Wireless World

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Valve Symbols

BRITISH Standard 1409:1947 "Letter Symbols for Electronic Valves," issued some three years ago, was stated to be "*based* on proposals prepared . . . with a view to standardizing the letter symbols used by valve manufacturers in their catalogues and other technical literature." At the time, *Wireless World*—not unreasonably, we hope—took the publication of this specification as implying a desire that the symbols proposed should be generally adopted by a wider circle. So, in spite of typographical difficulties, we accordingly used the symbols as far as was practicable.

Having gone thus far in the interests of uniformity, it comes as something of a shock to us to see the revised specification B.S. 1409:1950, just issued.* This publication, under the same title as its predecessor, carries on its cover the prominent statement "Mainly for use in valve catalogues and similar technical literature." That seems to put forward a highly undesirable principle: are we to have a state of affairs where users of valves (which means all of us) are to learn two languages—one for use in dealing with manufacturers and another in reading (or writing) technical journals?

Stereophony

OUR correspondence columns bear witness to the widespread interest that exists in stereophonic broadcasting. Stereophony will no doubt attract still more attention next year, as we believe the multi-channel principle is to be used in the sound-reproducing equipment to be installed at the Festival of Britain. That being so, it is a pity that a plea for B.B.C. experimental transmissions on a binaural system, made in this journal last March, was so uncompromisingly turned down. The B.B.C. Chief Engineer, in a letter published in our April issue, pointed out the admitted complications of the system, and expressed doubts as to whether the Corporation would be justified in spending money on a specialized service of interest to a relatively small number of listeners. The French broadcasting authorities were, however, less pessimistic about stereophony, and staged an experimental transmission a few months later.

We are certain that interest in this subject is greater than the B.B.C. imagines, and venture to suggest the Corporation should make another attempt to find ways and means of staging experiments in which listeners can participate, as they did in France.

[* British Standards Institution, 28 Victoria Street, London, W.1. Price 2s. The revised specification includes a considerable number of extra symbols.]

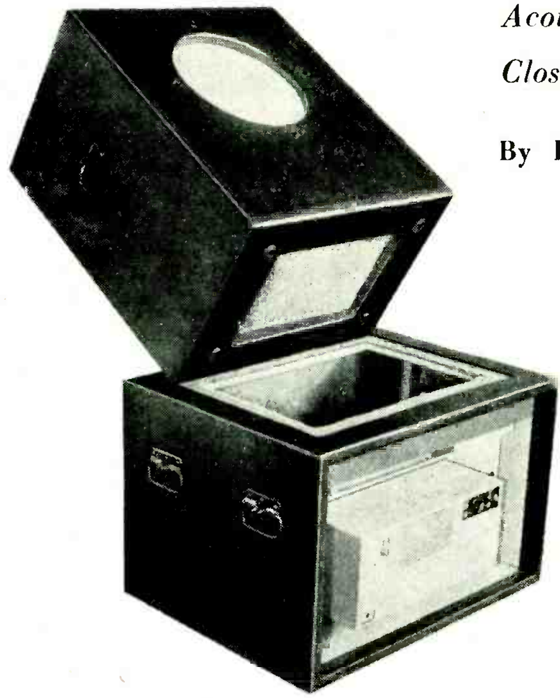
Too Many Bosses?

THOUGH the uproar provoked by the withdrawal of the political play "Party Manners" from the B.B.C. television programme was a regrettable and unworthy episode that by now has been largely forgotten, it raised a matter of principle that will, we hope, be borne in mind when the B.B.C. Charter comes up for renewal next year. *Wireless World* does not concern itself with details of programme organization, but we deplore anything that tends to reduce the status of British broadcasting.

As we see it, the B.B.C. attitude over this matter betrayed that weakness against which the Corporation should be most strongly on its guard—timidity. This point of view was admirably expressed in a leading article in *The Times* of 10th November: "The listening public will always be behind them [the B.B.C.] in refusing to turn broadcasting into a colourless bore for the sake of this or that crank or fanatic. There would be no intellectual or aesthetic worth in broadcasting if it were controlled to please every shade of minority opinion. Censorship by timidity can be as effective as the blue pencil of a dictator." As things are, the organization of the B.B.C. tends to favour the timorous. Heads of "Programmes" should have sweeping powers, and be discouraged from passing on the responsibility for awkward decisions to higher authority.

Sidelights on

Loudspeaker Cabinet Design



Experimental two-section vented cabinet with top half tilted back to show sound-absorbing material covering the communicating window.

Acoustical and Electrical Damping in Closed-cabinet Loudspeakers

By D. E. L. SHORTER,* B.Sc.(Eng.), A.M.I.E.E.

IT is not the purpose of the present article to enter deeply into the mathematical treatment of the problems of loudspeaker cabinet design, since this field has already been covered in standard works on applied acoustics as well as in a number of articles in the technical press. Instead, it is proposed to discuss certain aspects of the subject which do not always receive full attention in the literature, and to illustrate these by a few experimental results obtained in the course of development work on cabinets during the period 1938–1947.

Standing Wave Effects

The subject of loudspeaker cabinet design is usually approached by a simplified theory, in which the mechanical properties of the cone unit and the acoustic properties of the enclosure are represented by a set of inductances, capacitances and resistances. Equivalent circuits containing these elements can then be drawn and the basic features of the design calculated.

Clearly, this simplified theory is only valid at frequencies so low that the wavelength of the sound is large compared with the dimensions of the cabinet. At higher frequencies, at which this condition is not fulfilled, the cabinet volume does not behave as a lumped acoustic capacity, and standing wave effects may appear unless the enclosure is adequately damped by sound absorbent material.

Unfortunately, the performance of a cabinet at these higher frequencies cannot be readily calculated, and in the absence of facilities for response measurement the degree of damping actually achieved is often in doubt.

The full extent of the standing wave effects in loudspeaker cabinets is not always appreciated. Cabinets intended to give good response down to 50 c/s generally have at least one dimension which is equal to a half wavelength of sound in the frequency range 125 c/s to 250 c/s. Moreover, as some recently published work[1] has shown, that the acoustic impedance presented by the cabinet to the cone may change from a capacitance to an inductance at a frequency of which the wavelength of the sound is some seven times the maximum dimension of the enclosure. In some cases, therefore, the simple theory based on lumped constants may break down even below 100 c/s. Reference to a table of absorption coefficients will show that the effectiveness of any sound absorbent lining of practicable thickness falls off below 500 c/s. It will thus be seen that the frequency band within which standing wave effects are to be expected may extend over some two octaves in an important part of the audio-frequency spectrum.

A practical example will illustrate the foregoing discussion. An experimental closed cabinet (the so-called "infinite baffle" type) was required for a 10in. cone unit; the resonance frequency of the unit with the cabinet volume was not to exceed 45 c/s.

The suspension of the cone unit had been experimentally modified to give the maximum compliance consistent with mechanical stability, but even so a volume of 8 cu. ft. was found to be required to meet the specification. For reasons connected with high-frequency distribution, the axis of the present loudspeaker was required to be about 3ft. from the floor and this consideration led to the adoption of a design 4ft. high.

Fig. 1(a) shows the free-air axial frequency response obtained with this cabinet, the cone unit being driven by an amplifier of low output impedance. The curve was taken with the cabinet lined with

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[1] "The Acoustical Impedance of Closed Rectangular Loudspeaker Housings" by Meeker, Slaymaker and Merrill, *Journal of the Acoustical Society of America*, March 1950.

absorbent material of conventional type. Standing wave effects are nevertheless apparent at low frequencies, showing that the internal damping is inadequate.

Damping by Partitions

The ineffectiveness of sound absorbent linings at low frequencies is due to the fact that all the absorbent material lies within a small fraction of a wavelength of the inner wall, which is, of course, a velocity node. Without motion of the air particles, or of the material itself, acoustic power cannot be absorbed and dissipated. Consideration of these facts suggests that the best position for damping material would be somewhere out in the space inside the cabinet, where the standing waves could be caught "on the wing." Theoretically, the material would have to be divided up into many parts, so disposed that at any one frequency there should be an absorbing element in the neighbourhood of a velocity antinode. In practice, however, such a complication has been found unnecessary and effective low frequency damping can be achieved by concentrating the absorbent material into one or two partitions strategically placed across the cabinet. Fig. 1 (b), for example, shows the response of the loudspeaker previously referred to when a single sheet of ¼-in carpet felt was stretched horizontally across the inside of the cabinet at right angles to the longest dimension; the reduction in standing wave effects can be clearly seen.

In this system[2] of damping by partitions, the cabinet can be regarded as being divided into sections, each so small that any standing wave effects occur at high frequencies, at which the sound absorption of a lining of the conventional type is adequate. It may further be noted that those sections of the cabinet which are separated from the cone by one or more sound absorbing partitions receive little sound at the high frequencies and therefore require very little "acoustic treatment."

The principle of subdivision can be applied in a number of ways to suit different cases. The photograph, for example, shows part of an experimental vented cabinet constructed in two separate sections. The lower of the two sections houses the power amplifier and takes the form of a plinth on which the upper section stands. In the illustration the upper section is tilted to show the underside which has a window communicating with the plinth and covered with carpet felt.

Impedance Test

Reference was made earlier to the strategic placing of absorbent partitions. This operation would appear at first sight to require facilities for measuring the overall frequency response of the loudspeaker. Fortunately, however, it is possible to make the necessary experimental adjustments by quite rough impedance measurements. Fig. 2 shows the circuit used for this purpose. R_1 is the resistance of the speech coil of the loudspeaker which is fed at constant current from an audio-frequency oscillator though a

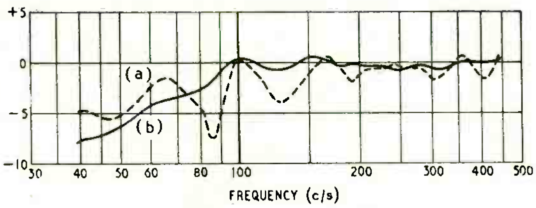


Fig. 1. Axial response below 500 c/s of 10-inch speaker in closed cabinet (a) inner surface lined with absorbent material in conventional manner; (b) with the addition of an absorbent membrane stretched horizontally across the cabinet at right angles to the longest dimension.

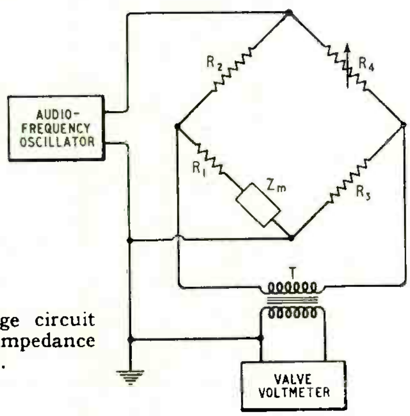


Fig. 2. Bridge circuit for motional impedance measurements.

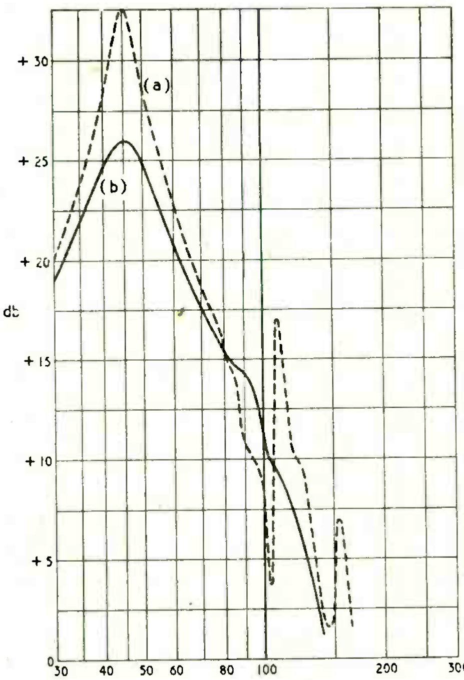


Fig. 3. Typical response curves obtained with the circuit of Fig. 2. Curve (a) is for an undamped cabinet and (b) for the same cabinet with internal damping partition.

[2] Patent Application No. 24528/49

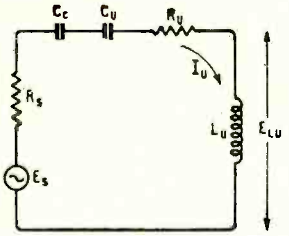


Fig. 4. Equivalent electrical circuit of acoustic elements in a closed-cabinet loudspeaker at low frequencies.

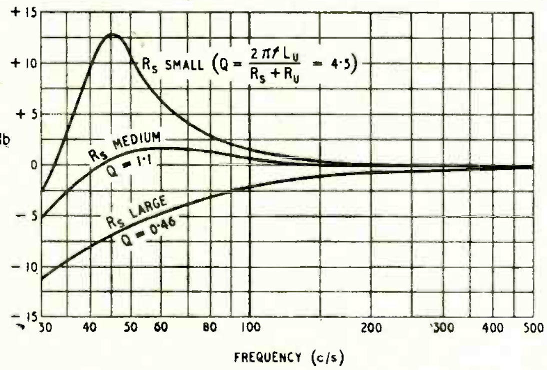


Fig. 5. Response of closed-cabinet loudspeaker for various valves of the effective damping resistance R_s.

relatively high resistance R_2. Z_m is the motional impedance of the loudspeaker, so that the voltage developed across Z_m represents the back e.m.f. generated by the motion of the speech coil when driven by a constant current. Since we are dealing only with the frequency range in which the cone moves as a whole, this back e.m.f. is a measure of the cone velocity. The cone aperture is the only outlet from the cabinet ; any internal resonances can only influence the sound output from the system by modifying the motion of the cone, and must therefore reveal themselves by irregularities in the curve of motional impedance against frequency.

In general, the resistance R_1 will tend to swamp all but the largest of these irregularities so that the total impedance of the loudspeaker is not a very sensitive index of cabinet performance. In the circuit of Fig. 2, therefore, the effect of R_1 is roughly balanced out. Resistance R_3 is made approximately equal to R_1, and the variable resistance R_4 approximately equal to R_2, the whole circuit forming a bridge, the output of which is taken off through the isolating transformer T to a valve voltmeter. The primary impedance of T should be high compared with the maximum speech coil impedance at low frequencies, a requirement which is generally easy to meet.

To make a test, the speech coil is temporarily prevented from moving, either by disconnecting the loudspeaker field supply or, in the case of a permanent magnet, by carefully inserting small wedges into the gap so as to grip the coil. Assuming complete clamping of the movement, Z_m will now be zero, and in this condition, the bridge is balanced at some convenient frequency, preferably in the 200/300-c/s region, by adjusting the value of R_4 and using the valve voltmeter as a null-indicator. The speech coil is then released and the bridge output, which now represents the voltage across Z_m (i.e. the back e.m.f. of the speech coil) is read direct on the valve voltmeter and plotted against the frequency of the oscillator. A typical curve of this kind is shown in Fig. 3(a) which was obtained in an ordinary live room with a completely undamped cabinet. The radiation efficiency of the loudspeaker is too low for any room resonances to affect the curve but the internal modes of the cabinet are clearly apparent. Fig. 3(b) shows how these modes are affected by the introduction of a felt partition.

It will be noted that in this test, the speech coil is being driven with constant force. If the cone were mass-controlled, i.e. if the compliance of the suspension were infinite and the effect of the cabinet nil, the speech coil would move with velocity inversely proportional to frequency. In this hypothetical case, the curves of Fig. 3 would be straight lines having a slope of 6 db per octave ; and it is sometimes convenient to use such a slope as a standard of reference. If desired, an equal and opposite slope can be introduced into the response of the test circuit (for example, by interposing in the input of the valve voltmeter a small series condenser). With this compensation, the valve voltmeter readings will be confined to a much smaller range, and may be plotted to a more open scale. Small irregularities in the curve may thus be better observed ; and the reference line representing the condition of mass control becomes horizontal.

The method of test described above has been used successfully up to about 300 c/s and the accuracy, though limited by the difficulty of ensuring complete clamping of the cone movement, is sufficient to disclose the more troublesome internal cabinet resonances, so that these can be dealt with without recourse to free-air response measurements.

Effect of Source Impedance

Returning to the response characteristic shown in Fig. 1, it will be seen that although the fundamental resonance frequency of the system is at 45 c/s, the acoustic output begins to fall away well above this frequency. For an efficient loudspeaker, driven by an amplifier of low output impedance, this type of response is in accordance with theory. The mechanism of the effect can be explained in the following way.

At the lower end of the audio-frequency band, the wavelength of the sound is large compared with the diameter of the cone, while the polar distribution of the sound output varies only slightly with frequency. It can be shown that in these circumstances the sound pressure produced is proportional to the product of the cone velocity and the frequency. Thus, constant sound pressure will be obtained if the cone moves with a velocity varying inversely as the frequency, while constant cone velocity will give a sound output falling towards the bass. If the cone unit is very efficient, its motional impedance at low frequencies will be high, or, in other words, practically the whole of the voltage across the loudspeaker terminals will be accounted for by the back e.m.f. generated by the motion of the speech coil. If, in addition, the impedance of the driving source is low, the back e.m.f. will be nearly equal to the source voltage, and must therefore remain nearly constant with frequency. In these circumstances, the cone must be moving with nearly constant velocity, and the sound output will therefore fall at the bass. Regarding the matter from a slightly different viewpoint, we may say that the rise in impedance of the speech coil at lower frequencies produces an electrical mis-match which so reduces the efficiency of power transfer from amplifier to loudspeaker that, however efficient the electro-acoustic power conversion of the system may be, constant overall efficiency cannot be obtained. The higher the magnetic flux density, the further up the frequency range does this effect extend, so that the "infinite baffle" may give disappointing results with the better class of unit. This does not, of course, mean that high efficiency in a cone unit is a bad thing, but that in some cases it is difficult to make full use of it.

It is sometimes suggested that one can never have too much electrical damping of a loudspeaker. The present case, however, appears to suggest the contrary, and in view of the general interest in the subject, it may be worth while to study the electro-acoustic system from yet another view-point.

Fig. 4(a) is a simplified electrical equivalent circuit of the acoustic system of the loudspeaker. For reasons which will appear later, the circuit elements are not placed in quite the usual order. L_U represents the cone mass plus the effect of radiation reactance, R_U the small radiation resistance (which unlike most other resistances, varies with frequency), C_C and C_U respectively the acoustic capacitance of the cabinet volume, and the equivalent capacitance of the cone suspension. R_S is a very important quantity which, nevertheless, is frequently omitted from these equivalent circuits. It represents the effect of the electrical circuit of the loudspeaker and driving amplifier reflected into the acoustic circuit of the loudspeaker in a similar way to that in which the motional impedance is transferred into the electrical circuit. At low frequencies,

$$R_S \propto \frac{B^2}{r_a + r_c}$$

where B is the flux density in the gap, r_a is the output impedance of the driving amplifier (assumed resistive) and r_c is the d.c. resistance of the speech coil. Any internal frictional resistance in the cone suspension system can, for simplicity, be lumped with R_S which, together with an equivalent constant voltage generator E_S, represents the source of power.

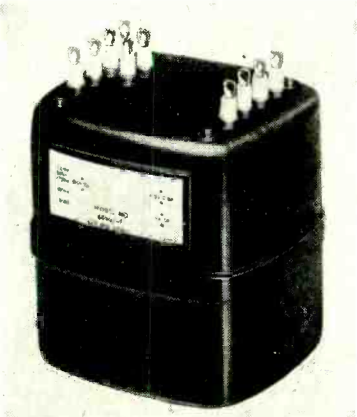
It has already been remarked that at low audio frequencies, the pressure response of the loudspeaker is proportional to the product of cone velocity and frequency. In the equivalent acoustic circuit of Fig. 4 the current I_U represents the alternating air current produced by the cone and is thus proportional to the cone velocity. Hence the acoustic response of the loudspeaker will be proportional to $I_U f$. The voltage E_{LU} is $2\pi f L_U I_U$. Thus E_{LU} is proportional to $I_U f$ and the variation in this voltage with frequency for any one value of L_U gives the frequency response of the loudspeaker. Over the frequency range for which the equivalent circuit is valid and the wavelength is large compared with the size of the cone, the loudspeaker can be reduced, as far as frequency response is concerned, to a half-section, high-pass filter working into open circuit. Small values of R_S, resulting from low flux density or high amplifier output impedance give a resonance peak and bad transient response, while large values of R_S, corresponding to high flux density and low amplifier output impedance can give a serious loss of bass.

The range of possibilities is illustrated by the three curves shown in Fig. 5, showing the variation of E_{LU} for a resonance frequency of 45 c/s with different values of R_S. Curve 3 will be recognised as approximating to the curve of Fig. 1(b), and it will be seen that when standing wave effects are disposed of, the response of the loudspeaker approaches the form predicted by simple theory. Curve 3 corresponds to a Q of 0.46, only slightly less than the figure of 0.5 required for critical damping. Whether critical damping is really necessary is another matter, to which we shall have occasion to refer later; but in the meantime it should be noted that this condition can only be achieved at the expense of a drooping frequency characteristic.

