Standard Upon NH_3." Meetings are held at 7.45 at the Municipal College Laboratories, Queen's Road, Southend. Sec.: J. H. Barrance, 49, Swanage Road, Southend-on-Sea.

Eliminating C.W. Interference

Some Experiments in a Television Fringe Area

By B. L. MORLEY

AMONG the many trials and tribulations of the fringe area viewer is the marring of the picture by continuous wave interference. The radio interference branch of the Post Office is very helpful in these matters, but it has no powers of compulsion and if the owner of the offending apparatus is unhelpful there is very little that can be done to remedy matters.

A case of this kind led to the experiments described in the following paragraphs. In this instance the interference caused bright bands of light, the thickness of one or two lines, to cover the whole of the picture. The lines not only made the scene appear as though it was being viewed through prison bars but it also played havoc with the line synchronization.

Another form of interference which was cured was the appearance of a broad band of light across the screen which was from $\frac{1}{4}$ to $\frac{3}{8}$ in wide. This was intermittent; sometimes on for a few minutes, sometimes on for an hour or more like the first type, but it yielded to the treatment to be described.

The receiving point was located almost at sea level 80 miles from Sutton Coldfield. A Yagi aerial array comprising director, folded dipole and reflector spaced 0.1 and 0.15 wavelength respectively was in use. The array was mounted on a 16-ft mast fitted to the chimney stack; a typical domestic type of installation.

Now the obvious answer to unwanted c.w. is simply a matter of filtering, so the first step was to construct filters of various forms which were inserted in the aerial circuit. The filters completely eliminated the interference—and the picture! It appeared that a circuit with a sufficiently high "Q" could not be obtained. The method was abandoned.

The next approach to the problem was on a different line. It is a well-known fact that each transmission line has a certain propagation velocity which directly affects its electrical length. In the television aerial the incoming signal generates currents and voltages which are carried down the transmission line to the receiver. An interfering signal will also generate in the aerial a current and a voltage which likewise are carried down the transmission line. At the receiving end we may have the position shown in Fig. 1.

The phase relationship between the two signals remains substantially the same throughout the whole length of the line and the time taken for the two to reach the receiver will depend upon the length of the line.

The physical length of a transmission line corresponding to the electrical length is given by:—

$$L = \frac{984V}{f}$$

where,

L = length in feet
V = velocity factor of the line
f = frequency of the signal in Mc/s.

It will be seen, therefore, that the time taken by the signals to traverse the length of the line depends upon the velocity factor of the line and the frequency of the signals.

TV signals occupy a broad band of frequencies but if the interference covers a single or narrow band then matters can be so arranged that the interference is eliminated without detracting too seriously from the quality of the picture; indeed it is generally preferable to sacrifice some quality in order to get rid of the interference.

The method employed was to arrange that the signal plus interference arrived at the receiver on two separate paths, the electrical length of the second path being such that the arrival phase of the interference was 180 deg out of phase with that in the first path (Fig. 2).

In the experiment an "X" aerial's feeder was connected directly to that of the Yagi array at the aerial socket of the receiver. The electrical length of the secondary path was adjusted quite simply by the rather laborious method of cutting one inch from the end of the line, testing, then cutting a further inch and so on until the correct conditions were found.

Eventually a stage was reached where the two signals completely cancelled each other and the picture, though decreased in strength by a small amount, was quite clear. The actual loss of quality was not noticed as the bandwidth of the vision receiver had been adjusted to just under 2 M/cs so as to obtain as much gain as possible. (This reduction in bandwidth is

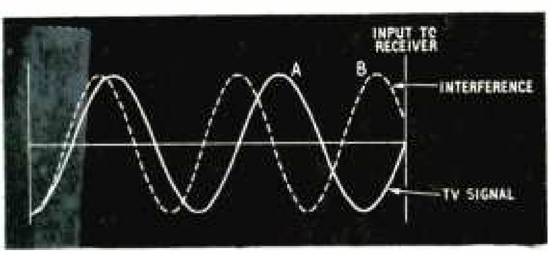


Fig. 1. Wanted (full line) and unwanted (broken line) signal currents flowing along the feeder of a typical television aerial.

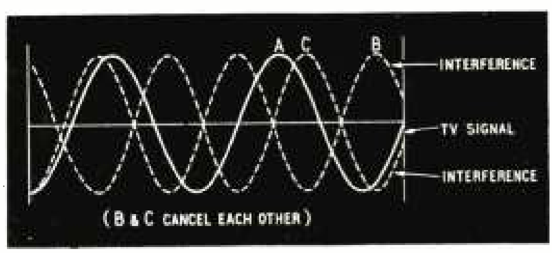


Fig. 2. If a second aerial is used and its feeder cut to the proper length the interfering signals can be cancelled out at the receiver.

not really so serious as it may appear at first sight, as generally the picture quality at extreme ranges leaves much to be desired, except on very rare occasions).

The system worked on both types of interference, the "prison bars" and the broad white band being eliminated from the screen, the single secondary path serving for both.

The word "eliminated" has been used deliberately; the interference was not merely obliterated; picture detail which had been concealed previously by the broad white band was once again visible, and beyond a slight loss in picture brightness (restored by adjustment of the contrast control) there appeared to be no noticeable deterioration in the overall quality of the picture.

For those who would like to try the scheme for themselves it will be found that, during the process, points will be found where (a) the picture is seriously attenuated, (b) the sound is seriously attenuated, (c) both are seriously attenuated, but a point can be reached where the interference alone is attenuated, there being little effect on the sound or the picture.

The writer does not claim that this is an ideal arrangement though it works quite well in practice. There are other methods of producing the necessary reversal of phase between the two signals—there is plenty of scope for the keen experimenter!