(To be concluded)

Standardized Components

THE Admiralty announce that their range of hermetically sealed transformers and chokes are the first type to qualify as fully Inter-Service Type-Approved Standards. The design comprises "C" core assemblies accommodated in deep-drawn steel cases, and owing to the many technical improvements which have been incorporated, the new transformers and chokes are as much as 40% smaller and give up to 50% reduction in external magnetic field compared with their counterparts using orthodox laminations.



Hermetically sealed power transformer to Admiralty design.

The contour for each size has been carefully determined to provide the maximum strength, and construction is such as to withstand the severest conditions of vibration and shock, as well as extremes of climate.

Thirty-two sizes are available covering a range of power transformers from 5-VA to 2-kVA, also a range of audio-frequency transformers and power chokes to suit all normal requirements. Thirty-one of these sizes have tapped fixing holes at each end, thus permitting upright or inverted mounting at will.

Although the design of this range is Admiralty property, it may be used freely for commercial purposes by any manufacturer who so desires. Where firms do not wish to tool the range for themselves, they can obtain supplies of cases, internal fittings, etc., from commercial sources. More than twelve firms have already taken advantage of this arrangement, and as their production increases so a greater flow of these standardized transformers and chokes will reach the home and export markets.

Pickup Input Circuits

Compensating for 78 and 33⅓ r.p.m. Recording Characteristics

By R. L. WEST, B.Sc., A.M.Brit.I.R.E., and S. KELLY

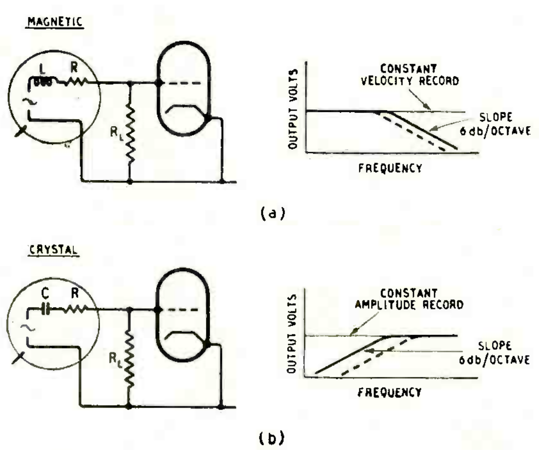
MUCH disappointment can be avoided by a simple understanding of the principles underlying the design and selection of input arrangements for standard 78 r.p.m. and 33⅓ r.p.m. long-playing records. An exhaustive treatment is not intended, but it is hoped that this article will help the beginner to avoid the commoner pitfalls.

Most pickups fall into two main types—crystal (or piezoelectric) and magnetic—the latter covering ribbon and moving coil, as well as moving-iron armature and "variable reluctance" types. Crystal pickups are always of high-impedance; they are thus suitable for more or less direct connection to a grid circuit. Magnetic pickups are sometimes wound with a large number of turns of wire to generate the relatively large voltage required for the grid circuit; this can introduce electrical resonance (of self capacity and inductance of coil) unless great care is taken in the design. For high-fidelity pickups it is normally more convenient to use fewer turns (only *one* in the ribbon) these produce very small e.m.f.'s but are capable of delivering a much larger current. Since it is voltage and not current that matters at the grid circuit a suitable step-up transformer is normally used. The following remarks assume the use of a transformer where necessary and apply mainly to the high-impedance (secondary) side.

Effect of Load.—The input impedance of a valve is usually very high compared with the generator impedance and can be neglected; the value of the grid leak will therefore be dictated by the load impedance requirements of the pickup.

Magnetic pickups have internal impedance which is principally L and R in series, whereas crystal types are principally C and R in series and R is usually very small. Fig. 1 shows the effect of load resistance and assumes constant output voltage on open circuit. In each case the dotted characteristic represents the effect of a lower value of load resistance.

Fig. 1.—Effect of resistance on output from magnetic and piezoelectric pickups.



Incidental Capacitance.—(i) *Screened lead between pickup (or transformer secondary) and amplifier.*—Again the internal impedance has to be introduced (see Fig. 2). By way of simplification the small resistive component has been omitted from the crystal case but should be included in the event of using very high cable capacities. The slight peak shown in the magnetic case is seldom noticeable since the internal R and the external R (not shown) damp it very thoroughly.

(ii) *Screened lead after the volume control.*—This is a common trap for beginners and is often overlooked by those who should know better! The Fig. 2 (c) shows the effective circuit, and the resulting top loss with intermediate settings of the volume control, which can be very considerable, particularly if a high-value volume control is used. The effect disappears as the slider approaches the "bottom end" and turns into an example of the previous type when the slider approaches the "top end." The use of a compensating condenser C_C as shown sometimes helps a little, but note that a capacity varying between C_L and $C_L/2$ is now permanently across the input, and only when the slider is half way (electrically) is the "compensation" correct! Far better, if enough gain is available, to use circuit of Fig. 2 (d). Here the very low output resistance will "swamp" the capacity of most normal screened lead requirements.

Pickup Resonances.—Low resonances, say under 1,000 c/s, include those due to the tone arm torsional resonance and the effective mass of the whole pickup resonating with the armature mounting compliance. If these are excessive within the working range, the pickup can be considered unsatisfactory, since it will be found that very heavy tracking pressures are necessary to keep the needle in the groove at these frequencies, with consequent increase in record wear. Electrical correction is no remedy.

The most noticeable high-frequency resonance is where the stylus and/or armature flexes. This ranges from about 3,500 c/s in the older pickups to well above audibility in some modern ones. The "height" of the resonance varies, from 12 db or more in the case of an undamped system, down to a barely perceptible rise if sufficient damping is added and in the right place. This is the resonance which, if within the audible range, considerably augments needle scratch. Above this resonance, the output usually falls off very rapidly (see Fig. 3a).

A simple treatment for magnetic types is to use a rather lower load than normal, and so produce top

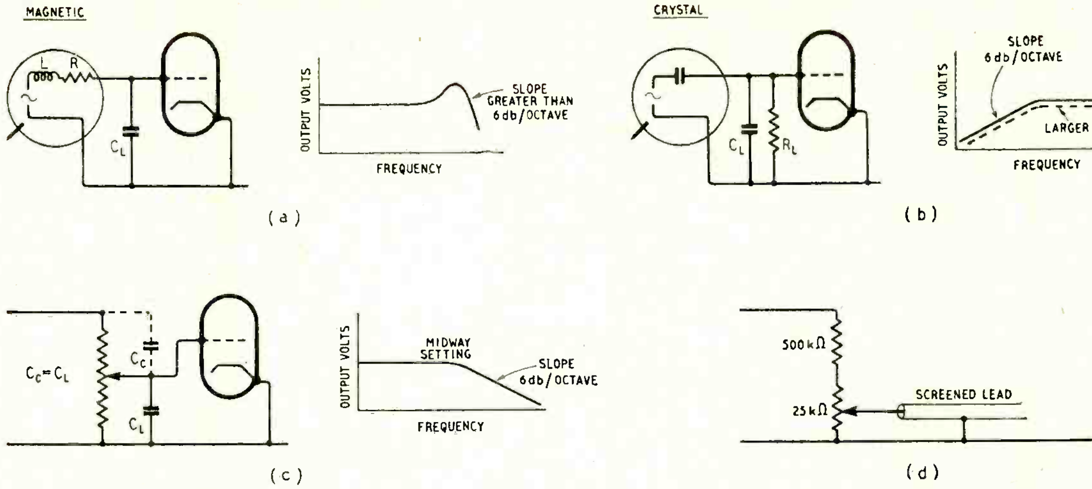


Fig. 2.—Illustrating the effect of external capacitance on the response of magnetic and crystal pickups.

attenuation at the rate of 6 db per octave. This improves the general balance—Fig. 3(b)—and assists the electromagnetic damping.

A more elaborate circuit uses a tuned series filter —Fig. 3 (c). R is seldom needed as the pickup impedance is usually sufficient. As a rule R_2 can likewise be dispensed with since there is some resistance in the inductance. It is better to over-emphasise the correction in order to reduce to a minimum surface noise due to the armature resonance. "L" can be an air-cored or dust-cored choke of between ¼ and 1 henry. An ordinary laminated core usually exhibits a marked change of inductance with signal strength at these very low operating levels.

The older crystal types usually had an overall output of the type shown in Fig. 3 (d). Here it will be seen that the overall balance is sufficiently good for average domestic use.

Results can be improved by a tuned filter, a parallel-tuned (rejector) circuit is the simplest to use. In Fig. 3 (e), "L" would be the same component as in the magnetic case.

Choice of Load.—In general, the higher the load resistance, the greater the voltage developed by the pickup. For magnetic types the load can be several megohms if the top resonance frequency is very high, the grid circuit capacitance low and no top attenuation desired at this point. The makers' recommendations will have taken these factors into consideration.

For the older crystal types it is usually necessary to use a load under one megohm in order to attenuate the bass response somewhat—unless one is trying to get bass from a small cabinet! Values of ½ megohm to 100,000 ohms are most common.

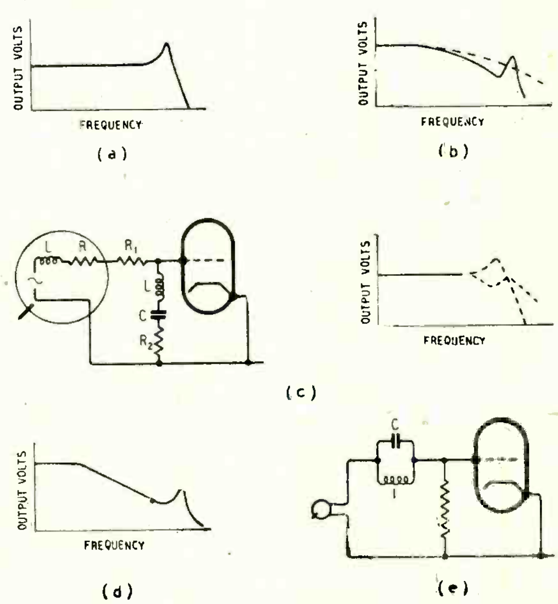
Hum—Causes and Cure.—There are two main sources of hum—by induction from an alternating magnetic field such as from the mains transformer or gramophone motor, and by electrostatic induction from wiring and components usually connected to the mains or other high voltage a.c. sources.

Magnetic hum introduced into the leads and wiring represents only a very small e.m.f., since only one complete turn is involved. This can be troublesome when a step-up transformer follows the lead in question, how troublesome depends on the transformer turns ratio and the e.m.f. generated by the pickup.

The best treatment is to twist tightly these low-impedance leads all the way from the pickup coil itself right up to the transformer input terminals. For the secondary connections, ordinary screened leads are sufficient, but it is advisable to keep all these leads as far from stray magnetic fields (including heater wiring) as possible. The transformer hum problem is dealt with later. On the high-impedance side the magnetic and crystal types experience mainly hum from electrostatic induction. The cure is simple—just plain good screening *everywhere*, and this precludes mains switches on volume controls, unless they are well shielded.

Rumble.—This consists usually of vibrations originating from the motor, with the main com-

Fig. 3.—" Top " resonances in magnetic and crystal pickups.



ponents between about 5 to 30 c/s. Magnetic pickups are seldom troubled with rumble since their output is proportional to velocity which falls with frequency for a given amplitude—hence very little output occurs at these low frequencies.

Crystal pickups, on the other hand, usually show up the motor deficiencies on this score, since the output voltage is proportional to amplitude. In a recent design (Acos GP20) a velocity type characteristic has been introduced below about 30 c/s and the trouble is considerably reduced.

Where necessary, a simple high-pass filter, such as that shown in Fig. 4, gives useful rumble attenuation without spoiling the bass response. This attenuates at 12 db/octave and gives a more rapid rate of fall at small values of attenuation than the more usual circuit, having equal capacities and equal resistances. Using the circuit shown, values of

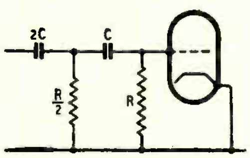


Fig. 4.—Simple " rumble " filter.

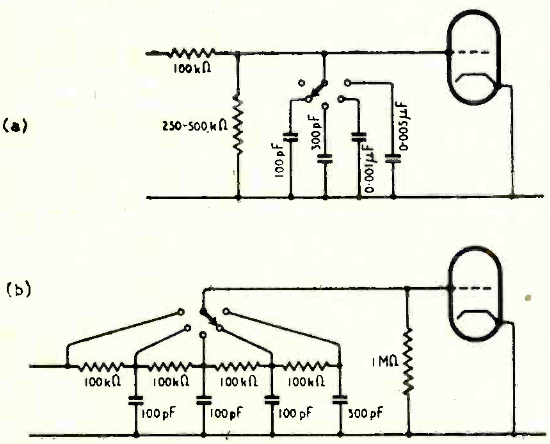
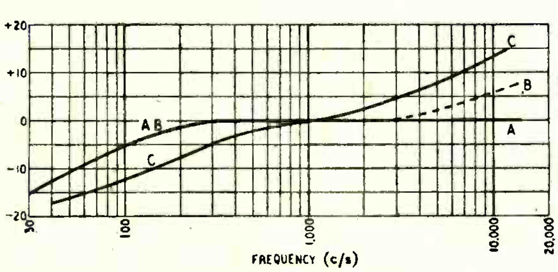


Fig. 5.—Top boost controls (a) with variable cut-off frequency, (b) with variable attenuation slope.

Fig. 6.—Principal commercial recording characteristics plotted on the basis of equal velocity at 1,000 c/s. A, standard 78 r.p.m. ; B, Decca FFRR, 78 r.p.m. ; C, Decca long playing.



C = 0.01 μF and R = 0.5 MΩ have proved satisfactory.

Pickup Transformers.—(*a*) *Step-up ratio.*—In general, as high a step-up ratio as practical is used. Suppose the grid leak-cum-load has been chosen as 1 MΩ, then the actual load on the pickup will be $10^6/N^2$ where N is the turns ratio. The larger N, the smaller is the load, so one must not make N too large by trying to increase the output voltage too far, or severe top loss will occur. If the d.c. resistance of the pickup is, say, 25 ohms, then its impedance at 1,000 c/s we know must be more than this, say 50 ohms, and the load should be much greater still, say, 100 ohms if minimum top loss is desired. This makes N equal to 100. If top loss is definitely desired N could be increased to, say, 200. This will not quite double the output voltage since the lower load will cause a larger voltage drop (at all frequencies) in the resistive component of the pickup impedance.

(*b*) *Choice of primary turns.*—For any given ratio and core, two few primary turns, i.e., low inductance, will lead to loss of bass.

At the lowest frequency involved the primary reactance must be equal to or greater than the pickup impedance or load, whichever is the larger. A rough and ready rule, which is liable to err only on the generous side is to put the same number of turns on the primary as there are in the pickup coil, be it one or many.

(*c*) *Core Material.*—In the interests of minimum distortion (due to hysteresis), at the very low signal levels involved, a nickel alloy such as Mumetal is by far the best material. Not much will be needed, a ¼-in square core section should be ample for any design.

(*d*) *Screening.*—Enclosure in any earthed metal can will look after the electrostatic component. From the magnetic point of view the best method is to select a spot as far as possible from the mains transformer, smoothing choke and motor. Use a Mumetal can, which should be earthed, care being taken to prevent the transformer core from touching the can, and remembering that the magnetic properties of Mumetal deteriorate if the material is stressed by cold working in any way. Any residual (magnetic) hum can be reduced by orienting the transformer in the can, or the can as a whole. In severe cases, a second Mumetal can, to enclose without touching the first, may be necessary.

Mechanical Feedback.—On occasions, when the loudspeaker is in the same cabinet as the turntable, mechanical feedback will occur when the pickup stylus is in contact with the record. This is usually due to flimsy cabinet construction or to attempting a very large low-frequency output. Each case must be treated on its merits, but trouble of this nature emphasises the desirability of a separate speaker. When this is not practicable cases may be dealt with by rubber or felt mounting for the whole baseboard, stiffening the baseboard, tightening or slackening slightly the motor mounting, or even reducing the bass response at the extreme low frequencies.

Simple Pickup Measurements.—Very little apparatus is necessary to carry out useful checks on frequency characteristics. A standard frequency record, preferably the type with bands of fixed frequency ranging from, say, 30 c/s up to 14,000 c/s or more, a fixed resistor of 5 to 10-watt rating equal to the nominal speaker load, an a.c. voltmeter (rectifier type) of range 0 to 5 V or 0 to 10 V.

Most modern amplifiers employ sufficient feedback to be virtually flat over the audio range, so, with a resistive load in place of the speaker and the voltmeter across that, they make a very nice valve voltmeter, provided the volume control is not disturbed after the initial setting.

A response curve can then be obtained quite easily by converting voltage ratios to the voltage at, say, 1,000 c/s into decibels by the usual formula: Decibels = 20 × log. ratio—or by referring to decibel tables or abacs if these are available.

Be careful not to overload the amplifier when taking these readings. Knowing the maximum power output of the amplifier and remembering that Watts = V^2R calculate the highest reading V you can allow to be seen on the voltmeter.

In the absence of an LP test record, the circuit can be checked satisfactorily using a 78-r.p.m. standard frequency record, run at 78 r.p.m. and using the correct stylus. To the readings obtained, when converted to decibels, add the bass-cut figures quoted on the record, then the final curve should look like the inverse of curve C in Fig. 6 if equalization is correct. This method is quite accurate except for the top resonance, if any.

Controls for a Pickup.—Two controls are really sufficient—a top attenuator, preferably switched in 4 or 5 stages, to cover age, origin, and condition of 78-r.p.m. records, and a changeover switch to effect the major 78—LP change. A three-position switch is useful, in the form 78—LP—Radio. The more ambitious might like to expand it to:—78 NORMAL—78 FFRR—LP—Radio, but the extra top of the Decca FFRR can be dealt with quite adequately by the normal top control.

Two top cut circuits are shown. Fig. 5(a) is the conventional one with 6 db/octave attenuation, starting higher or lower in the scale according to the capacity chosen. With the values given attenuation starts, according to the switch position, at frequencies in the neighbourhood of 10, 6 and 3 kc/s and for really bad records at about 300 c/s. Fig. 5(b) varies the slope from 5 to 20 db/octave, with a little variation of the starting point, which is in the region of 1,000-2,000 c/s.

A 78/LP changeover is suggested, rather than using the top and bass controls; this enables the changeover to be made with a single operation. Further, exact equalization of LP recordings is not possible with simple cut/boost controls, and it is in any case desirable that the whole of the variable top and bass control range should be available for special conditions.

78 r.p.m.—(i) *The recording characteristic.*—Fig. 6 shows (A and B) the two recording characteristics produced in this country in terms of velocity against frequency.

(ii) *Correction circuits.*—The magnetic types require a bass-lifting circuit of the type shown in Fig. 7(a). In reality it "attenuates-everything-but-the-bass," a matter of 10 times for both sets of values given, so that adequate gain must be available in the amplifier.

The circuit of Fig. 7(b) for the crystal type is similar in this respect. With the older crystal types it must be used with discretion, though, on account of the rather large high-note resonance. An elaboration of this circuit which was recommended for use with the Acos GP12 is shown in Fig. 8. This pickup followed closely the theoretical amplitude operation of piezo crystals.

With the later types of crystal pickup, such as the Acos GP20, the high-frequency response does not follow this law, but has an internally-compensated response which approximates to a velocity law at high frequencies when terminated by a resistive load. For those who would like to improve the response, a circuit is shown in Fig. 9.

R_1	R_2	R_3	C
100kΩ	10kΩ	≥ 500kΩ	0·05μF
200kΩ	20kΩ	≥ 1MΩ	0·03μF

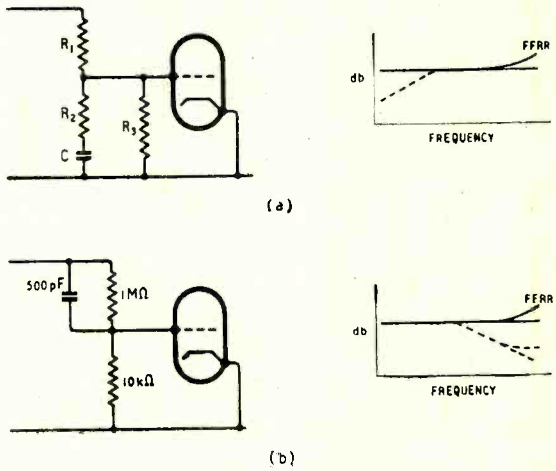


Fig. 7.—Simple compensating circuits for 78-r.p.m. recordings (a) magnetic (velocity) pickups, (b) crystal (amplitude) pickups. The dotted curves indicate voltage output before correction.

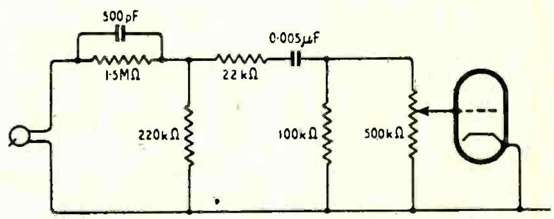


Fig. 8.—Correction circuit for the Acos GP12 pickup on 78 r.p.m. records.

Fig. 9.—Correction circuit for Acos GP20 pickup on 78 r.p.m. recordings.

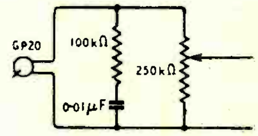
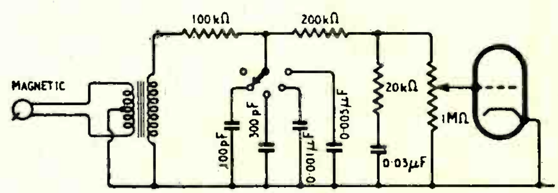


Fig. 10.—Complete compensating circuit (78 r.p.m.) for magnetic (velocity) pickups.



None of these circuits include top correction for the difference between standard and FFRR characteristics, but this will be covered by the suggested top control.

A complete circuit for a magnetic pickup is shown in Fig. 10, and for an Acos GP20 in Fig. 11. This latter includes the anti-rumble circuit of Fig. 4.

Long-playing (33⅓ r.p.m.).—The successful adaptation of standard pickups for microgroove recording is dependent on the recognition of several factors. If the pickup will not track standard 78-r.p.m. test recordings satisfactorily at 14 grams or less, it is improbable that the same pickup (with a correct radius stylus, of course) will track long-playing records at 7 grams. The tracking problem is not only important at the low frequencies, but also at the extreme high frequencies, where the velocity of the microgroove recording approaches that of the standard record, although the tracking weight of the pickup is considerably less and mechanical impedance of the armature is rising rapidly.

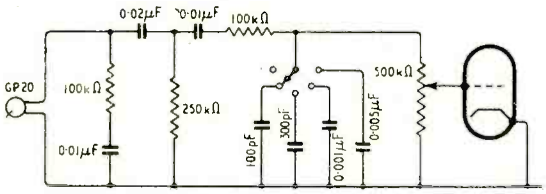
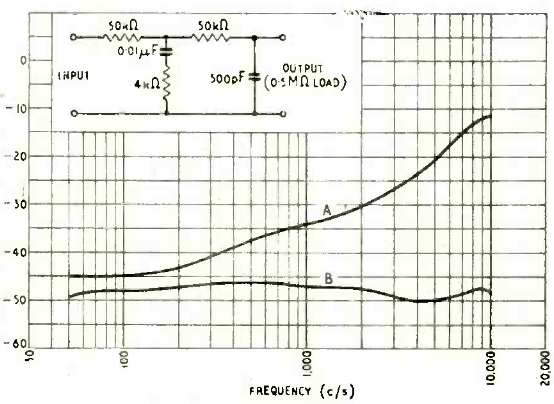


Fig. 11.—Complete compensating circuit (78 r.p.m.) for Acos GP20 pickup.

Fig. 12.—Output of high-impedance Decca Model D2 (3-pin type) moving-iron pickup on 33⅓ r.p.m. test record ; A, without correction ; B, with equalizer circuit shown inset.



Assuming, however, that the pickup is satisfactory in this respect, there is no reason why it should not give satisfactory results on microgrooves, providing it is correctly equalized. It should be noted that the effective resonance frequency of the armature system is usually decreased by about half an octave on microgroove compared with standard records, so that if any resonance is at all apparent in the upper register on standard records it will, in general, be more prominent and at a lower frequency on microgrooves.

Frequency correction.—As examples, two high-fidelity magnetic pickups and a similar type crystal pickup are presented herewith. The open-circuit response characteristic of the Decca Model D2, 3-pin type, magnetic pickup is given in Fig. 12(A). It will be seen that this response, in the mid and lower registers, approximates to the recording characteristic, Fig. 6(C), but in the higher frequencies rises rather more steeply because of the lowered resonant frequency of the armature system. The electrical network, shown inset, corrects the response of the pickup and gives the overall response shown in curve B. Although this final response is not in the "straight line from d.c. to infinity" beloved by the pedants, it is well within ±2 db. The components in question were radio-tolerance units. It may be pointed out that the 500 pF terminating condenser and the 4,000-Ω resistance may have to be varied with individual pickups to get a satisfactory balance between the middle and upper frequencies. This equalizer has been successfully used with a variety of pickups of up to 5,000 ohms impedance (connected direct or taken on the secondary of the coupling transformer) which normally require a load resistance of quarter to half megohm.

The best of the moving-coil pickups show a resonance of at least 20 kc/s on standard 78-r.p.m. records and even when played on microgroove records the resonance is seldom lower than 15 or 16 kc/s and the pickup response is very nearly that of the record. With care the low-frequency resonance can be below 30 c/s and the low-frequency response will also be

Fig. 13.—Low-impedance Leak moving-coil pickup and transformer on 33⅓ r.p.m. test record ; A, without correction ; B, with equalizer circuit.

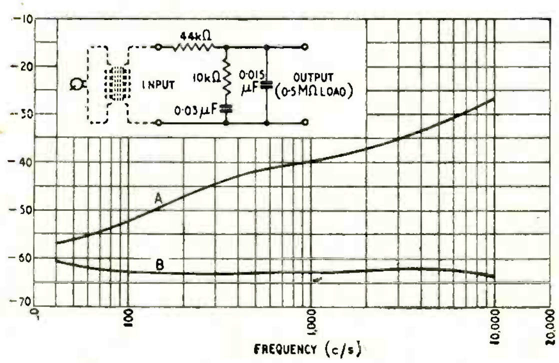
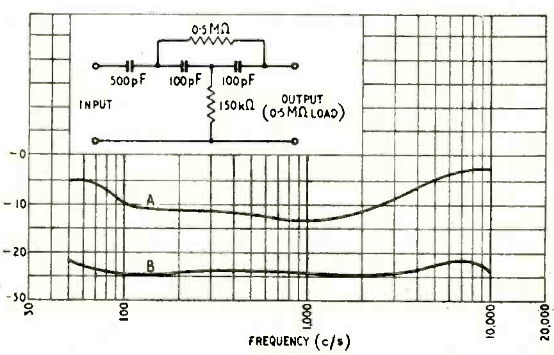


Fig. 14.—Cosmocord GP20 crystal pickup on 33⅓ r.p.m. test record ; A, without correction ; B, with "bridged T" equalizer circuit.



very nearly that of the recording characteristic. The Leak moving-coil pickup and its transformer are shown as being representative of this type of instrument. The open-circuit response is given in Fig. 13(A); when connected with the appropriate equalizer network the response shown at B is obtained. The high-frequency "roll-off" is controlled by the 0.015-μF condenser; decreasing it to 0.01 μF will increase the 10-kc/s response by about 4db. This condenser can be adjusted to meet individual requirements. If the low-frequency end is considered excessive a condenser can be inserted between the transformer secondary and the 44,000 Ω resistor. A value of 0.25 μF will give a reduction of about 6 db at 50 c/s. The "roll-off" at low frequency can be adjusted to suit conditions by varying the value of this condenser, lower values increasing the attenuation.

The case of the crystal pickup is shown in Fig. 14, the unequalized response being shown at A and the equalized at B. It will be seen that a modified "bridged T" network is used, and, within reason, the equalizing is independent of the pickup impedance. In all cases the terminating resistance should be 0.5 MΩ. If the input impedance of the amplifier is other than this value, a simple potential-divider matching arrangement should be used.

It may be found, especially with cheaper type turntables or units that have been modified from 78 r.p.m., that motor rumble is excessive. Should this be the case, the high-pass filter unit described earlier may be used successfully, but should be connected between the equalizing unit and its load resistance.

In conclusion, the authors are indebted to Messrs. Decca Radio and Television, Cosmocord and H. J. Leak & Company for information regarding characteristics of records and pickups.

SHORT-WAVE CONDITIONS

October in Retrospect : Forecast for December

By T. W. BENNINGTON (*Engineering Division, B.B.C.*)

DURING October the average maximum usable frequencies for these latitudes increased very considerably during the daytime, and decreased considerably during the night. These variations were in accordance with the normal seasonal trend.

Daytime working frequencies for long-distance communication were fairly high, though not so high as had been expected. The 28-Mc/s band was sometimes, but not often, usable to the U.S.A., though it was frequently usable in more southerly directions. The failure of the working frequencies to increase as much as was expected was probably due, in part, to the large amount of ionospheric disturbance, and in part to the rapidly decreasing solar activity. Night-time working frequencies were also low, being generally below 9 Mc/s. There was a small decrease in the rate of incidence of Sporadic E, and not much communication on high frequencies occurred by way of this medium.

Sunspot activity was, on the average, slightly higher than during September, but the general level has now fallen by well over one-third since sunspot maximum.

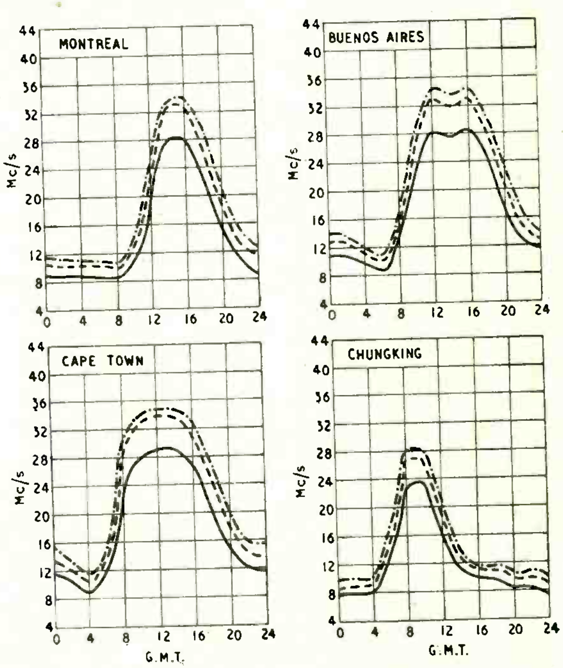
Several severe ionospheric storms occurred during the month, the most disturbed periods being 1st to 8th, 14th to 18th, 23rd to 24th and 28th to 31st. No Dellinger fade-outs have, as yet, been reported.

Forecast.—There may be a small decrease in the daytime m.u.fs for these latitudes during December, as compared with those for November. Night-time m.u.fs should also decrease and perhaps reach their lowest values for the present winter season.

As a result of these variations, the long-distance working frequencies should be rather high by day, though the higher frequencies will be usable only for relatively short periods daily. It is doubtful whether 28 Mc/s will be regularly usable over most circuits, though it may well be so on those running in southerly directions. The medium-high frequencies will provide the main means of daytime communication in most directions, and at night 6 to 7 Mc/s should be the highest regularly usable frequencies.

Sporadic E is not likely to be very prevalent and medium-distance communication on high frequencies by way of this medium should be very infrequent. Ionospheric storms are not, as a rule, particularly common during December, but those which do occur are likely to be troublesome, particularly at night.

The curves indicate the highest frequencies likely to be usable over four long-distance circuits during the month.



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

- - - - - PREDICTED AVERAGE MAXIMUM USABLE FREQUENCY

—·—·— FREQUENCY BELOW WHICH COMMUNICATION SHOULD BE POSSIBLE FOR 25% OF THE TOTAL TIME intermediate frequency slightly. If it is increased to 80 kc/s, the sharpest sections in the high-frequency filter become 1.09 $\left(\text{i.e., } \frac{1{,}500 \text{ kc/s} + 160 \text{ kc/s} - 5 \text{ kc/s}}{1{,}500 \text{ kc/s} + 10 \text{ kc/s}}\right)$ while the sharpest sections in the intermediate frequency filter are correspondingly reduced to 1.047 $\left(\text{i.e., } \frac{80 \text{ kc/s} + 9 \text{ kc/s}}{80 \text{ kc/s} + 5 \text{ kc/s}}\right)$. However, as will be seen below, this process should not be carried too far as the very sharp filter sections become relatively inefficient.

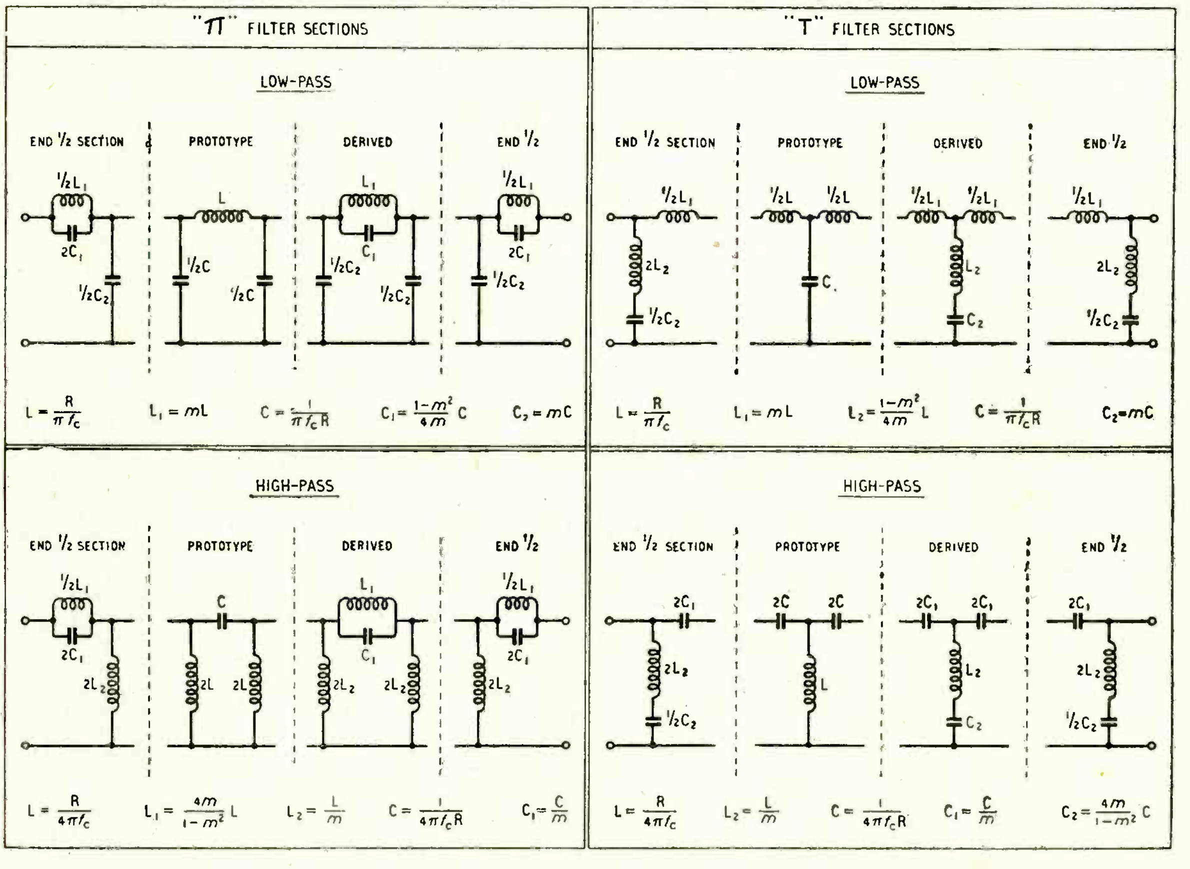
Considering now the actual filter sections available, the filters can be built in the form of high- and low-pass filters in tandem, the former having a lower cut-off frequency than the latter. Taken together, they jointly form a bandpass filter. This arrangement, although requiring a few more components than conventional bandpass filters, is preferable as the component values are in general much more convenient.

The sections we can use are tabulated in Fig. 12, together with the relevant formulae for calculating component values expressed in terms of R the terminal impedance of the filter, f_c the cut-off frequency, and a term m. The latter term is evaluated by the formula $m = \sqrt{\frac{a^2 - 1}{a}}$ where a is the ratio of the frequency of maximum attenuation to the cut-off frequency of the filter section. We can use either the "π" form of the section of the "T" form, whichever is the more convenient. As we want to keep the variable condensers down to a minimum, we shall in general use the "T" form of the low-pass filter and the "π" form of the high-pass filter.

In each case there are two main sections, the prototype sections and the derived sections. (In each case the filter ends in half a derived section.) The prototype section begins to attenuate at the cut-off frequency and continues with steadily increasing attenuation all the way to infinite frequency in the case of the low-pass filter (or to zero frequency in the case of the high-pass filter). The derived sections, however, are arranged to give their maximum attenuation at some frequency between infinite frequency (in the case of the low-pass filter or zero frequency in the case of the high-pass filter) and cut-off frequency. Between these limits we can make the frequency of maximum attenuation of a derived section what we like, and we describe the section by the ratio of this frequency to its cut-off frequency in the case of the low-pass filter or the inverse in the case of the high-pass filter. This ratio is usually known as the "a" of the sections and a is always greater than 1. (We can, in fact, now describe the prototype section as being merely a special case of the derived section where a = infinity.)

The attenuations obtainable with sections having various values of a are shown in Fig. 13 where f_c is the cut-off frequency. In these curves it is assumed that the coils used have a ratio of reactance to resistance (Q) of 100 which should be quite practical at

Fig. 12. Filter design formulae.



these frequencies. (The coils should be either wave-wound or wound on dust cores using formers with at least four slots in order to keep down their capacitance.)

The characteristic impedance of various sections—by which is meant the impedance looking into such a section when terminated with an infinite train of similar sections—will vary with frequency, and only equals the value R at zero frequency in the case of the low-pass and at infinite frequency in the case of the high-pass sections. For all values of a the derived sections quoted in Fig. 12 have the same characteristic impedance as the prototype sections, and therefore the two types can be connected together without introducing any impedance mismatch. But the mid-section impedance of a derived half-section, when correctly terminated with its characteristic impedance, will not be equal to the characteristic impedance of the whole section, but will vary with a as is shown in Fig. 14 where the mid-section impedance is expressed in relation to R. For certain values of a around 1.25 the ratio is constant over a large portion of the pass band of the filter. Such a half-section is therefore very useful for terminating a filter, as its mid-section impedance is approximately a constant resistance.

An inspection of the curves of Fig. 13 shows the relative inefficiency of the sections having low values of "a," for not only do they put in less attenuation at their resonant frequency but they require to be used in conjunction with other sections of higher value of "a" if the filter is to maintain its attenuation in the stop range. For instance, it becomes necessary to follow a section having $a = 1.02$ by a section of $a = 1.09$, if the attenuation is to be maintained beyond the cut-off frequency. Similarly, a section of $a = 1.09$ will require to be followed by a section having an "a" of about 1.6 and so on. There are, of course, an infinite number of values of "a" which might be chosen, but as it is impossible to give a complete set of filter tables in an article such as this, the above values for "a" have been chosen as being representative. These particular values are advantageous because $a = 1.02$ gives $m = 0.2$, $a = 1.09$ gives $m = 0.4$, while $a = 1.6$ gives $m = 0.8$. As these three values of "m" are each double the previous value, it will be seen from the formulae given in Fig. 12 that using such values there will be a great deal of similarity in the component values of the various sections. Similarly $a = 1.06$ gives $m = 0.33$, $a = 1.35$ gives $m = 0.66$ and $a =$ infinity gives $m = 1$, and again using these sections together we may expect to get a certain similarity in component values.

A further inspection of the formulae in Fig. 12 will reveal that in the formulae for the prototype low-pass filter

$$L = \frac{R}{\pi f_c} \text{ and } C = \frac{1}{\pi f_c R}$$

Eliminating R we get,

$$LC = \frac{1}{(\pi f_c)^2} \text{ or } f_c = \frac{\sqrt{LC}}{\pi} \quad \ldots \quad \ldots \quad (1)$$

From this we see that we can vary the cut-off frequency by altering either L or C or both.

Eliminating f_c we get,

$$\frac{L}{C} = R^2 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

From equations (1) and (2) we see that if we alter both L and C maintaining the ratio $\frac{L}{C}$ constant, we can

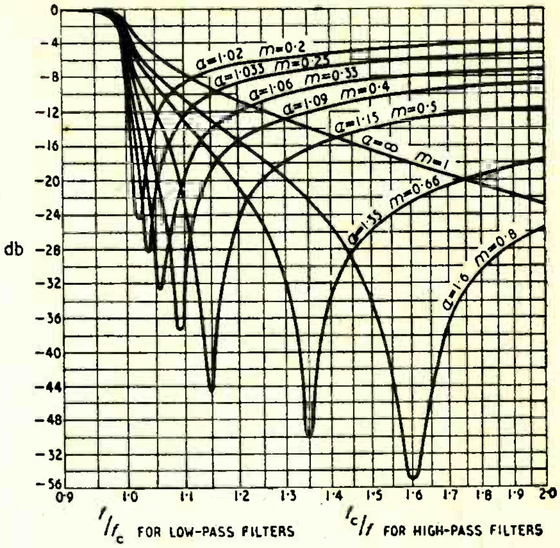


Fig. 13. Attenuation curves of typical filter sections.