"Plug and Socketry"

A Plea for New Standardization of Nomenclature

By C. LISTER

"WHEN is a plug not a plug?" From the evidence to hand at this moment the answer would appear to be, "When it is a socket."

Consider Fig. 1. A is a device equipped with metallic contact pins and intended for attachment to the end of a cable. B is a device equipped with metallic contact-pin receptacles and intended for mounting in some relatively fixed position. C is a device equipped with metallic contact-pin receptacles and intended for attachment to the end of a cable. D is a device equipped with metallic contact pins and intended for mounting in some relatively fixed position.

There appears to be no argument whatever about the nomenclature of A and B: A seems to be universally accepted as a plug, B as a socket. The difference of opinion arises over C and D. Party No. 1 maintain that C is a socket and D is a plug. Party No. 2 maintain that C is a plug and D is a socket. In effect, Party No. 1 see a common factor in the physical appearance of certain constituent parts of the objects, whilst Party No. 2 see a common factor in the function and location of the object as a whole.

The main argument appears to go as follows:—

Party No. 1. The device known in electrical work as a "pin" may be inserted into a receptacle of similar size and shape which it will fill completely. The pin is then by dictionary definition a plug (something fitting into and filling a hole) whilst the receptacle is a socket (a hole for something to fit into). It therefore appears reasonable that the term plug should be applied as a collective noun to any assembly of such pins, whilst the term socket should similarly be applied to any assembly of such receptacles.

Party No. 2. From the dictionary definition just given, X in Fig. 2 is clearly a plug whilst Y is a socket. Whatever arrangement of smaller plugs and sockets we make on the two surfaces 1, 2 and 3, 4 should not alter the names already given to the two devices X and Y. Whichever way the smaller plugs and sockets are moving X will still be plugged into Y, and X will still be attached to the end of a cable whilst Y will still be mounted in some relatively fixed position.

If we accept the recommendations of the first party, then we must find some way of indicating whether we require our plug (or socket) to be "loose" (i.e. cable attached) or "fixed." Each manufacturer appears to devise his own method of effecting this discrimination and their catalogues reveal such descriptions as, "with mounting brackets," "chassis mounting," "flex-mounting," "cable mounting," "panel mounting" etc.

If we accept the recommendations of the second party then we must find some means of indicating whether our plugs (or sockets) are equipped with pins, or pin-receptacles. One method which has been in satisfactory use in some factories for many years utilizes the term "male" to indicate pins and "female" to indicate pin-receptacles. Thus A, B, C, D, (Fig. 1) are described as "male-plug," "female-socket," "female-plug," and "male-socket" respectively.

Support for Party No. 1 is found in the drawings of

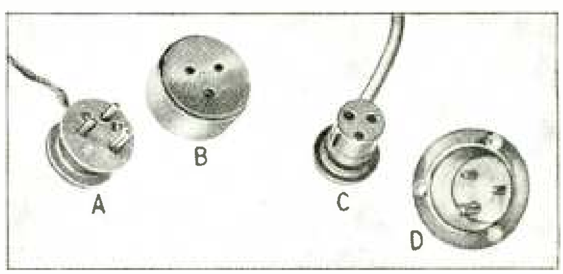


Fig. 1. Some plugs and sockets in common use.

some Government departments and in the catalogues of some manufacturers whilst support for Party No. 2 comes from other Government departments and other manufacturers.

Let us see what the British Standards Institution has to say on the subject. We look up British Standard No. 205 "Glossary of Terms Used in Electrical Engineering." Part 3 (1943) Section 3, Sub-section 37. It looks at first sight as though the issue has been very carefully side-stepped, for reference 3701 reads: "Plug-and-socket. A device consisting of two portions, a plug and a socket, having metallic contacts and arranged to engage with each other, so that it forms a ready means of connecting or disconnecting current-using apparatus to or from a source of supply." However, looking further, we discover the following :—

"3706. Outlet plug-and-socket. A plug-and-socket intended for use at a supply point.
3707. Inlet plug-and-socket. A plug-and-socket intended for use on current-using apparatus.
3708. Outlet socket. One portion of an outlet plug-and-socket, intended for mounting at a supply point and provided with untouchable metallic contact-tubes.
3709. Outlet plug. The other portion of an outlet plug-and-socket, intended for attachment to a cable and provided with metallic contact-pins.
3710. Inlet plug. One portion of an inlet plug-and-socket, intended for attachment to a cable and provided with untouchable metallic contact-tubes.
3711. Inlet socket. The other portion of an inlet plug-and-socket, intended for mounting on current-using apparatus and provided with metallic contact-pins."

Clearly in the light of these definitions the British Standards Institution regards our original C and D (Fig. 1) as plug and socket respectively. In other words it supports Party No. 2. At the same time, however, it introduces these terms "inlet" and "outlet" which, in my personal view, tend to confuse the issue rather than to clarify it.

Consider the two references 3709 and 3711. In each the following words appear "provided with metallic contact-pins" (Similarly in both the references 3708 and 3710, the words "provided with untouchable metallic contact-tubes"). With a common factor in the description we might, therefore, reasonably expect to find a common factor in the accepted titles; instead of which we find "outlet-plug" and "inlet-socket"—two precise opposites.

The trouble arises here, I think, from use of the terms "inlet" and "outlet." I have already suggested that once we accept the arguments of Party No. 2 (as the B.S. clearly does) all that we then need consider is how to indicate which device has the pins and which the pin-receptacles. To my mind the terms "outlet" and "inlet" do not perform this function in a sufficiently clear-cut manner. On the other hand the terms "male" and "female" leave no one in any doubt. Moreover, the argument of "no common factor in the titles" cannot be levelled against "male-plugs" and "male-sockets" (which would be the equivalent of references 3709 and 3711).

What we might term this "physiological system" would appear, at first sight, to be the most logical for standardization. However, further consideration now leads me to the conclusion that we have readily available an even simpler method of differentiation.

Suppose we wish to purchase the device which answers the description of reference 3709. If we belong to Party No. 1, and we stroll up to the counter and ask for "a plug" the assistant will immediately

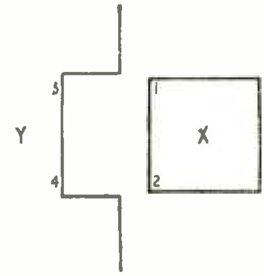


Fig. 2. Illustrating one method of defining a plug and socket.

come back at us with either two or three questions:
(*a*) How many pins?
(*b*) Cable mounting or fixed mounting?
(*c*) (If it is a power plug) What current rating?

If we belong to Party No. 2 and ask for "a male-plug" we shall still be asked question (*a*). If we belong to the B.S.I. section of Party No. 2 and ask for "a outlet-plug" question (*a*) will still be fired at us. Does it not seem reasonable, then, that, whatever party we belong to, our title for the device which we require should contain a term specifying the number of connections that we desire this plug-and-socket to be capable of handling?

"But," it might be objected, "this we already do; we don't ask for things in the vague manner suggested above." Taking "n" as representing any number, if we belong to Party No. 1 we ask for an "n-pin plug"; Party No. 2 "an n-pin male-plug"; and Party No. 2 (B.S.I.), "an n-pin outlet-plug". In reply I should say "I agree with you entirely: that is precisely what we all do; and look at the redundancy that we involve."

Take Party No. 1 member. He asks for an "n-pin plug"; and yet the whole basis of the argument which divides Party No. 1 from their fellows is "that the device with the pins is *always* the plug." He is on an even stickier wicket when he asks for "an n-pin socket," for then redundancy gives place to inconsistency. If he changes from "an n-pin socket" to "an n-hole socket" he is back to redundancy again.

Precisely similar arguments apply to the terms put forward by both sections of Party No. 2. In the expressions "an n-pin male plug" and "an n-pin

Designation	Definition	Equivalent BS205 Number
N-hole socket	One portion of a plug-and-socket, intended for rigid mounting, and having n untouchable contact-tubes.	3708
N-pin plug	The other portion of a plug-and-socket, intended for attachment to a cable, and provided with n metallic contact-pins.	3709
N-hole plug	One portion of a plug-and-socket, intended for attachment to a cable, and having n untouchable contact-tubes.	3710
N-pin socket	The other portion of a plug-and-socket, intended for rigid mounting, and provided with n metallic contact-pins.	3711

outlet plug" neither "male" nor "outlet" contributes one iota to our specification of the device which we require, once we have accepted the main contention of Party No. 2 that the portion of a plug-and-socket which is designed for attachment to a cable is the plug, whilst the portion which is designed for more rigid mounting is the socket.

What sort of definitions, then, do these considerations suggest? Surely something on the lines indicated in the table.

Well, that is my system. Until I meet a simpler system that is how I, as an individual, shall classify these objects within my own mind. If you, dear reader, can produce an even simpler system, good luck to you. I for one shall be only too happy to discard mine and to embrace yours. Meanwhile I think I have written sufficient to indicate that a problem exists and requires attention. If it does not receive attention then it would seem that we are to be faced for ever with the state of affairs in which drawings of plugs and sockets made by one Government department are converted to sockets and plugs by a second Government department, only to be converted back to plugs and sockets again when they are passed on to the manufacturer. Moreover, as the last British Standard on this subject was in 1943, I feel that the time may now be ripe for once again reopening discussion of this matter.

In closing I must hasten to take evasive action against the reader who is even now reaching for his scissors to clip out that extraordinary "plug-and-socket" recently advertised in an American contemporary. I've already seen it, and I suggest that, in the terms of the "physiological" system the most apposite title would appear to be the "hermaphrodite" plug.

Manufacturers' Literature

Switches, lampholders, jacks, knobs, connectors and other chassis fittings listed in a new revised catalogue (No. 192) available from A. F. Bulgin & Co., Bye Pass Road, Barking, Essex; price 1s including postage.

Television Pre-amplifier with gain control, available with any number of coaxial outlets up to eight. Leaflet from the Rainbow Radio Manufacturing Co., Mincing Lane, Blackburn.

Miniature Plug and Jack (approx. 1½in long) and a B7G plug are amongst new products listed in a catalogue of Ediswan Clix chassis fittings; available from The Edison Swan Electric Company, 155, Charing Cross Road, London, W.C.2.

Television Pattern Generator (40-70 Mc/s) with simple controls, giving patterns of seven horizontal bars and six vertical bars, described in a leaflet from Homelab Instruments, 615-617, High Road, Leyton, E.10. Seven types of test can be carried out.

Circuit-symbol Stamps for rapid printing of circuit diagrams; mounted on transparent blocks so that the user can see where he is placing them. Leaflet describing a complete kit from John Griffin Company, 2157, James Avenue, St. Paul 5, Minn., U.S.A.

Aircraft Intercommunication Equipment consisting of three units weighing 8¾lb (total) capable of operating up to ten headsets. Specification and general description on a leaflet from Airmec, Ltd., High Wycombe, Bucks.

Signal Generator covering 100 kc/s to 100 Mc/s on fundamental frequencies in six ranges, with output variable from 1 μV to 100 mV. Specification on a leaflet from Advance Components, Back Road, Shernhall Street, London, E.17.