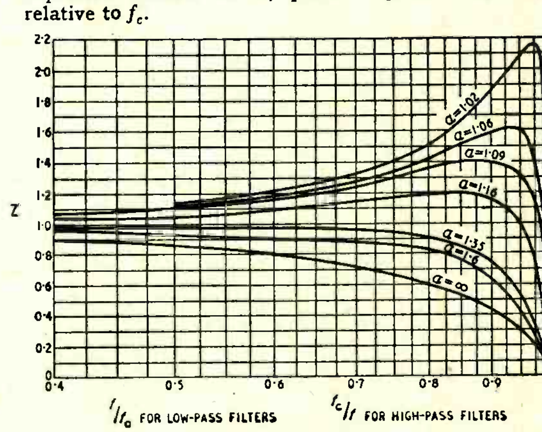
alter the cut-off frequency of the filter and at the same time keep R constant, and this is, in fact, what is generally done.

If, however, we are prepared to let the value of R vary according to equation (2), then by equation (1) we can vary the cut-off frequency by altering either C or L. In practice it is easier to alter C, as ganged condensers are readily available commercially.

Considering the medium-wave band, the frequency range is from about 600 kc/s to 1,500 kc/s, or a ratio of 2.5. By equation (1) this will require a change of L or C by 2.5^2 and this in turn will cause R to alter by a ratio of 2.5. To be absolutely correct we could make the termination of the filter a variable resistance and adjust it to the right value for the particular cut-off frequency. In practice this is not necessary, and if it is made a fixed resistance of $\sqrt{2.5}$ its correct value when the filter is adjusted for a cut-off of 600 kc/s, then the error introduced is not serious and we need not worry about it.

If it is chosen to alter the cut-off frequency by varying C (keeping L constant), then the "π" type

Fig. 14. Mid-section impedance of derived sections expressed relative to R, plotted against frequency relative to f_c.



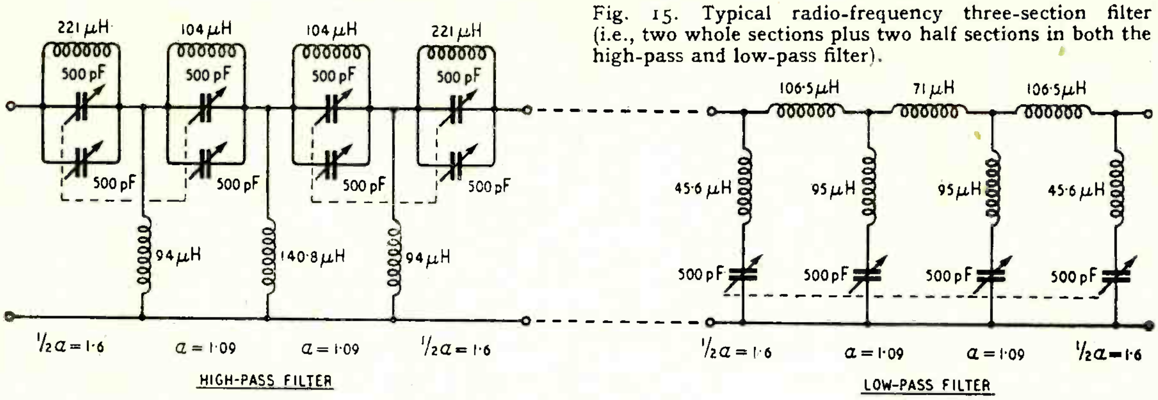


Fig. 15. Typical radio-frequency three-section filter (i.e., two whole sections plus two half sections in both the high-pass and low-pass filter).

of low-pass filter and the "T" type of high-pass filter should be avoided, as the derived forms of these sections call for two variable condensers of different value, which are not readily available in ganged form.

By way of an example, let us consider the design of a high-frequency filter with a cut-off ratio of 1.09. Using the "T" form of the low-pass filter, we can keep all the condensers to the same value if all the sections are derived and the half sections at the end have an "m" of double the middle sections, i.e., if the middle sections are $m = 0.4$ ($a = 1.09$) and the half sections at the end are $m = 0.8$ ($a = 1.6$), then all the condensers in the filter are 0.4 of the value of the condenser in the prototype section, which is

$$C_{lp} = \frac{0.4}{\pi f_{lpc} R} \quad \ldots \quad (3)$$

where f_{lpc} is the cut-off frequency of the low-pass filter.

Again, using the "π" section of the high-pass filter, we can keep all the condensers in the filter to the same value if all the sections are derived and if the half sections at the end have an "m" of double the middle sections. Again, using $m = 0.4$ ($a = 1.09$) for the middle sections and $m = 0.8$ ($a = 1.6$) for the half sections at the end, the condensers are $\frac{1}{0.4}$ of the condenser for the prototype section, which is

$$C_{hp} = \frac{1}{4\pi f_{hpc} R} \times \frac{1}{0.4}$$

$$= \frac{1}{1.6\pi f_{hpc} R} \quad \ldots \quad (4)$$

where f_{hpc} is the cut-off frequency of the half-pass filter.

Bearing in mind (Fig. 3 of previous instalment) that we required f_{hpc} to be 0.8 of f_{lpc}, we get

$$C_{hp} = \frac{1}{1.6\pi\, 0.8 f_{lpc} R}$$

$$= \frac{0.8}{\pi f_{lpc} R} \text{(approx.)} \quad \ldots \quad (5)$$

From the above it will be seen that we have now got all the condensers in the low-pass filter the same and all the condensers in the high-pass filter equal to and double the value of those in the low-pass filter. This was another important reason in the choice of these particular values of "a" as it means that standard condensers can be used throughout, the only difference between high- and low-pass filters being that each condenser in the former is built by putting two condensers in parallel.

The above completes the design considerations for the high- and low-pass filters except to give an idea of practical values. If a commercial $0.0005\mu F$ ganged condenser is made the basis of the design, then putting $C_{lp} = 0.0005\ \mu F$ when $f_{lpc} = 600$ kc/s in equation (3), we get R = 400 ohms at 600 kc/s.

As already explained, a

Fig. 16. Calculated characteristic of radio-frequency filter as in Fig. 15 for position where all variable capacitors are set to $0.0002\mu F$.

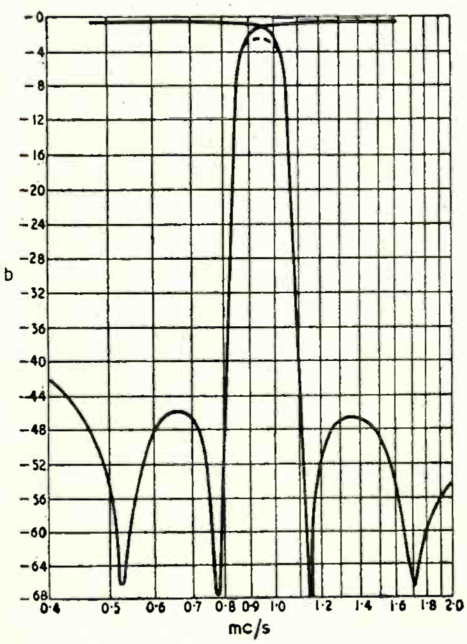
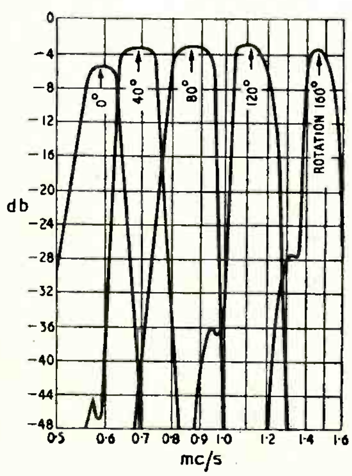
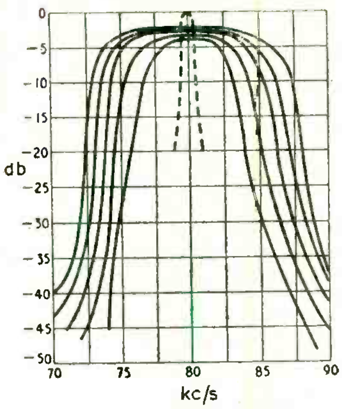


Fig. 17. Measured attenuations for various capacitor settings of radio-frequency filter as in Fig. 15.





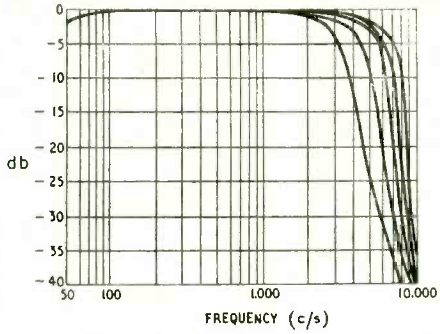


Fig. 19. Overall a.f. response of the receiver for various positions of the variable i.f. filter.

Fig. 18. Measured characteristics of variable intermediate-frequency filter for various capacitance settings.

suitable mean terminating resistance would be this value multiplied by $\sqrt{2.5}$, i.e., 650 ohms.

The circuit of the above filter is given in Fig. 15, its calculated characteristic is given in Fig. 16 and its measured characteristic at various points on the medium-wave band is given in Fig. 17.

The above is a typical r.f. filter. The i.f. filter follows on similar lines but from consideration of component values and in order to work at a suitable intervalve impedance, it is designed with a characteristic impedance of 12,000 ohms. In addition the condensers are not made completely variable, but consist of a fixed portion and a 10 per cent variable portion: further the variable portions in the high- and low-pass sections of the filter are connected in opposition in such a way that the cut-off frequency of the one rises as the other falls and finally the ratio of the high- and low-pass variable condensers is chosen to be such that for any movement of the condensers both filters change their cut-off frequency by the same amount in cycles per second.

Overall A.F. Response

The measured characteristic of this filter for various positions of the condenser shaft is shown in Fig. 18. (The dotted curve represents the characteristic of a sharply-tuned circuit which is in the "magic eye" circuit and enables the receiver to be tuned to the centre of its i.f. characteristic—an important requirement in such a receiver as this.) The audio-frequency response of the receiver for various positions of the i.f. condensers is shown in Fig. 19.

In its simplest form the practical design of such a receiver is shown in Fig. 20 which is a back view. It contains five sub-chassis namely :—

(1) The decoupling resistor and condenser assembly.
(2) The valveholder assembly.
(3) The r.f. filter assembly.
(4) The screened coils assembly.
(5) The i.f. filter assembly.

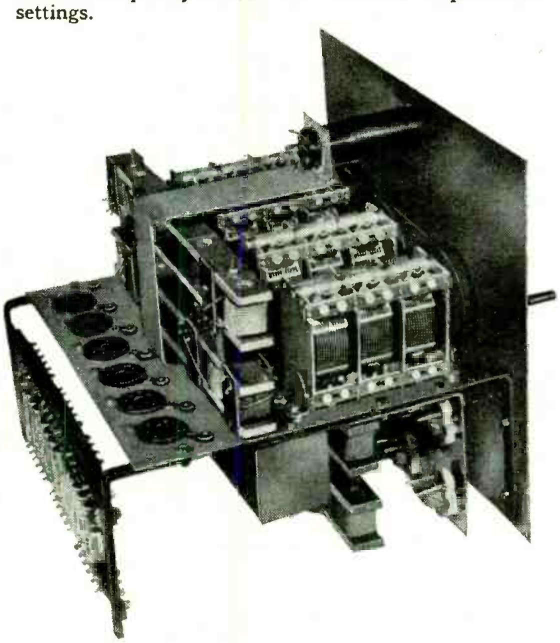


Fig. 20. Practical layout of a filter-tuned receiver as seen from the back.

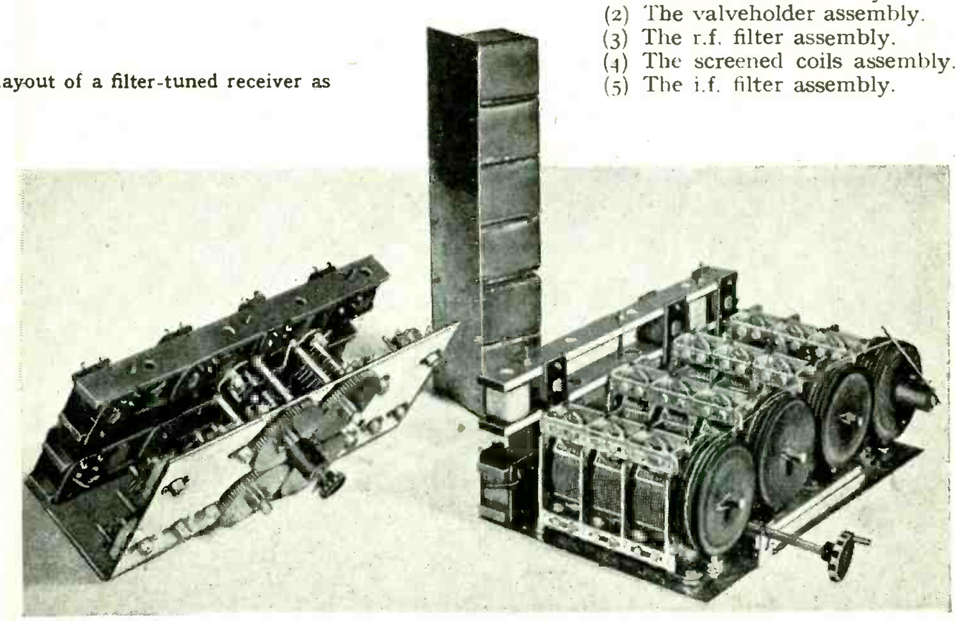


Fig. 21. The three main assemblies. (Left) the i.f. filter, showing the ten fixed capacitors (air-spaced trimmers are used for convenience) and the eight variable condensers (four "split stator" condensers were used for convenience) connected by gears. (Centre) the screened coil assembly and (right) the r.f. filter showing the wire and drum drive.

The last three assemblies are shown removed in Fig. 21 which indicates the method of ganging the condensers in the r.f. and i.f. filters. In the former case a wire and drum drive is used, and as two of the condensers are above earth potential they are mounted on a sheet of Paxolin and the drums are made of ebonite: no difficulty is experienced in ganging the condensers if the grub screws in the drums are tightened when all the condensers are maximum. The condensers are not likely to get out of gang if suitable wire is used, but if they should they can quickly be re-ganged by slackening off the grub screws, setting all the condensers to maximum and then retightening the screws.

In the case of the i.f. filter, air dielectric trimmers have been used for the fixed portion of the capacitances and the variable portions are coupled together by means of gears, though a wire and drum drive could equally well have been used.

Space has precluded giving complete details of the receiver design but it is hoped that enough has been given to show the general lines of approach. The resulting receiver has much to recommend it, particularly its relative freedom from noise and its variable i.f. filter, which can be adjusted continuously and without introducing clicks or noise of any kind until the best position is found. It is, however, a complicated design and cannot be built without adequate test equipment. Furthermore, when built it is still only a compromise solution. In the author's opinion, it is the best compromise possible in modern listening conditions.

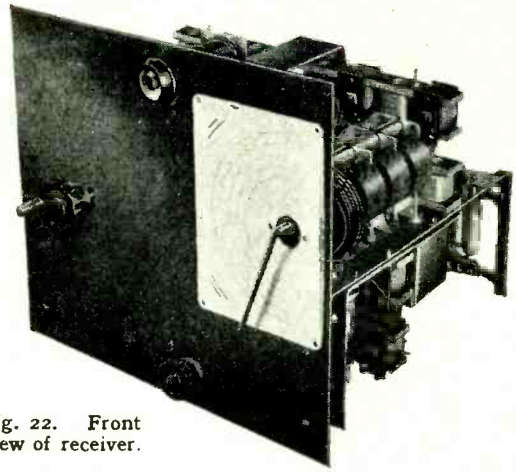


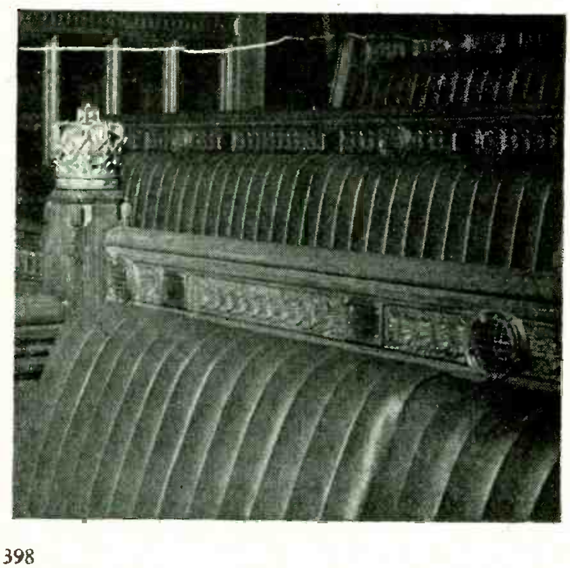
Fig. 22. Front view of receiver.

HOUSE OF COMMONS S.R.E.

APART from the general interest in the sound reinforcing system in the new Chamber of the House of Commons this low-intensity installation is of particular interest in that it has been designed to ensure that all members can hear and, if desired, be heard without having to leave their seats.

To achieve this a large number of low-intensity loudspeakers have been installed in the woodwork at the back of the seats—one unit for two members—and six uni-directional microphones have been suspended from the ceiling over the front benches and three each side, mounted on cantilever arms, over the back benches. The selection of the microphones during debates and the general supervision of the installation is undertaken by an operator in a cubicle overlooking the chamber.

Loudspeakers behind bronze grilles in the carved oak rail above members' seating in the new House of Commons.



To obviate "howl" caused by acoustic feedback when microphones and loudspeakers are in close proximity, the reproducers are arranged in groups which are co-related with the pick-up area of the microphones. When a microphone is brought into circuit the reproducers in the immediate vicinity are muted and in certain cases the input to those in adjacent areas is attenuated.

The main equipment comprises fourteen microphone pre-ampifiers with stand-by units. After pre-amplification, frequency and volume correction, the signals are passed through a "buffer" amplifier to raise the level sufficiently to energize the power amplifiers. There are eighteen of these, plus spares, and each one provides power for one loudspeaker zone, the input to which is connected through two relays and attentuators to provide, automatically, the correct degree of muting or volume reduction associated with the microphone employed in each particular zone. Separate amplifiers are provided for operating db volume indicator meters, which provide visual indication of output signals at the main operating position and at the alternative control position below the floor of the House. A periscope is provided at this position to enable the operator to view the chamber and select the appropriate microphone.

In addition to the microphones and loudspeakers already referred to there is a microphone above the Speaker's chair and another on the Table of the House. It should be pointed out that the reproducers on the tables in the Press Gallery and in other galleries are operated at a constant level.

The entire installation was undertaken by Tannoy Products (Sound Rentals, Ltd.).

WORLD OF WIRELESS

International Vision Standards ♦ Short-Wave Broadcasting ♦ R.T.E.B. Exam. Results ♦ Training Opportunities ♦ Television Relay Service

European Television

DETAILS of the standards drawn up by the Television Study Group of the International Radio Consultative Committee (C.C.I.R.), following the investigation of systems at present in use in France, the U.S. and the U.K., have been published by the European Broadcasting Union, and we give below a summary of them:—

The width of the channel is to be 7 Mc/s (U.S. standard is 6 Mc/s and the British 5 Mc/s) with the vision carrier 5.5 Mc/s below the sound carrier—in this country, of course, it is 3.5 Mc/s below.

There are to be 625 lines per picture with interlaced scanning. The line and frame recurrence frequencies are 15,625 c/s and 50 c/s, respectively. The British line frequency is 10,125 c/s. The aspect ratio of the picture is that now used in this country—4:3, horizontal to vertical.

The lower sideband of the vision channel is to be partially suppressed, and, as in the U.S., negative modulation will be used. The pedestal level (normal black level) will be represented by a definite carrier level independent of light and shade in the picture, and this will be transmitted at 75 per cent—with a tolerance of $\pm 2\frac{1}{2}$ per cent—of the peak carrier amplitude. Peak white will be at least 10 per cent of the full carrier amplitude.

It is recommended that frequency modulation be used for the sound transmission. No reference is made in the recommendations to the polarization of the transmissions.

H.F. Broadcasting

WHEN the Hague Radio Conference, due to have opened in September, was called off (see page 318, September issue) the delegates to the International High-Frequency Broadcasting Conference, which had been in session, first at Florence and then Rapallo, since April 1st, decided by 39 votes to 13 (with 4 abstentions) to conclude their deliberations. This was on August 19th. The main reason for discontinuing all work on preparing a plan for h.f. broadcasting was that such a plan, based on the new bands allocated at Atlantic City (1947), could be implemented only if another Conference, such as that planned for the Hague, made available other frequencies to the services at present occupying these bands.

The Conference was convened to draw up plans for the allocation of frequencies (between 5.95 and 26.1 Mc/s) to the world's short-wave broadcasting stations on the basis of time sharing and simultaneous channel sharing. These plans were based on the various phases of the sun-spot cycle.

Being unable to produce the plan envisaged, the Conference, at its final meeting, made a number of recommendations which are included in the September 15th issue of the European Broadcasting Union *Bulletin*. To encourage the use of the higher frequencies for broadcasting and thereby reduce the congestion in other sections of the h.f. band, it is recommended that the frequency coverage of receivers should be extended to include the upper limits of the band.