Books Received

TV Repair Techniques. Gernsback Library No. 50. Collection of hints by practising servicemen on unusual faults occurring in American television receivers. Pp. 128; Figs. 98. Price $1.50. Gernsback Publications, 25, West Broadway, New York, 7.

Introduction a l'Électronique by P. Gran, L.ès S. Survey of electron tube devices and their applications. Pp. 212; Figs. 205. Price 1,650 Fr. Dunod, 92, Rue Bonaparte, Paris, 6.

Cours Practique de Television by F. Juster. Vol. 1. Design of wide-band r.f. amplifiers for use in television. Pp. 127; Figs. 71. Price 490 Fr. Editions Techniques et Professionelles, 18 bis, Villa Herran, Paris, 16.

Cours sur les Ondes Ultra-Courtes by Y. Place. Elementary theory and practical application of metric, decimetric and centimetric waves. Pp. 186, Figs. 232. Price 1,300 Fr. Edition Eyrolles, 61, Boulevard Saint-Germain, Paris, 5.

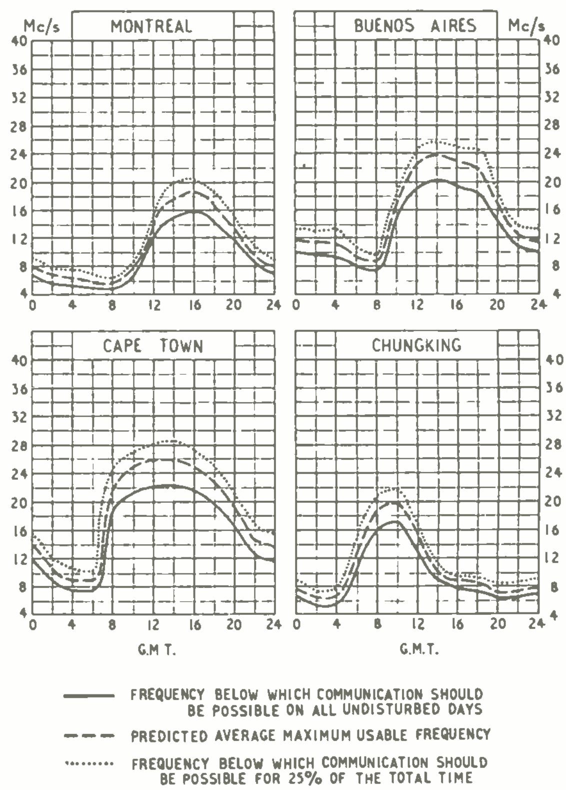
Industrial Electronics, by R. Kretzmann. Survey of vacuum and gas-filled valves, photocells, voltage stabilizers and cathode-ray tubes and their application as relays, counting and control devices, etc., in industrial processes. Sections are devoted to radio-frequency heating of dielectrics and metals. Pp. 236; Figs. 266. Cleaver Hume Press, 31, Wrights Lane, London, W.8. Price 25s.

Short-wave Conditions

Predictions for February

THE full-line curves given here 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 February.

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



Resistances in Parallel

Calculating Effective Values on the Slide Rule

By FRANCIS OAKES,* M.Inst.E.

A NUMBER of methods for rapid calculation of the equation

$$R_{1,2} = \frac{R_1 R_2}{R_1 + R_2}$$

have been published in recent years. Unfortunately these suffer either from considerable inaccuracy (particularly when R_1 and R_2 are of different orders of magnitude) or when they have the drawback of necessitating tiresome intermediate calculations, such as the finding and adding of reciprocals, adding of resistance values, or calculation of auxiliary currents. The method described here suffers from neither of these disadvantages, and lends itself readily to a number of further applications.

To find the numerical solution of the equations above, proceed as follows:

(1) Bring cursor line over R_1 on the stock (Fig. 1, one arrow).

(2) Move the end-mark of the slide (1 or 10 as required) over R_2 on the stock (two arrows).

(3) Read R_1/R_2 on the slide under the cursor line (three arrows) and add 1 to this reading.

(4) Move the slide so as to bring this sum, i.e. $R_1/R_2 + 1$ under the cursor line (four arrows).

(5) Read result $R_{1,2}$ on the stock under the end-mark of the slide (five arrows).

In the example shown in Fig. 1 the following numerical settings are indicated:

$R_1 = 770, R_2 = 124, R_1/R_2 = 6.2, R_1/R_2 + 1 = 7.2$ and the result $R_{1,2} = 107$.

Proof: *1st step*: The section on the slide between the end-mark and R_1/R_2 is equal to the section on th stock between R_1 and R_2. Therefore $\log R_1/R_2 = \log R_1 - \log R_2$.

2nd step: The section on the slide between the end-mark and the new setting $R_1/R_2 + 1$ is equal to the section on the stock between R_1 and $R_{1,2}$, thus

$$\log R_{1,2} = \log R_1 - \log\left(\frac{R_1}{R_2} + 1\right)$$

$$\therefore R_{1,2} = \frac{R_1}{\frac{R_1}{R_2} + 1} = \frac{R_1 R_2}{R_1 + R_2}$$

A series combination of capacitances C_1 and C_2 is equivalent to a capacitance $C_{1,2} = C_1C_2/(C_1 + C_2)$. It is therefore obvious that the same method can be used also for the solution of series-capacitance problems. An analogous relationship holds good for parallel inductances.

It should be observed that the settings are so arranged that the result appears on the stock. This is of importance when more than two resistances are connected in parallel, or more than two capacitances in series.