Servicing Examinations

THE result of the first Television Servicing Certificate examination held last May by the Radio Trades Examination Board, which was restricted to the London area, shows that of 30 entries 16 passed and 12 were referred in the practical examination. Of the 264 candidates who entered for the Radio Servicing Certificate examination, also held in May, 137 were successful and 45 were referred in the practical tests.

Application forms for the next examinations, to be held in May, 1951, may be obtained from the R.T.E.B., 9, Bedford Square, London, W.C.1. The closing date for entries for the Television Certificate is January 15th and that for the Radio Certificate is February 1st.

Frequency Control

THE need for a simple method of quoting frequency stability was stressed by C. F. Booth, the new chairman of the I.E.E. Radio Section, in his inaugural address on "The Evolution of Frequency Control." A proposed method, that he felt was worthy of consideration, is to express frequency stability in terms of the common logarithm of the reciprocal of the frequency variation when the latter is expressed as a fraction; for example, an oscillator subject to frequency variations of 1 in 10^6 would have a stability of 6 stability units, or, say, 6 S.U.

Technical Experience Abroad

OF the 1,672 University and College students who, through the International Association for the Exchange of Students for Technical Experience, gained experience in industry overseas during the summer vacation this year, 353 were from Great Britain, 204 from France, 197 from the Netherlands and 184 from Sweden. Twelve countries, including, for the first time, the U.S.A. and Germany, took part in the exchange scheme. Great Britain and Sweden headed the list of countries receiving students with an intake of 368 and 344 respectively.

The third Annual Report of the Association records that there was an increase of 436 on the exchanges made in 1949. About a dozen British radio firms received overseas students under the scheme.

Particulars of the Association, which, it is stressed, organizes these exchanges on a reciprocal basis, are obtainable from the General Secretary, J. Newby, Imperial College, South Kensington, London, S.W.7.

B.B.C. Changes

FOLLOWING the much-talked-of resignation of Norman Collins as Controller of B.B.C. Television, the politics of which we will not enter into, George Barnes, who has been B.B.C. Director of the Spoken Word since the creation of the post in 1948, has been appointed to the new post of Director of Television. Norman Collins has stated that he has left the Corporation because of the principle which was being adopted in the development of television—its merger "into the Colossus of sound broadcasting."

T. W. Chalmers, Controller of the Light Programme, has been seconded for three years to become head of the new Nigerian Broadcasting Service (see "In Brief") and has been succeeded by Kenneth Adam.

Electronics Scholarships

TO meet the growing need for technicians in the research and design sections of E.M.I. a scholarship scheme for a special four-year course in electronics has been provided by E.M.I. Institutes.

The scheme provides for a grant of £50 p.a. to each successful applicant towards the £400 course and a maintenance grant of at least £50 p.a. Candidates, who must be between 16 and 18 years of age, and preferably of Higher School Certificate standard in science, must enter the company's service for four years after the satisfactory completion of the course.

Application forms and particulars of the course, which provides for three years at the Institute and one year's practical experience in the company's factories and workshops, are obtainable from the Principal, E.M.I. Institutes, 10, Pembridge Square, London, W.2. The first course commences on January 17th.

It is stated that, in normal circumstances, students will receive a deferment from National Service during the period of the course.

News in Morse

SINCE the publication of the schedule of the morse transmissions of the London Press Service in our May issue, a number of changes have been introduced, and we give below a revised list. In addition to the morse transmissions listed, the speed of which is between 20 and 27 w.p.m., a large number of bulletins are transmitted by Hellschreiber.

G.M.T.	Call	Freq. (Mc/s)	Areas
0030–0130§ ...	MIK	9.725	1
	GPJ	10.885	2
0045–0230* ...	MIK	9.725	1
	GPJ	10.885	2
0130–0230§ ...	MIK	9.725	1
	GPJ	10.885	2
0130–0300* ...	GDI	7.780	3
	GAH	8.065	4
0130–0300 ...	GCX	8.920	5
0945–1045* ...	GCV	19.365	6, 8.
1100–1200‡ ...	GCV	19.365	6, 8.
1115–1215‖ ...	GAG	17.105	7
1200–1300‖ ...	GCF	19.005	5
1215–1315‡ ...	GAG	17.105	7
1600–1700* ...	GCF	19.005	5
	GBI	10.865	6, 8.
1600–1800* ...	GIB	11.980	7
1700–1800‖ ...	GBI	10.865	6
1815–1930 ...	GBG	9.395	7
	GBI	10.865	6, 8.
1845–1945* ...	GIM	12.957	3
	GBO	13.665	4
1945–2215* ...	GDT	8.925	6, 8.
	GBG	9.395	7
2045–2200† ...	GBG	9.395	7
	GDT	8.925	6, 8.
2100–2200* ...	GBO	13.665	5
2251–0030* ...	GPX	11.645	1
	GPJ	10.885	2
2330–0030† ...	GIB	11.980	5

* Weekdays only.
† Sundays only.
§ Mondays only.
‡ Mondays and Saturdays only.
‖ Alternate Fridays.

The number in the fourth column of the table denotes the area for which the transmissions are destined: 1, N. America; 2, S. America; 3, Distant Europe; 4, Middle East; 5, Africa; 6, N.E. Asia; 7, S.E. Asia; 8, Australasia.

There is no restriction on the reception of these transmissions, which are radiated by Post Office stations, and the use of their contents outside the United Kingdom.

National Exhibition

THE Radio Industry Council has announced the date of next year's National Radio Show—August 28th to September 8th. As already stated, the show—the 18th in the series—will be at Earls Court, London, and not Olympia, so that the well-established title Radiolympia will not be applicable.

Greenwich Time Signal

A MEAN time signal is now being transmitted twice daily from the Royal Greenwich Observatory, Abinger Common, Surrey, in addition to the present rhythmic signal. The schedule is:—

G.M.T. h m s	
09 54 00 to 09 54 45	*Preamble*: "GBR GBR TIME" (4 times) followed by tuning dash.
09 55 00 to 10 00 00	*Mean time signal*: Seconds dots, lengthened to dashes at the minutes.
10 01 00 to 10 06 00	*Rhythmic signal*: Dots spaced 61 to the minute, lengthened to dashes at the minutes.
10 06 05 to 10 06 15	*Tuning dash.*

This sequence is repeated from 1754.

The morning transmission is radiated by GBR, 16 kc/s; GIC, 8,640 kc/s and GIA, 19,640 kc/s, and the evening transmission by GBR, 16 kc/s; GIC, 8,640 kc/s and GKU3, 12,455 kc/s.

The duration of each dot is approx. 0.1 sec, and that of the dashes at the minutes is approx. 0.6 sec. The beginning of each dot or dash is the timing reference point.

Hotel Television

A TELEVISION relay service has been installed in each of the 940 bedrooms in the Cumberland Hotel, London, W.1. The hotel was already equipped with an a.f. distribution system giving a choice of four programmes, and the same wiring is used for television.

A four-element aerial is employed on the roof of the building to minimize the pick-up of interference and its output is fed to seven amplifiers, of which one is a spare. With a maximum gain of 55 db they provide an output of 2 V r.m.s. in 75-ohm feeders.

The audio wiring of the hotel is carried out in 63 vertical ducts each feeding about 16 rooms. The r.f. television signal is fed by 75-ohm balanced cable to the tops of these ducts, each amplifier feeding 9-12 ducts. They are there connected by resistance hold-off pads to the audio wires which are used in a quad phantom circuit. A $\lambda/4$ stub is connected a quarter-wavelength beyond the junction to prevent r.f.s. passing back to the a.f. source.

Resistive stopper pads are included at the loudspeaker for the audio channel to divert the television r.f. signal to the outlet socket. Standard television receivers are used and the hotel charges 3s a night for the service.

The equipment was installed by British Relay Wireless.

Television Components

IN preparation for the expected demand for television receivers when the projected stations open in Montreal and Toronto, the Canadian Government has authorized the release of U.S. dollars to fifteen Canadian set manufacturers for the purpose of buying components in the U.S.A. Attention having subsequently been drawn to the availability of television components in the U.K., the Canadian Department of Trade and Commerce has agreed, in principle, that where practicable the components should be secured in this country. British manufacturers who are represented in the Dominion, and wish to bring their components to the notice of the Canadian set manufacturers, should send catalogues and price lists in duplicate to E. J. McWilliams, Assistant Director, Emergency Import Control Branch, Department of Trade and Commerce, Ottawa. Firms without agents in Canada may like to use the services of the Board of Trade to secure representation, in which case communications should be sent to the Commercial Relations and Export Department, Thames House North, Millbank, London, S.W.1, quoting reference C.R.E. 5902/50.

IN BRIEF

Consol.—The second edition of the Ministry of Civil Aviation publication "Consol—A Radio Aid to Navigation" (M.C.A.P. 59), which has been published by H.M. Stationery Office, price 1s 6d, contains complete details of the service and coverage of the existing Consol stations at Bushmills, Stavanger, Lugo and Seville and also of the service to be provided by the new station at Plonéis, near Quimper, Finistère (France), which will be brought into use in the near future.

Amateurs and Distress Calls.—In contrast with the facilities provided by American amateurs for a network of stations in cases of emergency, such as forest fires, floods, etc., which were tested during a recent nation-wide exercise, the Ministry of Transport has declined the offer made by the Radio Society of Great Britain for British amateurs to place themselves at the disposal of the appropriate authority for receiving distress messages from vessels at sea.

M.F. Air Navigation.—It is pointed out by the Ministry of Civil Aviation that, while every effort is made to assign to m.f. navigational facilities frequencies from the aeronautical bands (255 to 285 kc/s and 315 to 405 kc/s), it is not always possible to do so because of the congestion within those bands. Use is, therefore, made of broadcasting stations as non-directional beacons and of other non-directional beacons operating on frequencies outside the aeronautical bands but within the limits of 200 to 1,750 kc/s.

Netherlands F.M.—According to information issued by the European Broadcasting Union, the Netherlands Government is planning the erection of a network of 12 f.m. stations operating on frequencies between 92.5 and 94.7 Mc/s.

Suppressing the ignition system of motor vehicles is dealt with in one of the chapters of the fourth edition of "Automobile Electrical Equipment," by A. P. Young and L. Griffiths, which is issued by our Publishers for our associate journal *Automobile Engineer*. This 386-page book, which deals exhaustively with electric lighting, starting and ignition as applied to the internal combustion engine, costs 25s.

Multitone.—The results of investigations, using the "Optimeter," in the volume requirements of five hundred hearing-aid users are given in the article "How Loud Should I Listen?" included in the first issue of *Hearing Aid News* which will be issued at irregular intervals by the Multitone Electric Co.

Hearing Aids.—The National Institute for the Deaf has issued a booklet, No. 481, giving approved lists of manufacturers and suppliers of hearing aids in the United Kingdom. Makers of mechanical as well as electronic aids are listed and those supplying group hearing aids are indicated.

Christmas lectures "adapted to a juvenile auditory," which will again be given at the Royal Institution this year, will be on "Waves and Vibrations," by Prof. E. N. da C. Andrade, D.Sc., F.R.S. This 121st course of six lectures, the fee for which is 10s 6d for children between 10 and 17 years of age, will be given on December 28th and 30th and January 2nd, 4th, 6th and 9th at 3.

"The Use of Radar at Sea" is the provisional title given to a textbook on the operational use of marine radar, which is in course of preparation by the Institute of Navigation. The book will contain contributions by twelve authors and will deal with every aspect of the subject. This is announced in the annual report of the Institute for the year ended June 30th, 1950, in which it is reported that the membership is now over 1,100.

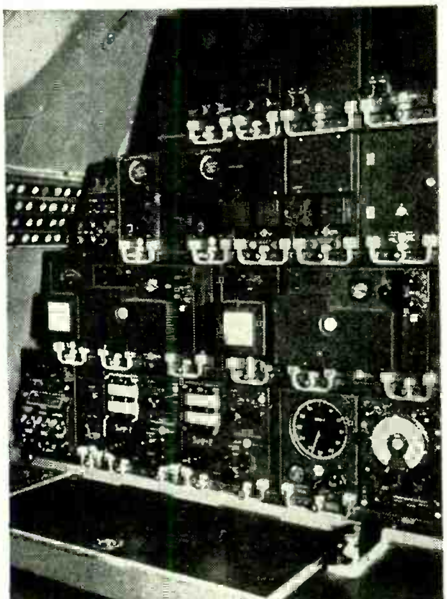
"Decca News" is the title given to the recently introduced journal of the Decca Navigator Company, which at present is issued bi-monthly. Descriptive articles on both radar and Decca Navigator installations are included.

Post-graduate Training. — Twenty-eight university graduates and technical college students recently commenced a special training course at the New Southgate Works of Standard Telephones and Cables. The course, which lasts a year and is the fourth since the commencement of the company's present post-graduate training scheme, is designed to provide opportunities for candidates to relate their theoretical and practical training to the whole field of activities within the Standard organization.

Convention Cancelled.—The Radio Section of the I.E.E. had proposed to hold a convention covering "Current Researches in Electron Valves" during the Festival of Britain, but having been advised that to hold such a convention in prevailing circumstances might not be in the National interest, it has been decided not to proceed with the arrangements.

Interference Suppression.—The television-conscious motorist who fits Lucas suppressors to his car ignition system will be easily identified by a transparency bearing the words "This car has been suppressed," which is being fixed to windscreens. At both the recent Motor Shows in London the firm demonstrated the effects on television reception of suppressed and unsuppressed car ignition systems which, according to the Radio Industry Council, are responsible for 85 per cent of the interference caused. Lucas have recently produced a prototype of a distributor incorporating a carbon brush of resistive material which acts as a suppressor.

Nigeria, which at present relies on a wired-wireless distribution system for radio programmes, is to be served by six broadcasting stations to be erected at a cost of about £350,000, which is being shared by the Nigerian Government and the U.K.



COMET RADIO.—The Marconi radio installation in the de Havilland "Comet" jet air liner. The equipment shown includes intercom. units, direction finders (duplicate control units for which are in the cockpit) and high-power transmitters.

Instrument Show.—Scientific and industrial instruments are to have an exhibition of their own in London next year. Among the supporting organizations of the exhibition, which will be held at Olympia from July 4th-14th, is the Scientific Instrument Manufacturers' Association.

Television in Industry.—The use of television to permit the remote observation of dangerous industrial processes was recently demonstrated when the English Electric Co. employed it to show the operation of high-power switch gear. Standard 405-line Marconi apparatus was used.

Blind Technicians.—The Report of the National Institute for the Blind records that an experimental training scheme has been arranged with Electric and Musical Industries to ascertain to what extent the blind can be instructed to undertake receiver repairs. This has necessitated the provision of circuit diagrams in relief and Braille-calibrated test equipment.

"Broadcast News," which is published by the Radio Corporation of America and is devoted almost entirely to descriptions of transmitting equipment for sound and vision, is now available to subscribers in this country from RCA Photophone, 36, Woodstock Grove, London, W.12. It is published at two-monthly intervals and the subscription rate is £2 for twelve issues.

Vox Populi.—The International Short-Wave Club has announced the result of a census taken among its members in all parts of the world to ascertain the most popular short-wave broadcasting station. Leopoldville (OTC) comes first with 609 votes, Radio Australia second with 446 and Switzerland third with 435, followed by Canada (419), B.B.C. Overseas Service (401), Hilversum (388), The Voice of America (380) and many other stations with fewer votes

Sound Letters—magnetically recorded messages on metallized paper tape—have been introduced by the Welfare Council of the Norwegian whaling fleet for use by the men working on the factory ship and their relatives. They are regularly flown to and from the Antarctic whaling grounds.

B.I.F.—Next year's British Industries Fair will be held from 30th April to 11th May, at Olympia and Earls Court, London, and Castle Bromwich, Birmingham.

Institute of Physics announces an increase in its membership of some 200 during 1949.

Airborne Television.—A Marconi image-orthicon camera and 30-watt "suitcase" transmitter were used by the B.B.C. for the first television broadcast from the air which was radiated from the London and Sutton Coldfield stations on October 1st.

BUSINESS NOTES

Rural Radio.—The Persian Government is considering the purchase of 50,000 radio receivers for use in rural areas. They should be battery-operated, six-valve sets, fitted with "magic eye" tuning and covering the 60 to 120-metre and 180 to 360-metre bands. Interested firms should communicate with Esfandiar Bouzourgmehr, Director, Government Propaganda Department, Tehran, forwarding details and prices of their products. It is stated by the Board of Trade that it will be appreciated if copies of correspondence are sent to the Counsellor (Commercial) British Embassy, Tehran.

R.T.S.—We understand that it is only the stock and plant of the *transformer* business formerly operated by R.T.S. Electronics which has been acquired by EARL Services and to which reference was made in our last issue. R.T.S. are continuing the manufacture of the "Motoradio" car set and the "Minicomm" intercommunication equipment.

I.A.L.—Consequent on the withdrawal of the R.A.F. from Hargeisa Airfield, British Somaliland, International Aeradio, Ltd., will provide an Airport Controller for service in the Protectorate.

A contract for the supply of Decca navigational radar gear to be installed in ships of the Royal Navy has been received by Decca. The company states that orders to equip nearly five hundred naval and merchant ships have been received during the past twelve months.

British Radar for Japan.—The first Japanese ship to be fitted with British marine radar equipment is a whale-oil refinery vessel which was equipped by Cossor Radar prior to leaving for the Antarctic.

Marconi Marine Radio gear, including two transmitters, two receivers, direction finder and echometer, is being installed in the new 28,000-ton turbine tanker *Verena* under construction for the Anglo-Saxon Petroleum Company. The radio-communication and navigation equipment installed in the new Argentine liner *17 de Octubre* has also been supplied by Marconi's.

Trawler Radar.—Ten trawlers now under construction in this country for the Icelandic Government are to be equipped with Decca radar gear, Type 159A.

Pakistan.—Seven more ships of the Pakistan merchant fleet are being fitted with radio equipment by the Marconi International Marine Communication Co., Ltd.

Plessey announce the resignation of Wing Commander G. C. Cunningham, O.B.E., who was the company's communications sales manager.

Aerialite, Ltd., of Stalybridge, Cheshire, announce that O. E. Trivett, M.Brit.I.R.E., A.M.I.E.E., has been appointed personal assistant to the Managing Director. Before taking up this appointment he was concerned with the setting up of a plastics extrusion and radio factory in India in conjunction with General Electric of America.

Ersin Multicore Solder is being exported to an increasing number of countries; among the latest are Brazil, Argentina, South Africa, Syria and Mexico. In addition agents have recently been appointed in Iceland and Iran.

Oldham & Son, the battery manufacturers, are to establish a factory in Madras, India, which is to be managed by Oldham & Son, India, Ltd.

Denco announce that, following the recent resignation of D. W. Heightman from the Board, A. W. Allwright has rejoined the company as Managing Director.

I.M.R.C.—The Brazilian Navy training ship *Almirante Saldanha*, recently refitted at Barrow, has been equipped with m.f. and h.f. transmitters by the International Marine Radio Company. The vessel was equipped by I.M.R.C. when built in 1934.

Sobell Model 610, six-valve superhet has been tested by the School Broadcasting Council for the United Kingdom and approved for use in schools.

E.E.G. Exports.—Edison Swan have recently received orders from Spain, Poland, Egypt and Ceylon for their Mark II electro-encephalograph.

E. K. Cole announce that Bentley Jones has resigned from the position of sales manager of the company's radio division. He has joined Thorn Electrical Industries as commercial director of the Ferguson television and radio division.

Dubilier Condenser Co. announce that F. H. McCrea, Managing Director, is undertaking an extensive business tour of Canada and the United States.

The Electrical Apparatus Co., of St. Albans, announce that J. de Gruchy has been appointed Head of the Instrument Department which at present is concentrating on the production of moving-iron and moving-coil meters.

NEW ADDRESSES

British Standards Institution has opened an office at 12, Hilton Street, Manchester, 1 (Tel. Central 4856), where a complete set of British Standards may be consulted and copies purchased.

Marconi's have recently established an Inspectorate at Mombasa providing radio and radar maintenance for vessels calling at ports in the area.

Depots are being opened by Aerialite, Ltd., at 343, Deansgate, Manchester, 3 (Tel. BLA. 3524); and 50, Cathay, Redcliffe, Bristol (Tel. 26130).

Southern Radio Supply, Ltd., have moved from 46, Lisle Street, London, W.C.1, to 11, Little Newport Street, London, W.C.2 (Tel. Gerrard 6653).

MEETINGS

Institution of Electrical Engineers

Radio Section.—"Crystal Diodes," by R. W. Douglas, B.Sc., and E. G. James, Ph. D., and "Crystal Triodes," by T. R. Scott, B.Sc., at 5.30 on December 6th.

Discussion on "Have Post-War Broadcast Receivers taken Full Advantage of Wartime Development?" opened by R. B. Armstrong, B.Sc., at 5.30 on December 18th.