If, for example, the parallel equivalent $R_{1,2,3}$ for the three resistances R_1, R_2, R_3 is required, the calculation is started by finding $R_{1,2}$ in the manner described above. To continue, the cursor line is moved over $R_{1,2}$ and the process repeated with $R_{1,2}$ instead of R_1, and with R_3 instead of R_2. In other words, $R_{1,2}$ is considered as one single resistance to be shunted by R_3. The result $R_{1,2,3}$ then appears in the same way as $R_{1,2}$ was found in the original example. In this way any number of resistances in parallel, or capacitances in series, can be worked out.

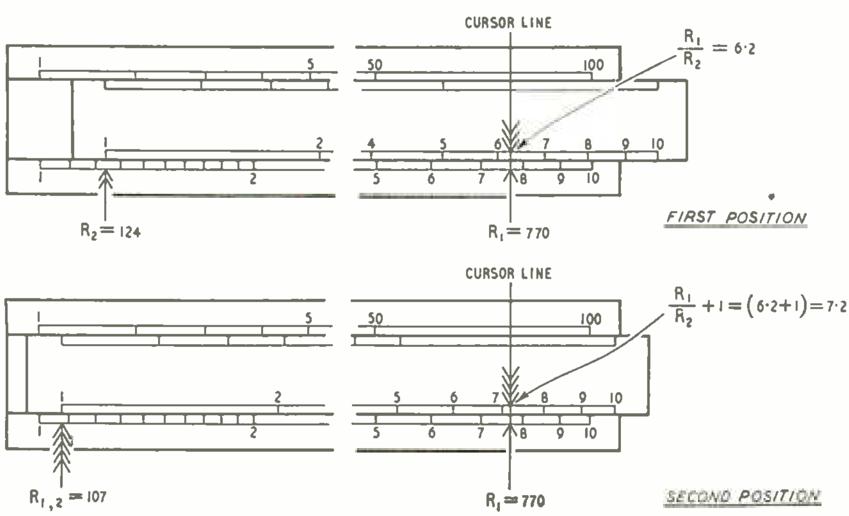
A similar process, with the only difference of subtracting 1 instead of adding, can be used to find the shunt value R_2 required to reduce a resistance R_1 to a desired value $R_{1,2}$. This is illustrated in Fig. 2 on the next page and is carried out as follows:

(1) Bring cursor line over R_1 on the stock (one arrow).

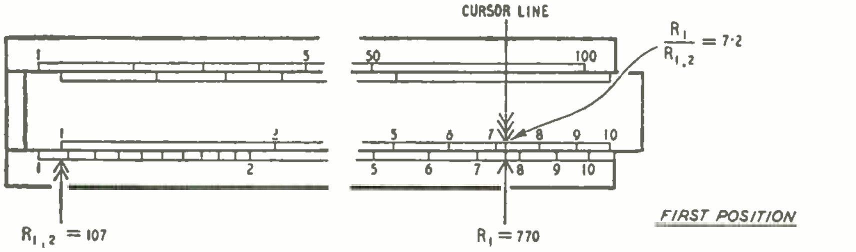
(2) Move the end-mark over $R_{1,2}$ on the stock (two arrows).

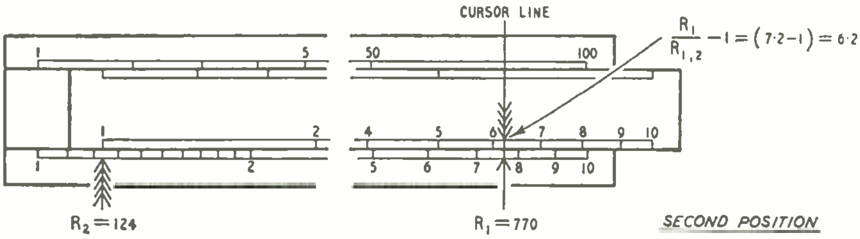
(3) Read $R_1/R_{1,2}$ on the slide under the cursor

Fig. 1. Slide rule settings for calculating the effective value of 124 and 770 ohms in parallel. Answer 107 ohms.



* Ferguson Radio Corporation





Complementary problem to that of Fig. 1. What resistance must be connected in parallel with 770 ohms to give an effective value of 107 ohms? Answer 124 ohms.

line (three arrows) and deduct 1 from the reading. (4) Move the slide so as to bring this difference, i.e. $R_1/R_{1,2} - 1$ under the cursor line (four arrows).

(5) Read resulting shunt resistance R_2 under the end-mark of the slide (five arrows).

The proof is quite analogous to the additive operation. Similarly, as the result falls on the stock, it can be used as a starting point for further calculations.

The subtractive method can be used for numerical solution of resonant circuit problems. Since the reactance of a parallel resonant circuit above resonant frequency is a capacitive reactance of magnitude $X_a = X_L X_C/(X_L - X_C)$ and below resonance of the magnitude $X_b = X_C X_L/(X_C - X_L)$ inductive reactance, the method described is obviously valid. Other problems of this kind, having the same mathematical formalism, and therefore being solved by the same slide rule operations, are the equivalent admittance of a series resonant circuit off tune, or the equivalent resistance of a positive and a negative resistance in parallel.

Manufacturers' Products

NEW EQUIPMENT AND ACCESSORIES FOR RADIO AND ELECTRONICS

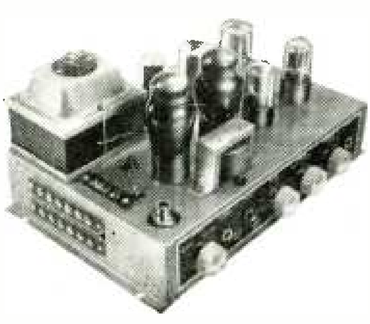
Recording Amplifier

DESIGNED for use with the leading makes of tape recording mechanisms, the "Elpico" Model AC/54 Mark II amplifier is suitable for use with either high- or low-impedance heads, and alternative levels of bias and erasing output are provided. Wide-range tone compensation circuits enable an overall characteristic level from 80 to 8,000 c/s, within ±4 db, to be obtained at a tape speed of 7½ in/sec.