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

Cambridge Radio Group.—"A Review of some Television Pick-up Tubes," by J. D. McGee, M.Sc., Ph.D., and "The Design of a Television Camera Channel for Use with the C.P.S. Emitron," by E. L. C. White, M.A., Ph.D., and M. G. Harker, B.Sc. (Eng.), at 6 on December 5th at the Cambridgeshire Technical College.

North-Eastern Radio Group.—"Electronic Counters and Some Applications," by R. B. Conn B.Sc., at 6.15 on December 18th at King's College, Newcastle-on-Tyne.

Sheffield Sub-Centre.—"Some Electromagnetic Problems," by Prof. G. W. O. Howe, D.Sc., LL.D., at 6.30 on December 13th at the Grand Hotel, Sheffield.

North Lancashire Sub-Centre.—"The General Aspects of Television," by A. J. Biggs, Ph.D., B.Sc., at 7 on December 20th at the Harris Institute, Corporation Street, Preston.

South Midland Centre.—"Generation and Flow of Harmonics in Transmission Systems," by S. Whitehead, M.A., Ph.D., and W. G. Radley, C.B.E., Ph.D.(Eng.), at 6 on December 4th at the James Watt Memorial Institute, Great Charles Street, Birmingham.

Reading (Berks) District. — "Television Engineering," by D. C. Birkinshaw, M.B.E., M.A., at 7 on December 11th at the Great Western Hotel, Reading.

British Institution of Radio Engineers

London Section. — Discussion on "Progress in Loudspeaker Design," opened by R. L. West, B.Sc., at 6.30 on December 15th at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, W.C.1.

North-Eastern Section.—"A Survey of Television Development and its Problems," by H. J. Barton Chapple, B.Sc., at 6 on December 13th at Neville Hall, Westgate Road, Newcastle-on-Tyne.

Scottish Section.—"Vacuum Engineering Applied to Electronics," by D. Latham, B.Sc., at 6.45 on December 7th at Heriot-Watt College, Edinburgh.

North Western Section.—"High Fidelity Reproduction," by H. J. Leak, at 6.45 on December 7th at the College of Technology, Manchester.

British Sound Recording Association

"The Application of Magnetic Coatings to Film Stock," by G. F. Dutton, Ph.D., D.I.C., at 7 on December 6th at E.M.I. Studios, Ltd., 3, Abbey Road, St. John's Wood, London, N.W.8 (Joint Meeting with the British Kinematograph Society).

"Modern Recording Technique," by C. E. Watts at 7 on December 13th at the Central Library, Guildhall, Portsmouth. Demonstrations from 5 p.m. (Joint Meeting with the Institution of Electronics).

"The Crystal Pickup With Particular Reference to Long-Playing Records," by S. Kelly at 7 on December 20th at the Royal Society of Arts, John Adam Street, London, W.C.2.

Television Society

Engineering Group. — "Television Transmission for the Amateur" by M. Barlow (Hon. Sec. British Amateur Television Society), at 7.0 on December 14th, at the Cinema Exhibitors' Association, 164, Shaftesbury Avenue, W.C.2.

Institution of Electronics

Midlands Branch.—"Electronic Instruments for Temperature Measurements and Control, and for Safeguarding Combustion," by H. A. Stevenson and C. Smith at 7 on December 5th at the Warwick Room, Imperial Hotel, Temple Street, Birmingham, 2.

Tolerances and Errors

"CATHODE RAY" Explains How They Add Up in the Final Result

SOMEONE has written to me to ask: what about tolerances? And to make his point clear he proceeded to fire a number of diverse examples in rapid succession. Some of these concerned combinations of resistors, and he ended by asking "Is there a 'tolerance arithmetic' for simple series/parallel networks?" To tell the truth, I hadn't given the matter much thought, but after having done so I can answer with a definite "yes."

The subject of errors, even if confined to the field of measurement, is a very large one, and to the mathematically-minded a very attractive one. Large and excessively learned books have been written on it. But they concentrate on the question of *probable* error, which must be clearly distinguished from *maximum* error or, as it is called in engineering, tolerance. The tolerance is so important in connection with radio components that the colour code applicable to them has one unit devoted to indicating it.

So when one buys even such a simple thing as a resistor one must be prepared to answer the question "Yes, sir; what tolerance?"—or look a fool. It is not merely an academic question; it has more to do with the price, apparently, than anything else. The reason lies in the fact that the manufacture of resistors (of the ordinary composition type) is rather like shooting at a target from a considerable distance. The resistances no more come out all exactly the right value than all the bullets go through a single hole exactly in the centre. In the absence of any special trends, the distribution of bullets relative to the centre of the target, and of resistances relative to the nominal value, is found to follow what is referred to in the learned books as a normal (or Gaussian) error curve, Fig. 1. Over a narrow range on each side of the nominal value the quantities are distributed almost evenly. Those falling within 5% of the nominal value are picked out and marked "±5%." From the remainder, those falling within 10% are picked out and marked "±10%." Similarly for the ±20%. Those not within 20% of one nominal value come within 20% of another nominal value and can be marked accordingly. So, on this plan, buyers of ±10% resistors are unlikely to find them within 5%, and the usual assumptions made by the "probable-error" school of thought fall down.

If all were offered at the same price, the makers would have no sale for the 10% and 20% stocks, so the prices are graduated to equalize the demand.

Generally one does not buy a resistor as a self-contained unit, to be preserved for ever in complete isolation. It is intended to be used in conjunction with other components, to achieve some desired result. Even if it is wanted as a single fixed standard of resistance, the ultimately important matter is not the maximum error in that resistance but the error in the results of measurements based on it. So one ought to have a clear idea of how tolerances in components affect the maximum possible error in the final result. It is because I suspected that one does not have this clear idea that the subject struck me as being just the thing for considering here.

The sort of question one ought to be able to answer can be indicated by an example: We want to pass a current of 50 mA ± $7\frac{1}{2}$% from a 200-V supply and we have a 6.8kΩ resistor with a tolerance of 5%. This resistance is too high, because what is wanted is 4kΩ; but a 10kΩ in parallel would do the trick (within about 1%); what tolerance can this 10kΩ be allowed?

Series Combinations

Let us, then, tackle resistance networks, or at any rate those whose overall resistance can be calculated by the two simple principles of series and parallel addition. Before starting there are one or two things we ought to be quite clear about.

When a resistor is marked "200Ω ± 10%" (read as "200 ohms plus-or-minus 10 per cent") it means that if its actual resistance is anything between 180Ω and 220Ω you have to be satisfied; but if it is outside those limits you can claim your money back. Dimensions in engineering drawings are sometimes marked with unequal positive and negative tolerances; but we shall exclude them, or (if you insist) alter the main dimension so as to divide the tolerance equally. We make this assumption so that we can simplify our calculations by using + signs for all tolerances, except where a positive overall error is contributed to by a negative tolerance, as for example in the effect of shunt resistance on meter current.

If we had been interested in *probable* errors we would have had to take account of the fact that when two quantities are combined, each having random variations from the nominal value, there is a lucky chance that the errors will tend to cancel one another out, as well as the unlucky chance that they may add up. So the most probable error is less than the sum of the two. But here we are taking a sternly engineering attitude, leaving nothing to chance, and (whatever we may secretly hope) being prepared for the worst. So we shall assume in every case that the tolerances combine in the worst possible way.

If in an unguarded moment one were to be asked

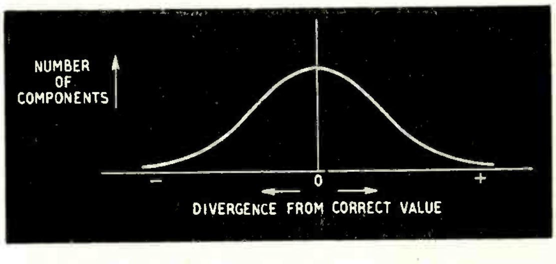


Fig. 1. If the components in a very large batch are arranged according to their departure from the nominal value, their quantities tend (theoretically) to follow a curve something like this.

about the overall tolerance when two equal $\pm 5\%$ resistances are connected in series one might (without thinking) answer "$\pm 10\%$" But this would be confusing percentages (or proportional errors) with absolute errors. If the two resistors were each 1,000 Ω, each would have a tolerance of 50 Ω, so the tolerance in the combination would be 100 Ω, it is true. But relative to the resistance of the combination, 2,000 Ω, this would still be 5%. One can go further and say that in any combination of resistances having equal percentage tolerances the overall percentage tolerance is the same as that of the components. The proof, if one is wanted, will emerge as a special case of the less obvious problem of any-value tolerances.

This problem can be solved by at least three methods: by common sense, by simple algebra, and by differential calculus. I am leaving out of account a fourth method—by arithmetic—because that solves only one example at a time, and I assume that anybody reading this article is more interested in getting to the root of the matter.

The common-sense method is to argue that in a combination of any number of resistors in series the tolerances in ohms add up together, just like the nominal resistances, but when they are expressed as percentages of the whole combination they affect it only in proportion to the individual resistances. For example, if a 20% resistor comprises one quarter of the resistance of the combination, its contribution to the overall tolerance will be one quarter of 20%. Similarly for the other resistors.

Simple algebra reaches the same result by denoting the resistances by symbols and subjecting them to the ordinary arithmetical operations. Suppose there are two resistances, nominally R_1 and R_2 (Fig. 2), and their respective tolerances, expressed in the same units as R_1 and R_2, are r_1 and r_2. The corresponding percentage tolerances, p_1 and p_2, are therefore $100\ r_1/R_1$ and $100\ r_2/R_2$. The nominal value of the combination, which we shall denote by R, is of course, R_1+R_2; and according to the rules we have just laid down the tolerance of the combination (call it r) is r_1+r_2. What we want to find is p, the percentage tolerance of the combination. It is, of course

$$p = \frac{100r}{R} = \frac{100(r_1+r_2)}{R_1+R_2}$$

Since $p_1 = 100r_1/R_1$, r_1 must be $p_1R_1/100$. So

$$p = \frac{100\left(\dfrac{p_1R_1}{100} + \dfrac{p_2R_2}{100}\right)}{R_1+R_2} = \frac{p_1R_1+p_2R_2}{R_1+R_2}$$

If we had had three resistances, it would have been

$$p = \frac{p_1R_1+p_2R_2+p_3R_3}{R_1+R_2+R_3}$$

and so on.

This just puts in symbols what we have already said in words. Perhaps this would be made clearer if we rewrote the formula thus:

$$p = \frac{p_1R_1}{R} + \frac{p_2R_2}{R}$$

etc. Example: A 200-Ω ± 10% resistor is connected in series with a 500-Ω ± 5% resistor; what is the overall percentage tolerance and the contribution of each resistor? The first contributes $10 \times 200/700 = 2.86\%$, and the second $5 \times 500/700 = 3.57\%$; total 6.43%.

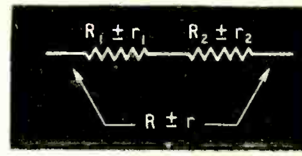


Fig. 2. Two resistances in series, the nominal values being indicated by capital letters and the tolerances by small.

As a matter of fact it is rather silly to give this answer to two decimal places, because the resistor sorters certainly do not work to that degree of precision. Another reason is that in general the accepted methods of calculating tolerances are only approximate. As it happens, however, this simple case of adding two quantities is an exception, thanks to the custom of reckoning tolerances relative to the *nominal* values. You can check this by taking an extreme case: suppose the tolerance of the 200-Ω had been 1% and that of the 500-Ω had been 60%. Then with positive errors the components would have been 202 Ω and 800 Ω respectively, so R_2 would have been nearly four times R_1. With negative errors they would have been 198 Ω and 200 Ω, making R_2 and R_1 almost equal. So it would seem as if the proportions in which each error contributed to the overall result would be greatly influenced by the errors themselves. And so they would, if they were reckoned on the *actual* values, of if the errors interacted on one another (as would be indicated if there were terms containing both p_1 and p_2). Check it with the example if you like; the maximum error (positive or negative) is 302 Ω, which relative to the nominal value of the combination (700 Ω) is 43.15%. The calculated contributions are $1 \times 200/700 = 0.29\%$ and $60 \times 500/700 = 42.86\%$, which add up to 43.15%.

But what about the differential calculus method? In this case it offers no advantage whatever; in fact, it only tells us what we have already accepted as obvious, namely that $r = r_1+r_2$. But it is quite otherwise with more complicated cases, which by simple algebra are usually unbearably tedious.

And Now in Parallel

Even such an apparently simple situation as two resistances in parallel is bad enough. The nominal value R, according to the well-known formula, is $\dfrac{R_1R_2}{R_1+R_2}$. We can see that a positive error in either leads to a positive error in the combination, so + signs throughout are in order, and the maximum value of the combination is

$$R+r = \frac{(R_1+r_1)\ (R_2+r_2)}{(R_1+r_1) + (R_2+r_2)}$$

and r is obtained by subtracting R from this. As before, $p = 100r/R$. Now you can go ahead and work it out, on the same principle as for resistances in series. But make sure you have plenty of paper! The result, in spite of a considerable amount of boiling down and tidying up, is the rather unpleasant

$$p = \frac{p_1R_2\left(1+\dfrac{p_2}{100}\right) + p_2R_1\left(1+\dfrac{p_1}{100}\right)}{R_1\left(1+\dfrac{p_1}{100}\right) + R_2\left(1+\dfrac{p_2}{100}\right)}$$

But provided that the tolerance percentages are reasonably small, one can get a sufficiently good approximation by neglecting them where they are divided by 100; thus:

$$p \simeq \frac{p_1R_2+p_2R_1}{R_1+R_2}$$

This is rather interesting, because it is the same as for resistances in series, except that each tolerance contributes in proportion to the *other* resistance. Which fits in with common sense, because if 100 Ω is shunted by 10,000 Ω the 100-Ω resistance is thereby affected only very slightly (being reduced to about 99 Ω) and the effect of small tolerances in the 10,000 Ω is quite negligible. On the other hand, the tolerance in the 100 Ω is practically the same as that of the combination. In the parallel connection, then, the two tolerances are not independent of one another; the effect of varying one resistance depends on the value of the other.

Having neglected $p_2/100$ in comparison with 1, we should not expect to find this formula very accurate if applied to our 500-Ω ±60% resistor. In parallel with the 200-Ω ±1% resistor, the result is (by exact calculation) 142.8 Ω +12.9% or −30.2%. (Note how much smaller the positive tolerance is than when they are in series, because the greater part of the current flows through the 1% resistor. This is much less so with the negative tolerance.) According to the approximate formula, p is ±17.86%.

I have made rather a lot of this difference between the two cases because it forms an interesting analogy with intermodulation in amplifiers. If an amplifier is perfectly linear, then the effect of amplifying two signals at once is equal to the sum of the effects of separate amplification. But if, as is always more or less so, there is non-linearity, the signals intermodulate. And while this may be negligible when the amplitudes (relative to the steady valve current) are small, it will probably not be when they are large. The tolerances or errors correspond to the signal amplitudes.

The differential calculus method is a considerable help with the parallel circuit. Normally, for the benefit of readers who look on it as something much too intellectual, I keep the calculus out of these pages; but this time, for the benefit of those who have learnt the elements of it and are looking around for something not too hard to practise on, I will just stop to point out the way. It is based on the assumption that over the range of variation represented by the tolerance the "curve" is linear. In other words, exactly the same assumption as we make in most valve calculations. Using the same symbols as before, one can write it

$$r = r_1\frac{\partial R}{\partial R_1} + r_2\frac{\partial R}{\partial R_2} + \ldots.$$

which means that to find the contribution of r_1 to the overall error one multiplies it by the rate at which R changes when R_1 is varied; and similarly for any number of resistors *connected in any way whatsoever*. One only needs to know how R is related to the component resistances and how to differentiate with respect to each of these.

With two resistances in parallel the result of the differentiation is

$$r = r_1\left(\frac{R_2}{R_1+R_2}\right)^2 + r_2\left(\frac{R_1}{R_1+R_2}\right)^2$$

and when the substitution has been made for p, etc., the result is the same approximate formula as before.

The more complicated the problem, the greater the saving by using the calculus.

By one method or another we now have formulae for dealing with both series and parallel arrangements, and with these can solve any resistance network that can be reduced to such arrangements. And remembering that capacitances in series are calculated as for resistances in parallel, and vice versa, we can deal with them, too; which is rather useful when designing oscillator circuits for superhets.

In practice, one may have to take into account temperature tolerances as well as manufacturing tolerances; but the methods are the same.

Meter Tolerances

When one comes to meters there is more need to consider the causes of the errors. Meter tolerances are generally stated as a percentage of full-scale reading; in other words, as a constant amount regardless of reading. For instance, if a 0-500 voltmeter is said to have an accuracy of ± 1%, it means that the readings are (or should be) reliable within 5 V. If one tries to read 10 V on such a meter, p is ± 50%, which is not very good. Moral: use a lower range. The only sort of error I can think of that would strictly follow this law is a faulty adjustment of the zero-setting device, and that doesn't count! Most of the inherent errors of the instrument —temperature, lack of balance, non-linearity of field and spring, etc.—have some sort of proportionality to the deflection; but it is not necessarily simple proportion, so to be on the safe side the maker quotes a full-scale error everywhere.

When using multipliers and shunts the plot thickens. Presumably any errors arising from uncertainty in the resistance of the meter are not included in the quoted inaccuracy and have to be added. So the question "A meter ± 1% f.s.r. is used with a shunt ± 2%; what is the accuracy of the reading?" is less simple than it looks. Assuming that the ± 1% refers to the meter used unshunted, we would have to know the maximum error in the specified or measured value of the meter resistance.

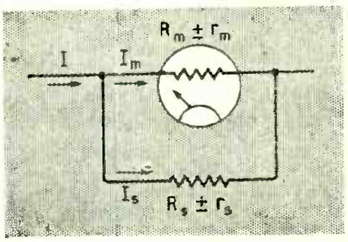


Fig. 3. Symbols used in working out the shunting error due to tolerances in the shunt and meter resistances.

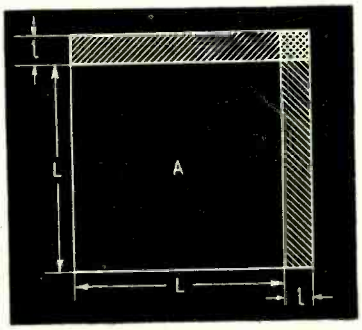


Fig. 4. Showing how a tolerance in a dimension is approximately doubled when the quantity is squared.

This would enable us to calculate the corresponding figure for the meter current in relation to the total current to be measured. We assume that this total current is unaffected by inserting the meter; otherwise that error would have to be calculated, too. The 1% meter error is additional to the shunting error.

The symbols in Fig. 3 are, I hope, self-explanatory. A shunting-error formula can be obtained in much the same way as the parallel-resistance formula, but the starting point is different:

$$I_m = I\frac{R_s}{R_s + R_m}$$

The result, either by straightforward algebra, neglecting terms divided by 100, or by short-cut calculus, is

$$p \simeq \left(p_s - p_m\right) \frac{R_m}{R_m + R_s}$$

This shows that if both meter and shunt resistance are high *or* low by the same percentage, the shunting error is nil (which is what one would expect).

An important thing to know is that if the value of a component has to be squared to give the answer, the overall tolerance is doubled. Similarly, cubing multiplies the tolerance by 3; a square root by $\frac{1}{2}$; and so on. This is another of the rules that is a good approximation for small tolerances only. It is very obvious to anybody who has absorbed the first stages of the differential calculus; and can be demonstrated to others by the simple diagram Fig. 4. The area A of a square is of course equal to L^2. If L is increased by a small amount, l, A increases in the same proportion in two places, plus a little corner piece. If the corner is neglected, the area therefore varies twice as fast as L.

The same sort of game can be played with a cube, but beyond that it is difficult.

If there is still space I would like to refer to a formula quoted on page 358 of Scroggie's "Radio Laboratory Handbook" (5th edn.) as an example of a type that should be avoided for its insidious error-multiplying nature. It refers to the method of measuring the total initial capacitance of a tuned circuit by noting the frequencies f_1 and f_2, to which it resonates when two known capacitances, C_1 and C_2, are added. The formula is

$$C_0 = \frac{C_1 f_1^2 - C_2 f_2^2}{f_2^2 - f_1^2}$$

Unless you have some time on your hands I don't advise working out the maximum error formula for this; but having done so I would like to give a typical example, assuming these values:

$C_1 = 200pF \pm 0.5\%$; $C_2 = 400pF \pm 0.5\%$;
$f_1 = 1{,}000$ kc/s $\pm 0.1\%$; $f_2 = 733$ kc/s $\pm 0.1\%$.

Anybody using these figures might imagine that the data were pretty accurate; nevertheless, he would not be justified in relying on the answer to better than 20%. Yes; decidedly a method to be avoided.

Answer to Introductory Example

Apart from the 1% by which the nominal value of the parallel combination fails to fit the exact requirement, the tolerance in the 10-kΩ resistor could be (calculated by substitution in the given formula) 11.2%. So a ± 10% resistor would do.

APPLIED ELECTRONICS

Brit.I.R.E. Presidential Address

"SELLING" electronics to industry, the dissemination of technical information, aeronautical radio and the possibilities of employing vertically radiated transmissions in an endeavour to accommodate more stations within the limits of the h.f. broadcasting bands are some of the matters dealt with by Paul Adorian in his recent Presidential address to the British Institution of Radio Engineers.

He suggested that in order to stimulate interest in, and secure the acceptance of, electronic methods in industry and medicine, papers should be presented, not only to radio engineers but to those engaged in fields of research to which the techniques are applicable.

In regard to the problems associated with broadcasting, Mr. Adorian summarized the difficulties, so far as medium- and long-wave stations are concerned, by saying that, allowing for a 9-kc/s separation between channels, it would be necessary to use each available channel twenty-five times to cover the world's land mass with *one* programme.

On the question of h.f. broadcasting, he outlined a system employing aerials which radiate a large proportion of their power vertically, giving relatively short-range reflections from the Heaviside layer. The system, using the wavelength of 30 metres, has been used in Trinidad since 1947 and has given satisfactory reception throughout the island in daylight, but at night interference is caused by stations operating in different parts of the world on the same wavelength but with aerials radiating considerable power at low angles. Another station using the system has recently been opened in Jamaica.

RCA Receiving Tube Manual

A NEW and completely revised edition of this useful reference book has recently been announced by the RCA Tube Department. It contains general information on valves, ranging from elementary theory to descriptions of the latest applications of receiving valves, and has some new features reflecting developments in electronics. The section on valve and circuit theory has been expanded and includes formulæ and examples for the calculation of power output, load resistance and distortion for several classes of amplification, as well as information on the design of cathode followers. New designs for receivers and amplifiers have also been added, and there is a complete section on resistance-coupled amplifiers.

In addition, the manual provides technical data on more than 460 RCA receiving valves and television picture tubes, including many discontinued types. For quick and easy reference there is a classification chart which groups together the types having similar characteristics and the same filament or heater voltages.

Single copies of this new edition, RC-16, can be ordered from RCA Photophone Ltd., 36, Woodstock Grove, London, W.12, price 5s 6d, post free.

Long Range Television

Review of Propagation Conditions

Prevailing During Reception in South Africa

By T. W. BENNINGTON (B.B.C.) and R. MORRIS (Panorama Receiving Station, S.A.B.C.)

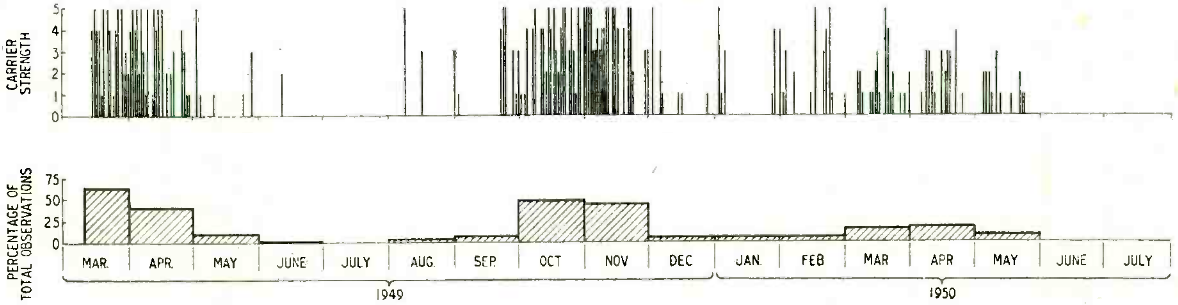
REGULAR reports on reception of the Alexandra Palace 41.5-Mc/s sound channel have been sent since 13th March, 1949, to the B.B.C. from the Panorama Receiving Station of the South African Broadcasting Corporation, near Johannesburg. At this station from 5 to 7 observations are made daily throughout the year on this frequency, covering both the forenoon and afternoon transmitting periods. The results of the observations are reported in a 5-figure code, in which the first figure designates the signal strength on a scale of 0-5, while the remaining figures indicate respectively the fading, noise, interference and overall merit. In this review we are concerned with the propagation conditions and so the signal strength figure only has been used. During all observations when it is not possible to allot a figure of 1, or greater, to the reception, either "Nil" reports are given, or else the designation "BNL" (Below Noise Level) is used, both of which classifications are taken to mean that the signal strength is, in fact, zero.

The reports have here been analysed for the period 13th March 1949 to 31st July 1950. In the upper section of Fig. 1 are shown the days on which reception was obtained. On each of these days the observation giving the strongest signal of the day was taken and the results are plotted as vertical lines on the scale 0-5. During 1949 reception was far more frequent, and signals were, in general, stronger during the months of March, April, October and November than during the other months of the year. It should be noted, however, that had observations been made during the early part of the year, frequent reception might have been had during February. Reception conditions were the most favourable in the early spring and late autumn, though mid-winter produced occasional reception. During the summer conditions were particularly poor and on one day only during June, and on not a single day in July, was reception obtained, though just as many observations were made then as during other months. In 1950 signals were heard on several days during mid-winter, though it again tended to increase towards the vernal equinox. It is again significant that not a single case of reception was obtained between 24th May and 31st July when our record finishes. It is to be noted that reception during the early spring of 1950 was much less frequent than during that of 1949, due, no doubt, to the decreased solar activity and the consequent fall in the ionization of the F_2 layer.

In the lower section of Fig. 1 there are given, in histogram form, the total number of cases of reception at strength 1 or greater, as a percentage of the total number of observations made during the month. Reception on 41.5 Mc/s was most frequent during March 1949, when 65 per cent of the observations produced signals, and it was least frequent during June and July 1949, while June and July 1950 were completely blank months. It will be noted that in the late winter/early spring period reception peaked during the equinoctial month of March, whereas at the late autumn/early winter period the equinoctial month of September did not produce a notable increase in reception, which reached its seasonal peak in the following month. It would be expected that reception would peak just after and just before the mid-winter period rather than at the equinoxes, and it is difficult to assign a reason for this assymmetry in regard to the peak reception months of 1949, particularly as sunspot activity during April and September was at similar levels.

It seems reasonable to assume that the best conditions for reception tended to occur towards both

Fig. 1. Graphical records of reception of Alexandra Palace 41.5 Mc/s sound signals in Panorama South Africa. Day-to-day signal strength is given in the top half, the lower showing the monthly reception as a percentage of the observations made.



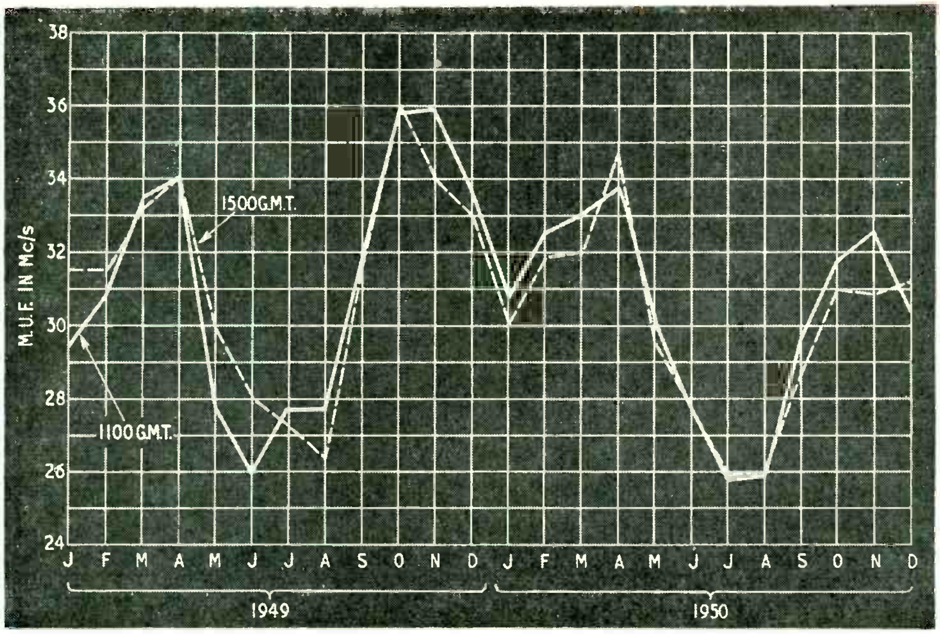


Fig. 2. Predicted monthly m.u.f.s for the Daventry/Johannesburg path at 1100 and 1500 hours G.M.T. during 1949 and 1950.

winter period and medium - high values at mid-winter. The general trend of the seasonal variations in m.u.f. thus agrees exactly with the observed results at Panorama, in that the seasonal periods when no reception was obtained occur when the predicted m.u.f. was lowest, the most frequent reception when it was highest and occasional reception when it was less than the highest expected. It is to be noticed that there is a general fall in predicted m.u.f.s with time, in accordance with the decrease in sunspot activity, so that the late winter/early spring peak in m.u.f. in 1950 is lower than either peak of 1949, and this agrees with the decreased amount of reception in the late winter/early spring of 1950 as compared with the peak reception periods of 1949. Actual values of predicted m.u.f. would appear to be somewhat lower than those which must have prevailed, for during no month did the predicted mean exceed 36 Mc/s, whereas during several months 41.5 Mc/s was received frequently.

In conclusion we can summarize:—

(1) Reception of 41.5 Mc/s over the London/Panorama transmission path was obtained; (a) frequently during the late winter/early spring and late autumn/early winter periods, (b) occasionally during the mid-winter period, and (c) not at all during the summer period.

(2) The seasonal variation thus disclosed is in exact accordance with the expected variation of m.u.f. over the path, as indicated by the predicted m.u.f. values. There is strong evidence, however, that the predicted m.u.f.s were somewhat lower than the actual frequencies for the path, at least during the equinoxes.

(3) Reception during the late winter/early spring period of 1950 was much less frequent than during both periods of peak reception of 1949, due to the general fall in sunspot activity and the consequent decrease in the ionization of the F_2 layer.

vernal and autumnal equinoxes. Again in March and April 1950 there occurred an increase in reception, followed by a sharp decrease in June. The level of reception in the spring of 1950 was very much less than in the same months of the previous year, which may be accounted for by the fact that the sunspot activity (as indicated by the monthly sunspot numbers) has decreased by approximately one-third as between March/April 1949 and March/April 1950.

Comparison with Ionospheric Data

It is not feasible to compare these results with any measured m.u.f. (maximum usable frequency) data, because no such charts are published, and there do not exist enough measured critical frequencies over this path on which to estimate the results with the predicted m.u.f. for the path, as obtained from the world ionospheric contour charts, which are compiled on the basis of past measured data supplied by the world network of ionospheric measuring stations.

It is not to be expected that, because reception was obtained on a few days during any particular month, the mean m.u.f. for that month would reach 41.5 Mc/s. It is known that there is a very considerable day-to-day variation about the monthly mean value, and so it might be possible to receive 41.5 Mc/s on several days during the month when the mean m.u.f. for the path was much lower. Nevertheless, when reception was obtained on 50 per cent, or more, of the observations made, it would indicate that the mean monthly m.u.f. for the path must have been near 41.5 Mc/s.

In Fig. 2 are plotted, for 1100 and 1500 G.M.T., the predicted monthly m.u.f.s for the path for 1949 and 1950, as obtained by the use of world ionospheric contour charts. It will be seen that there is a large seasonal variation in the predicted m.u.f. for the path, such that low values are to be expected in the summer, highest values before and after the mid-

INTERFERENCE MEASURING SET

THE Electrical Research Association has recently designed for the Admiralty a portable interference measuring set in conformity with the requirements of BS1597 (suppression of marine installations) and BS727 (general measurement of radio interference). Sets to this specification, which are equally suitable for marine or land use, are being made by E.M.I., though the Admiralty states other civilian organizations may use the design without change. Further information may be had from the E.R.A., Perivale, Middlesex.

Phase-Shift Oscillators

New Circuit Giving Constant Amplitude

By W. G. RAISTRICK (Pye, Ltd., Cambridge)

THE circuits to be described are all based upon the phase-shift oscillator shown in Fig. 1. In order to produce self-sustaining oscillation in this arrangement two conditions must be satisfied. First, the voltage introduced from the output of the amplifier must be in phase with that fed back to the input, and, secondly, the voltage gain in the amplifier must be rather greater than the loss in the resistance-capacitance network.

A further requirement, important when a variable-frequency oscillator is considered, is that the sum of the amplifier-gain and the network loss should be constant over the whole of the frequency range in order that the voltage output may remain constant and the amplifier valve work always on the same part of its characteristic. The success or otherwise of any RC oscillator with low harmonic distortion depends very largely upon how accurately one can maintain the system in a condition when it oscillates only very gently, and in practice most oscillators of this type embody some form of automatic amplitude control. The design of this control is greatly simplified if the amplitude variation in the first place is only slight.

If we make the assumption that the valve-amplifier gives a constant voltage-gain and a constant phase-shift of 180° over the whole range of frequencies to be considered, then we are left with the problem of designing a phase-shifting network which gives a phase change of 180° and a constant loss over the frequency range.

In the circuit of Fig. 1 it is not feasible to obtain a phase shift of more than 60° in each resistance-capacitance section so that the minimum requirement for oscillation is three sections. If the network loss is to remain constant then either all the capacitors or all the resistors must be varied simultaneously and it is this latter feature which has led to the comparative neglect of this type of oscillator for generating variable-frequencies.

Three-gang potentiometers are not easy to obtain, and if the normal type of tuning capacitor of 500-600 pF, is pressed into service then at least two will be required for each section, if frequencies of the order of 20 c/s are contemplated, otherwise the associated fixed resistors become of so high a value that the valve grid is extremely susceptible to hum pick-up. A further consideration is that the loss in the network decreases with the number of sections. It is 1/29 for a three-section network and 1/18 for a four-section one, necessitating valve voltage gains of rather more than 29 and 18 respectively. This is one reason why some of the oscillators described in the past have had as their tuning elements two four-gang capacitors coupled together.

By employing the more elaborate phase-shifting circuit of Fig. 2 it is possible to obtain a phase-shift per stage of approximately twice that obtained with the simpler circuit. As is well-known, the virtues of this particular phase-shifting circuit are that the phase may be changed from 20° to 160° without any appreciable change of amplitude at the output terminals, so long as no attempt is made to draw power from the circuit, and it thus becomes possible to design an oscillator with only two stages of phase-shifting. Also, only one variable element is required although, as will be pointed out later, it is not always advisable to avail oneself of this characteristic.

Phase-splitting Valve

In all the oscillator circuits which have so far been tried by the author the centre-tapped transformer of Fig. 2 has been replaced by a phase-splitting valve. Each phase-shifting section then becomes as in Fig. 3.

For a first analysis we may neglect the effects of the valve anode resistance, the input impedance of the succeeding stage and the cathode-bias resistor.

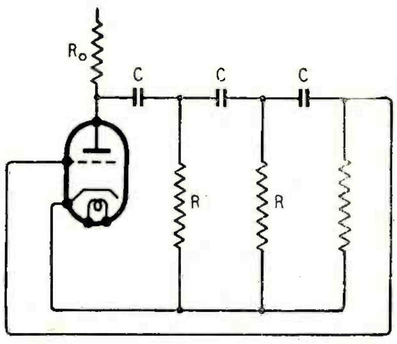


Fig. 1. Conventional phase-shift oscillator.

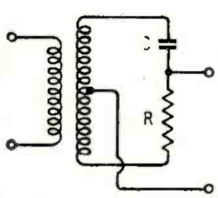


Fig. 2. Constant-amplitude phase-shift circuit with transformer input.

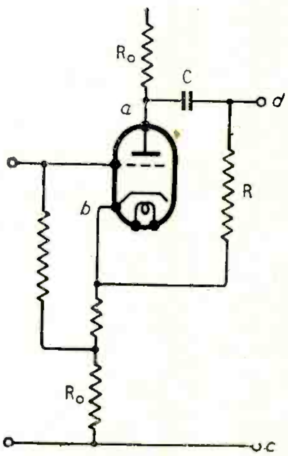


Fig. 3. Push-pull phase-splitting circuit which can replace the transformer of Fig. 2.

The equivalent circuit is then that of Fig. 4(a). If now a sinusoidal voltage of amplitude E is applied between terminals *ab*, then the current through the resistive branch becomes $\frac{E}{2R_0}$, and that through the RC branch $\frac{E}{R+1/j\omega C}$. The resulting voltage distribution is shown in the vector diagram of Fig. 4(b); note in this that the angle *adb* will remain a right angle as C or R is varied assuming C to be a capacitor of low power factor, so that the point *d* will describe a semicircle about the centre *c*, and *cd* will always be equal to both *ac* and *cb* since all three are radii of the same circle. The voltage *cb*, the cathode voltage, is in phase with the input voltage to the valve grid, and *cd* is the output voltage, so that the phase angle θ between input and output voltages is the angle *bcd*. By the process of completing the parallelogram, Fig. 4(c), and bisecting angle θ by the perpendicular *cf*, it can easily be seen by inspection that the tangent of half this angle is: $\tan\frac{\theta}{2} = \omega CR$. Now $\tan 2x = \frac{2\tan x}{1-\tan^2 x}$ from which

$$\tan\theta = \frac{2\omega CR}{\omega^2C^2R^2-1} \quad \ldots \quad \ldots \quad (1)$$

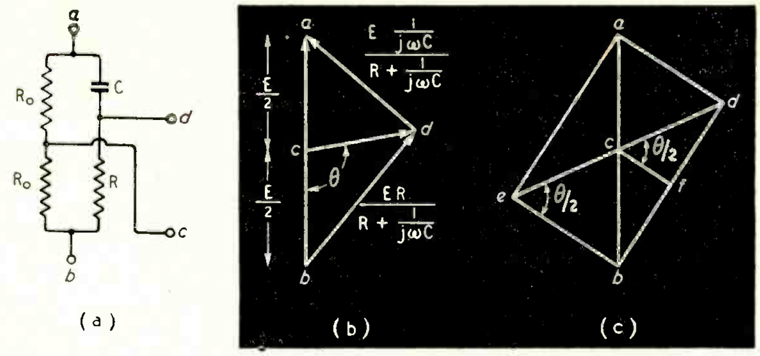


Fig. 4. Basic phase-shift circuit alone (a) and vector diagram of voltages (b). The parallelogram is completed in (c).

Fig. 5. Circuit of complete oscillator with two phase-shift and one amplifier stages.

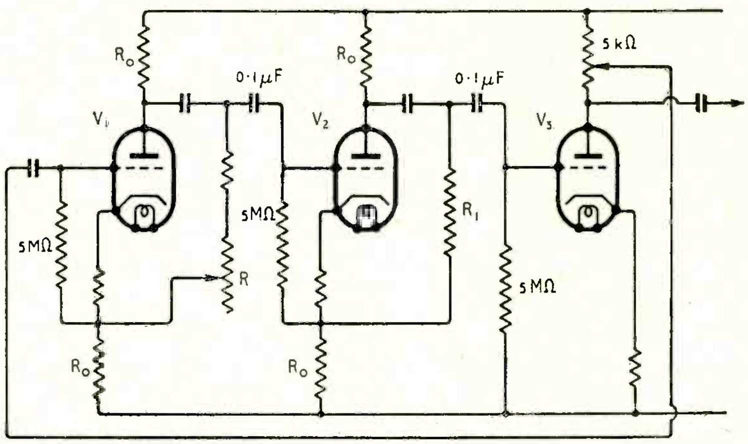


Fig. 5 depicts an oscillator constructed by associating two such phase-shifting stages with a valve-amplifier V_3. If we denote the phase shift obtained in the second stage by $\phi = \frac{2\omega C_1R_1}{\omega^2C_1{}^2R_1{}^2-1}$ then oscillation will be obtained when $\theta + \phi = 180°$.

Now $\tan(\theta+\phi) = \frac{\tan\theta + \tan\phi}{1-\tan\theta\tan\phi}$ and substituting from (1)

$$\tan 180° = 0 = \frac{\frac{2\omega CR}{\omega^2C^2R^2-1} + \frac{2\omega C_1R_1}{\omega^2C_1{}^2R_1{}^2-1}}{1-\left(\frac{2\omega CR}{\omega^2C^2R^2-1}\cdot\frac{2\omega C_1R_1}{\omega^2C_1{}^2R_1{}^2-1}\right)}$$

$$\text{From which } \omega^2 = \frac{1}{RCR_1C_1}$$

$$\text{And } f = \frac{1}{2\pi\sqrt{RCR_1C_1}} \quad \ldots \quad \ldots \quad (2)$$

It now can be seen wherein lies the disadvantage in having only one tuning element, for assuming we decide to allow the resistance R to fulfill this function then $C = C_1$ and the expression for oscillation frequency becomes $f = \frac{1}{\sqrt{R}\cdot\sqrt{R_1}C}$; in other words the frequency becomes proportional to $\frac{1}{\sqrt{R}}$ and a linear control will give an extremely cramped scale if a coverage of the order of 10 : 1 for each range is considered. In order to obtain an approximately logarithmic scale then a logarithmic potentiometer will have to be used and unfortunately logarithmic wire-wound potentiometers are not obtainable in large ohmic values.