In this redesigned version, the negative feedback has been increased, and precautions have been taken to prevent audio frequencies from getting into the erase head via the bias feed network. A biased neon lamp level recorder is fitted, and calibrated on each individual amplifier.

The makers are Lee Products, 63 Great Eastern Street, London, E.C.2, and the price is £16 16s.

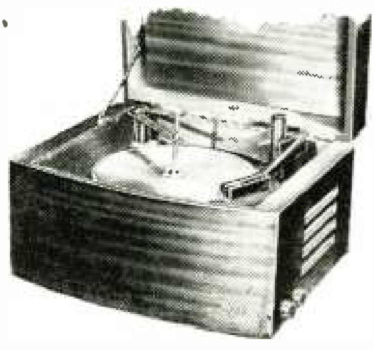
"Elpico" Model AC/54 Mark II tape amplifier



High-quality Record Player

AN unusual disposal of two identical loudspeakers in opposite sides of a ½-inch thick mahogany cabinet is said to give "presence" and the atmosphere of the concert hall in the reproduction from the "Black Box," the latest record player, produced by Pye, Radio Works, Cambridge. A "Monarch" three-speed record changer is incorporated and the push-pull amplifier is provided with tone and volume controls. The record changer will play up to ten 7in, 10in or 12in records mixed at any one of the following speeds: 33⅓, 45 or 78 r.p.m. The price is £40 19s (including tax).

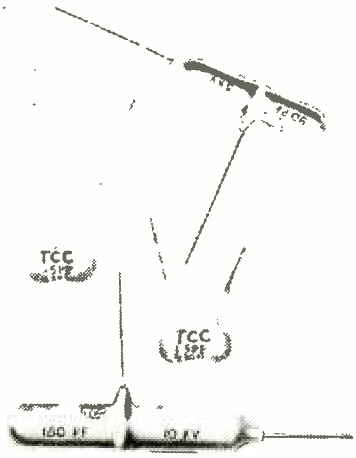
Pye "Black Box" record player.



New Ceramic Capacitors

AMONG the new capacitors introduced recently by the Telegraph Condenser Co., Ltd., Wales Farm Road, North Acton, London, W.3, are two series of ceramic types of unusual interest. One consists of small-capacitance tubulars (Type CC125A) primarily intended for "top-end" coupling in bandpass filters. Capacitances range from 0.5 pF to 5 pF at 500 V d.c. working, the closest tolerance being ±10% for all except the 0.5-pF model, for which it is ±20%. Overall size is 0.5 in × 3/16 in (approx) and side exit connecting wires of No. 22 s.w.g. are fitted.

The other series is for high working voltages, such as the e.h.t. positions in television sets and pulse-feed capacitors in radar transmitters and



T.C.C. high-voltage tubular and small capacitance tubular capacitors, both are ceramic types.

receivers. These are tubular ceramics also but with one axial wire and one centrally wrapped connecting wire.

Working voltages range from 1 kV to 10 kV and capacitances from 50 pF to 620 pF according to type and voltage rating. The largest capacitance for 10-kV working is 180 pF and for 1-kV 620 pF. They are quite small considering the high working voltages, a 250-pF, 3.5-kV capacitor, for example, measuring 1 in long and $\frac{5}{16}$ in diameter.

Redesigned Record Changer

WHILE retaining the essentially simple and reliable design of the earlier mechanism, and its quick-changing characteristics, the latest version of the "Monarch" three-speed changer has been given a more attractive appearance. The pickup pivot and corner trip mechanisms are now housed in a single "streamlined" moulding, and an ivory finish is standardized.

More important from the technical point of view, the record release arm has been reshaped and is now made in Perspex instead of metal to give more silent operation. The pickup arm has also been reshaped to give better accessibility to the centralized control knob.

Redesigned "Monarch" three-speed record changer.

The price of the "1954 Monarch" is £16 10s 3d (including tax), and the makers are Birmingham Sound Reproducers, Claremont Street, Old Hill, Staffs.

New Loudspeaker Enclosure

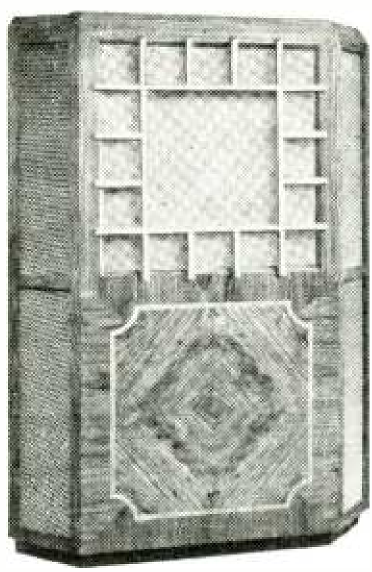
IN order that the full potentialities of the Dual Concentric loudspeaker unit may be realized, Tannoy have recently developed a new enclosure which provides horn loading throughout the frequency range. Hitherto the horn principle has been applied only above 1,000 c/s, but now the front of the large cone is loaded by a short horn with a flare efficient down to 200 c/s, while the back of the diaphragm is coupled to a larger folded horn covering frequencies from 200 c/s downwards. Radiation above 200 c/s from this larger horn is deliberately restricted by absorption at the discontinuities in the direction of the emerging sound.

The result is twofold: there is a noticeably "tight" control of transients and freedom from excitation of cavity resonances, often apparent in vented enclosures; and there is an effect of spaciousness consequent on the increase of source area. Since frequencies above 200 c/s are radiated from the single central source, there is no incongruity when speech or solo voices are being reproduced.

A 15-inch Dual Concentric unit is used, and this has now been redesigned for ease of dismantling and is fitted with a new phenolic-resin impregnated corrugated centring device. Plug-in connections are provided for the cross-over filter unit.

The makers are Tannoy Products, Norwood Road, West Norwood, London, S.E.27.

Tannoy "expanding source" enclosure for the Dual Concentric loudspeaker.



RANDOM RADIATIONS

By "DIALLIST"

Sticking My Neck Out?

A LETTER in a recent issue of the *Wireless Trader* called attention to the inconvenience caused to servicemen by a method of soldering leads to tags used in many—if not most—of our radio and television factories. This consists in securing the wire to the tag by twisting or hooking before the solder is applied. The serviceman's complaint is that it makes the substitution or replacement of components always a slow, and sometimes an exasperating business. One can see, and to some extent sympathize with the manufacturers' point of view. In the absence of that third hand which all solderers would like to possess, the preliminary securing of wires to tags speeds up the work. In most kinds of soldering, too, it is sound practice to make joints mechanically strong before the solder is applied. Manufacturers feel, no doubt, that sets made in this way are more likely than others to stand up to the shocks and bumps that come their way in transit. True; but I couldn't agree less that this kind of soldered joint is the right one to use in *factory-made* apparatus. Why? Well, because it can, and too often does, enable a dry joint to be passed as sound by inspectors applying the usual tests. Sooner or later a dry joint, even though the wire is twisted to the tag, is likely to give rise to one of those horrible intermittent faults which are responsible for the entry of so many black marks in the Recording Angel's notebook.

Alarm and Despondency

TRYING OUT a television set the other day on Test-card C, I was surprised to find it suffering from what appeared to be a markedly jittery frame scan. In particular, the black and white rectangles of the horizontal borders were quite unstable in their height. They just wobbled. A 'phone call to the Alexandra Palace elicited the information that film was being used and that a slight up-and-down movement was to be expected. Now, I don't think that that's quite fair. Test-card C should be something on whose faithful transmission experimenters and servicemen can bank. It should surely be *the* television image whose faultless transmission is guaranteed. Things become pretty difficult if this isn't so.

A Little Learning

THE VAST MAJORITY of radio dealers are first-rate fellows, who know their job and do well by their customers. But there is, more's the pity, nothing to prevent any Tom, Dick or Harry with a small amount of capital from taking a shop and erecting a sign describing himself as an "electrical, electronic, radio and television engineer," even though his knowledge of the very elements of any of these wide fields is of the scantiest and his practical experience *nil*. He can, without let or hindrance, undertake the wiring of houses and the installation and maintenance of electrical equipment of all kinds. The result is too often that electricity, the best and safest servant that Man has yet devised, becomes a menace to life and to property. One evening, long after the shops had closed, a neighbour came, with many apologies, to seek my help: with a child seriously ill in his house, all the lights had "gone"; fuses blew as soon as they were replaced. What I found left me gasping. One of these dabblers had sometime previously put electric light into two rooms. Since then the lighting had been extended by him to the rest of the house simply by tapping off the original cables. *One* fuse-box served not only all the lights, but also numerous 2-pin wall sockets feeding a variety of gadgets, such as a couple of 1-kW heaters and a washing machine. The whole 5-amp wiring system had been "strengthened" by fitting 15-amp fuses in the single fuse-box. . . . .

When it Comes to TV

It is a lamentable fact that up and down the country thousands of non-technical owners of radio and television receivers are completely at the mercy of these black sheep. I can't think why manufacturers don't exercise more care in appointing retailers of their wares; for there is no question that a first-rate make of radio or television set can gain a quite undeserved local reputation for lack of reliability through the misdeeds of one ignorant or unscrupulous dealer. Here are a few cases that have come to my knowledge. (1) The typical horizontal bars of sound-on-vision ascribed to camera faults; (2) Five radio and television sets installed by one dealer in a 230-V area with the mains tappings at 200 volts; (3) A new c.r. tube fitted, at a cost of over £20, to "cure" distorted reproduction of sound; (4) Poor results with an elaborate aerial array found, on investigation by its manufacturer, to be due to an error of some 40 deg. in its orientation; (5) An H-type array erected with its reflector towards the transmitting station. And I could go on and on.

Battery Operated TV

One firm of manufacturers of television receivers demonstrated at the Earls Court Radio Show that any of their sets could be operated from a pair of 12-volt car starter accumulators, or from a private lighting plant, if sufficient "juice" could be spared. For all that, I'm not persuaded that a standard television set, with power requirements of the order of 150 watts, is suitable for use in this way. I've put up the idea for a genuine battery-and-converter receiver to several firms without arousing any marked enthusiasm. What I'd like to see is a set equipped mainly with battery miniature valves, whose requirements in the way of power are very small indeed. It would probably be necessary to use specially designed battery valves with high-consumption filaments for most of the functions. I'm told that there wouldn't be a big enough market to make such a set worth while. That I just don't believe. I live in a small country town and I can think right away of over a score of people within a few miles of my home who want television and would have it if reasonably economical battery operation were possible. And that's just one small town. There must be tens of thousands of folk in television service areas—townsmen, villagers and farmers—who would give no uncertain welcome to such a set, if it became available.

Soldering Aids

Here are two soldering aids that I've found most useful since I made them a good few years ago. The first is a 230V-12V step-down transformer, mounted on a rectangular switch block. The primary and the core are connected by heavy flex to a 3-pin plug. The secondary connections go to a 2-pin socket, mounted on the same block. Each of my three small 12-V irons has a 2-pin plug at the end of its flex. The second gadget enables one to use the larger irons at some distance from a wall-socket. It is the simplest thing you can imagine. Just a 3-pin socket mounted on a circular switch block, which is itself attached to a plywood disc. To the contacts of the socket a 3-pin plug is connected through four yards of good flex.

UNBIASED

By FREE GRID

Plastic Plumbing

A KINDLY READER has sent me a bunch of cuttings from the local paper at Barnet, where they appear to be having a lot of trouble separating the Light and the Home Service programmes. Apparently the trouble is due to a rectification effect set up by the corroded joints in the guttering and piping and also in the metal window frames of Barnetonian houses. Such corrosion exists in all districts, of course, and doesn't have any serious effect but Barnet is so close to Brookman's Park that the resultant rectification causes the two main B.B.C. programmes to break through on each other in hopeless fashion.

It is astonishing that nobody seems to have thought of any really drastic method of tackling the problem. Irritating palliatives of doubtful efficiency seem to be all that the local experts can suggest. The obvious solution, of course, is to scrap the offending pipes and to substitute plastic plumbing; metal window frames and guttering could be similarly dealt with. The benefit to the nation of the large supplies of scrap metal which my plan would make available would be enormous and would more than justify the Treasury in making a substantial grant towards the cost out of the ill-gotten 15 per cent blood money which it squeezes out of the B.B.C.

Patients' Preference

ON MORE THAN one occasion in these columns I have complained of the inadequacy of hospital radio. In many of the cases brought to my notice the maintenance of the equipment has apparently been nobody's responsibility. When the hospitals were nationalized in 1948 the Government, through the various hospital boards, took over responsibility for all such necessary services as the plumbing and the electric lighting, but not apparently the radio installation—judging by the sorry state in which I have found it in certain cases. In some hospitals the headphones are in a bad state of repair; very often too, the reproduction is far too loud and an individual volume control for each patient is an unheard-of luxury.

It was, therefore, an agreeable surprise recently when I found a new installation being put in at an establishment which I had previously criticized. It is designed to give each patient a separate volume control and the choice of no fewer than four programmes.

I was unable to obtain any official information as to what these programmes were to be, but as the installation was being carried out by a well-known radio relay company I presume that the programmes—which I understood are to be fed to the hospital by landline—will be the usual ones that are "on tap" to subscribers to this particular company.

I cannot help feeling, however, that each of our large hospitals should reserve one of their audio channels for its own internal programme provided by gramophone records chosen by the patients themselves; in other words a "patients' preference" or "sufferers selection" service. The number of patients in even the largest hospital is infinitesimal compared with the B.B.C.'s listeners, and, therefore, each patient would have a certainty of hearing his own favourite record played. There would be little difficulty, I think, in obtaining the services of amateur disc jockeys from the local branches of voluntary organizations like the W.V.S.

I suppose that one day a TV screen will be found at the foot of every hospital bed or on the ceiling above. The expense of installation would be very great, but I do wonder why our cinema magnates do not seize their opportunity to boost business by bringing movies to each patient's bedside by means of a scanning unit in the local cinema and a closed-circuit link to the local hospital. Patients would almost certainly tell all their visitors to be sure and see such-and-such a film. Maybe commercial TV could be tried out in this way using films and a scanning unit in the hospital.

Baseless Ballyhoo

THE AMERICANS ARE a very likeable people and I number a great many among my readers and my friends—not always the same thing. But certain of them have the irritating habit of thinking that nothing ever happens or has its being outside "God's own country." Incidentally I may remind them that even the use of this expression to describe their homeland is not original. It was first employed by Dick Seddon, a famous premier of New Zealand, to describe that delectable land and is in fact recorded on his tomb in Wellington; it was probably shown to the Queen on her recent visit.

I recall being very irritated on one occasion by an American who had just been on a visit to what he kept on referring to as Cairo, Egypt. Eventually exasperation got the better of my manners and I pointed out that few people were ignorant of the fact that Cairo was in the land of the Pharaohs, but he promptly floored me by blandly explaining that there was another Cairo in the U.S.A., as indeed there is. Needless to say, I gave up.

After this incident it scarcely surprised me a few months ago when, at an international radio gathering, a tribute paid by the chairman to Franklin, the pioneer of long-distance beam telegraphy, drew vociferous applause from the Americans present. It was clear that the chairman ought to have said C. S. Franklin of England, as the applauders obviously thought that he meant that gifted American Benjamin Franklin who, in the 18th century, drew sparks from a kite

"They have the irritating habit . . . "

string. Maybe they were not altogether wrong to think of him as, after all, Marconi, when he first used an aerial for wireless purposes, was possibly not unmindful of Franklin's work.

However, it is not about Franklin that I wish to write but of the ballyhoo that is being made in the U.S.A. about the recording of TV programmes on magnetic tape. This is undoubtedly a first-class achievement and is without question "pregnant with possibilities," as one typical writer puts it. I would, however, remind people not only in the U.S.A. but over here also that Baird recorded television on discs some twenty years ago and I think it is axiomatic that what can be recorded on discs can also be done by means of tape, film or any other recording media.

I hope my American readers will not regard my remarks as unmannerly. No doubt they suffer equal irritation at certain of our national habits and are exasperated at instances of our unjustified ballyhoo.