However, when extreme accuracy and permanence of calibration are not important, quite useful instruments can be assembled around the ordinary carbon-track volume control with a log or semi-log law. A practical design along these lines would proceed somewhat as follows. The minimum value of R should not be reduced below about 5 kΩ, and from (2) it can be seen that the maximum value is equal to $(f_1/f_2)^2R_{min}$ where f_1/f_2 is the ratio between maximum and minimum frequencies on any one range. For decimal scales this ratio is, of course, 10, and R_{max} becomes 0.5 MΩ. R could conveniently be a fixed resistor of 5 kΩ in series with a 0.5-MΩ potentiometer. R_1 should be a fixed resistor equal in value to $\sqrt{\frac{R_{max}}{R_{min}}}\cdot R_{min} = 5\times10$ kΩ, and C would equal C_1, and be simultaneously switched for each range, increasing in capacitance in multiples of 10. It will be found that sufficiently good multiplication will be obtained over the whole frequency range to enable a single calibration to be used, and the range-changing switch used merely as a multiplier, labelled ×1, ×10, ×100, etc., so long as sufficient care is taken over decoupling arrangements at the lower frequencies. The coupling capacitors preceding the phase-splitting stages need not be embarrassingly large even for quite low frequencies as the input impedance of the particular type of phase-splitter used is high. A value of 0.1 μF is adequate for frequencies of the order of 20 c/s.

The anode and cathode load resistors R_0 should be of fairly low value—something between 2 and 5 kΩ will be found suitable. The "gain" of each phase-shifting stage is that which is normal for this type of phase-splitter and should not be less than 0.8 or 0.64 for the two together; thus the gain of the amplifier V_3 need not exceed 1.6 and its design becomes very simple.

No provision for automatic amplitude control is made in the circuit of Fig. 5. The feedback is controlled by the 5-kΩ potentiometer and, once set, it will be found that reasonably constant output will be obtained over the frequency range without further adjustment. When the output is required to be as free from harmonic distortion as possible, then it must be set at the lowest possible setting consistent with reliable oscillation, and under this condition the total harmonic content can easily better 1 per cent.

Readers who prefer to embody some kind of amplitude limiting in their designs can use any of the usual arrangements. In this connection it may be mentioned that both valve-operated control circuits and temperature-controlled devices, such as Thermistors, have been used by the writer with good results. Enough has been said to indicate that the use of the valve phase-shifter* principle makes available a RC oscillator allowing fair flexibility of design. A single- or a double-element control may be used as desired, and this control may be either resistive or capacitive; for instance the circuit of Fig. 5 could have employed a single capacitor as the tuning control with a range of 3.16 to 1, covering the audio-frequency band of 20-20,000 c/s in 6 switch-positions. Alternatively a twin-gang potentiometer can be made to give a range in excess of 30 : 1 in one sweep, and in all cases the output remains constant.

These advantages are secured at the expense of two extra valves, but this is not so great a complication when it is remembered that both phase-shifters can be sections of one of the popular small twin-triodes, and V_3 can be another section of a further valve of the same type. The complete oscillator plus output stage need therefore have no more than two "bottles." With the circuit of Fig. 1 the valve must nearly always be a multigrid type in order to obtain the necessary gain. In addition a cathode-follower is commonly added, so that the RC network may be fed from a low-impedance source, and two glass envelopes are still required, for the oscillator alone.

*British Patent No. 3516/1949.

B.B.C. REPORT FOR 1949/50

A COMPREHENSIVE account of the work and progress in the operation of both the sound and vision services of the B.B.C. during the year ended last March is given in the Annual Report of the Corporation, which is published by H.M. Stationery Office.

After dealing with the engineering developments of the year, the section devoted to the technical aspects of the Corporation's activities, concludes with some notes on the television research undertaken. In order to obtain data concerning the probable mutual interference which would be experienced with synchronized television stations working on the same wavelength (which will, of course, be necessary as there are only five channels available and ten stations are planned) six recording posts were in almost continuous operation during the year and an unbroken record was kept of reception from experimental transmitters over long distances. Recordings were also made of the Alexandra Palace transmissions in Scotland and of the Sutton Coldfield transmissions in the London area.

As a long-term project to appraise the relative merits of different systems, it is stated in the Report that preliminary experiments are being made on systems using higher standards of definition and on colour television. To facilitate work of this kind, a new flexible television transmitter designed to operate at will on standards of definition from 400 to 900 lines, has been constructed for use in the laboratories.

On the financial side, the Report records that although the Treasury retained 15 per cent of the licence revenue —£1,753,926—and the Post Office received £814,111 for expenses of collection and interference investigation, the Corporation's net licence income was £9,938,917—an increase of £494,445 on the previous year. Of this amount £272,747 was derived from the additional £1 charged for the combined sound and television licence. The revenue from the sale of publications was £1,039,464. It is noteworthy that 25.3 per cent of the year's expenditure on the Home and Television Services is classified as "engineering."

One of the best reproductions of an end-of-tube picture —showing Their Majesties at the Royal Opera House, Covent Garden—is among the illustrations in the Report, which costs 3s.

TELEVISION O.B. LINKS.—Six centimetre-wave transmitters, similar to that illustrated, are to be supplied to the B.B.C. by Marconi's to provide radio links for television outside broadcasts.

Communications on 460 Mc/s

Suitability of the Decimetre Waves for Mobile Services

By E. G. HAMER, B.Sc. (Eng.) (Hons.), A.M.I.E.E., Ass.Brit.I.R.E. (G.E.C. Research Laboratories, Wembley)

A FEW years ago it was thought that the frequency spectrum between 70 and 100 Mc/s would be wide enough to accommodate most of the necessary radio services, particularly short-range fixed links and mobile communication. The demand for frequencies in this band for use in essential services such as police work has, however, been so heavy that additional allocations are not now readily available. Higher frequencies were therefore sought for some less essential services, including taxis and the press, and, at the 1947 Atlantic City conference, the International Telegraph Union allocated the band between 156 and 184 Mc/s for this type of user. Here again, since only part of this band is available for commercial fixed link and mobile services, it appears that the congestion in this new band will shortly be the same as it is now between 70 and 100 Mc/s. All the available frequencies are rapidly being allocated and the next logical step will obviously be to move yet higher up the frequency spectrum to the range between 460 and 470 Mc/s, which was allocated at Atlantic City to fixed and mobile stations, and is used in America for "citizens' radio."

Previous work has shown that frequencies in the 700-100-Mc/s band give slightly better results than those between 156 and 184 Mc/s when used for mobile types of service. For frequencies of the order of 460 Mc/s, however, the performance has not been so accurately known. The various conflicting reports made in the past had led to the assumption that the usefulness of such frequencies for mobile communication largely depended on the location of the fixed station aerial.

Mobile Station

In order to obtain more precise information on this point and, further, to investigate the behaviour of the received signals under non-"line-of-sight" conditions, an extensive programme of tests was undertaken in the London area. During these tests, the opportunity was taken of measuring the field strengths received at the mobile station and comparing these measured values with those predicted from theoretical considerations.

The tests were made using various fixed station sites, roughly corresponding to sites in open country, together with a site in the centre of a built-up area. The receiver was installed in a car, which was used as the mobile station and, in some of the tests, the transmitted power and the receiver sensitivity were adjusted to a value likely to be obtained with "walkie-talkie" type of equipment.

The transmitter consisted of a low power r.f. unit giving a frequency modulated signal at a frequency of about 115 Mc/s. This unit was used to drive a series of doubler and earthed-grid amplifier stages. A power output of 30 watts was obtained from the final amplifier and, with the length of the feeder in use, gave a radiated power of 6 watts from a simple vertical dipole aerial fitted with a quarter wave co-axial stub standing wave suppressor. The immense loss of power in the feeder with this arrangement was due to the unavoidably large separation between the transmitter and its aerial. No attempt was made to increase the all-round aerial gain, although at these frequencies an aerial array is very attractive owing to its small physical size.

A normal frequency modulated receiver was used in the car and operated on a frequency of 40 Mc/s. This receiver was preceded by an extra frequency changing unit. Figure 1 gives a block schematic diagram of this arrangement, which consists of a capacity-loaded line connected to a silicon crystal valve used as a frequency changer. The local oscillator frequency is provided by a quartz crystal oscillator, followed by a chain of multiplier valves. An additional stage of amplification at the first i.f. of 40 Mc/s is included between the mixer head and the normal receiver. Such an arrangement gave a minimum receiver sensitivity for an intelligible output of 4 μV input across 70 ohms. A complete receiver designed in accordance with the latest practice might be expected to have a sensitivity of the order of 1-2 μV across 70 ohms. The aerial fitted to the car consisted of a quarter wave whip aerial mounted above a metal sheet acting as an earth plane. Again, no attempt was made to use an aerial array to give an increased gain.

Communication from the car to the fixed station was provided by normal v.h.f. equipment with a transmitted power of 10 watts and a receiver sensitivity of 1 μV across 70 ohms. This circuit was operated at a frequency of 100 Mc/s, so that an indirect comparison with the performance of the 460-Mc/s equipment was obtained by noting the areas in which signals to and from the car could not be received.

The characteristics of the equipment used can be

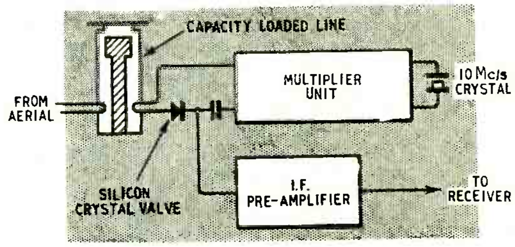


Fig. 1. Schematic layout of the experimental 460-Mc/s receiver.

summarized as follows: (a) transmitter; radiated power 6 watts; peak deviation ±45 kc/s; operating frequency 466 Mc/s; (b) receiver; sensitivity (for usable signal) 4 μV across 70 ohms; bandwidth ±160 kc/s at 3 db points.

For the first series of trials, the fixed station aerial was located on top of a water tower near Ealing, 120 feet above local ground level and some 200 feet above the surrounding terrain. The mobile set in the car was taken to a number of places, including non-"line-of-sight" locations behind near and distant hills. Field strength measurements were also made at selected sites, for subsequent comparison with the calculated values. The non-"line-of-sight" positions can be described as: (a) behind a long range of hills seven miles away; (b) behind a local hill two miles away; (c) behind a large hill four miles away, also partly screened by another hill between it and the fixed station.

The approximate service area for continuous reception had a radius of about eight miles, comparing very favourably with the 100-Mc/s signals. On good receiving sites, of course, much greater ranges were obtainable.

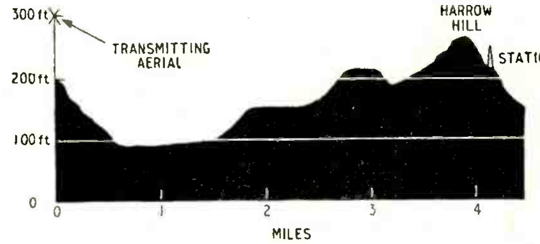
The second series of trials was made with the fixed station in the centre of London, the aerial being mounted 30 feet above roof level, the aerial height above ground level being 130 feet. Mobile tests were again conducted in and about the City of London, and field strength measurements were taken behind Hampstead Hill. Reliable communication in this instance was obtained up to a range of seven miles, and within a radius of two miles the effects due to fading of the signal were negligible.

Some Comparisons

The results obtained in the two series of tests described above gave rise to the following conclusions: communication results obtained during mobile working on a frequency of 460 Mc/s are, in general, inferior to those experienced using a frequency of 100 Mc/s. In isolated instances in built-up areas the 460-Mc/s frequency may give a better service owing to standing wave effect. As is usual with v.h.f. and e.h.f. installations, there is a variation in field strength depending on multi-path propagation and, as a car moves through the resultant field, a fluctuation in field strength is encountered causing the strength of the received signal to vary. The rate of flutter is greater at 460 Mc/s than at 100 Mc/s since the wavelength involved is shorter. When frequency modulated transmissions are used, and provided the receiver has good limiters, the effect on intelligibility is of the same order as when using 100-Mc/s equipment. If, however, the limiting action of the receiver is poor, or the a.g.c. time-constant incorrect, this rapid flutter fading may give rise to an effect which is similar to a superimposed low frequency modulating the speech intelligence. The effect is to mar the speech quality badly and to reduce the intelligibility.

During both trials the equipment operating on 460 Mc/s did not give as great a range as that used on 100 Mc/s. The difference between the two values was, however, usually small, being of the order of 10 to 20 per cent. It was also interesting to observe that, during communication to a heavily wooded country area, the trees appeared to cause more

Fig. 2. Ground contour of typical site used for field strength measurements.



attenuation of the 460-Mc/s signal than of the 100-Mc/s signal. This effect was more pronounced when the trees were wet, although the presence of wet buildings in a built-up area appeared, if anything, to improve the 460-Mc/s communications.

The effect of operating the mobile station under trolley-bus wires and bridges was negligible, unless the bridge was of metal and, at the same time, very low and wide. Even in a town in very heavy traffic, the amount of ignition interference experienced was very small, despite the use of an intermediate frequency of 40 Mc/s and a relatively poorly screened experimental receiver. Good signals were obtained in the centre of the City of London about 2 miles from the fixed station, even in very narrow "canyon"-like streets, and again the effects of passing traffic caused very little alteration in the signal. In particular, it was found that, in these narrow streets, there appeared to be no significant difference in signal level between adjacent streets which were radial and circumferential to the fixed station.

A further series of tests was carried out to simulate the conditions likely to be obtained using "walkie-talkie" type of equipment, and in some instances the receiver used was of the simple super-regenerative type. The transmitted power was 0.25 to 0.5 watt, and the minimum receiver sensitivity for a usable signal was 30 μV across 70 ohms. From a high site the range to the sensitive receiver (4 μV) was $2\frac{1}{2}$ miles in open country and 1 to $1\frac{1}{2}$ miles in a built-up area. With the super-regenerative receiver the range was reduced to 400 yards in a built-up area. In another instance the transmitter aerial was placed about 3 feet above ground level, adjacent to and outside the wall of a brick and steel building, halfway between the two ends of the wall. When using the super-regenerative receiver inside the building the range obtained was between 60 and 100 yards, depending on the type of obstructions inside the building and upon the floor level on which the receiver was used. Outside the building (which was approximately 100 yards square) signals were received along the side where the transmitting aerial was located and along the adjacent sides, but they were not received on the opposite side of the building.

As a general rule the simple "walkie-talkie" equipment gives service, when used in the open, over a range of 200-400 yards, depending on the location of the aerials. When used inside a building the range is reduced to 60-100 yards. It should, however, be remembered that at present it may not always be possible to achieve such performances using filament type battery valves.

An approximate analysis was made of the anticipated field strength in the areas where the field strength had actually been measured This analysis was based on the nomograms published by Bullington.* For the non-"line-of-sight" position, the field strengths were calculated at the crest of the intervening hill to determine whether smooth earth or free space conditions should be used. The appropriate shadow loss and, if necessary, the grazing loss were taken into account.

Figure 2 shows the ground contour of a typical site tested. Allowance is made for the grazing loss over the intermediate hill, and for the shadow loss due to the principal hill. The calculated transmission loss is 119 db, which is in satisfactory agreement with the measured loss of 124 db. A series of some 40 readings were made and the results were found to be consistent for any transmitting station site.

The results obtained with the transmitter on an open site show very close agreement with the results calculated by the Bullington method, the two values usually being within 3 db of one another for a simple non-"line-of-sight" path. This may, to some extent, be fortuitous in view of some of the assumptions made, particularly in regard to the gain or loss of the aerials and feeders. Using identical equipment in a built-up area, it was found that there was an extra loss of some 10 db in the measured values. This loss may be accounted for by the indeterminate extra "grazing" loss due to the roofs of surrounding buildings. Such extra indeterminate losses can be regarded as being a function of the transmitter aerial height above roof level rather than of its actual height above ground level. Small increases in aerial height are therefore likely to give much greater signals, while the converse is also true.

It can therefore be stated that, where a high transmitting aerial is situated in the open, the propagation loss may be evaluated to a fair degree of accuracy, even under non-"line-of-sight" conditions. In a built-up area, however, an extra fixed loss must be added to the calculated loss. This extra fixed loss may vary in any given direction depending upon the heights and types of building near to the fixed station aerial.

The general conclusion drawn from the entire series of tests was that frequencies in the 460-470-Mc/s band could be used for many mobile radio services. A satisfactory service would definitely be obtained, although the service area would be slightly less than when using frequencies in the 70-100-Mc/s band. The service area could be increased by the use of aerial arrays giving omni-directional gain, these aerials being physically small, and might then be comparable with the 100-Mc/s service area. This general statement may not, however, be applicable in extremely rugged terrain so that, as when lower frequencies are used, exploratory tests on the actual site are desirable under such conditions.

* K. Bullington, Radio Propagation at Frequencies Above 30 Mc/s. Proc. I.R.E., 35, 1122-1136 (October, 1947).

Presenting Pickup Characteristics

THE need for a standardized presentation of audio-frequency response curves, to facilitate comparison, has long been recognized, and, as a first step, the Gramophone Equipment Panel of the Radio and Electronic Component Manufacturers Association have recommended their members to adopt a scale ratio of 38 db per octave. Graph paper on this basis (actually 3 inches per octave of frequency and 1 centimetre to 5 db of vertical scale) has been prepared and is obtainable from H. K. Lewis & Co., 136, Gower Street, London, W.C.1. The chart includes a useful ruled panel for relevant data.

Nomenclature: Standard Terms

SEVERAL supplements to British Standard 204: 1943 ("Glossary of Terms used in Telecommunication") have recently been issued by the British Standards Institution, 28 Victoria Street, London, S.W.1.

Supt. No. 2: Glossary of Terms used in Radio Propagation.—Terms connected with radio propagation through the ionosphere and troposphere. Price 2s.

Supt. No. 3: Fundamental Radio Terms.—Definitions of the terms used for the various applications of radio in communication and location, with a chart showing the relation between the various methods. Price 1s.

Supt. No. 4: Glossary of Terms used in Radar.—Price 2s.

CLUB NEWS

Basingstoke.—The secretary of the Basingstoke District Amateur Radio Society advises us that owing to lack of support it has been decided to discontinue the Club's activities. Sec.: L. S. Adams, "Roslen," 16, Bramblys Drive, Basingstoke, Hants.

Belfast.—Two 150-watt transmitters, one 'phone and one c.w., are now in use at the headquarters of the City of Belfast Y.M.C.A. Radio Club, Wellington Place, under the call sign GI6YM. Morse classes are held on Wednesdays—the club night—and Thursdays. Sec.: S. H. Foster (GI3GAL), 31, Belmont Park, Belfast.

Birmingham.—At the meeting of the Slade Radio Society in the Parochial Hall, Broomfield Road, Erdington, on December 8th at 7.45, W. H. Yeates (G.P.O.) will speak on "Telephone Transmission Systems." Sec.: C. N. Smart, 110, Woolmore Road, Erdington, Birmingham, 23.

Bournemouth.—Meetings of the Bournemouth Radio and Television Society (G3FVU) are held on the first and third Thursdays of each month at 7.30 at the Cricketer's Arms, Windham Road. Sec.: F. G. Hamshere, 99, Elmes Road, Winton, Bournemouth, Hants.

Brighton.—Membership of the Brighton and District Radio Club is now about 80 and meetings are held every Tuesday evening at 7.30 at the "Eagle Inn," Gloucester Road. The club station, G3EVE, is operated on alternate Tuesday evenings on 80 metres (c.w. and 'phone). Sec.: L. Hobden, 17, Hartington Road, Brighton, Sussex.

Chester.—Morse classes are held for an hour prior to the weekly meetings of the Chester and District Amateur Radio Society (G3GIZ) which are held at 7.30 on Tuesdays in the Tarran hut in the Y.M.C.A. grounds. Sec.: R. C. Windsor, 17, Hough Green, Chester.

Coventry.—Fortnightly meetings of the Coventry Amateur Radio Society are held on alternate Mondays at 7.30 at the B.T.H. Social Club, Holyhead Road. On December 4th demonstrations will be given of aids to reception. Sec.: K. G. Lines (G3FOH), 142, Shorncliffe Road, Coventry.

Dorking.—Weekly meetings of the Dorking and District Radio Society (G3CZU) are held at the H.Q., 5, London Road on Tuesdays at 7.30. A lecture on valve technique will be given on December 19th. Sec.: J. Greenwell, G3AEZ, 7, Sondes Place Drive, Dorking.

Gravesend.—Weekly meetings of the Gravesend Amateur Radio Society are held on Wednesdays at 7.30 at the club headquarters, 30, Darnley Road, Gravesend. Sec.: R. E. Appleton, 23, Laurel Avenue, Gravesend.

Malvern.—Meetings of the Malvern and District Radio Society are held on the first Wednesday of each month at 7.45 at the "Foley Arms Hotel." A lecture on "Microphones and Loudspeakers" will be given at the December meeting.

Wakefield.—The Secretary of the Wakefield and District Amateur Radio Society will give members of the club "An Introduction to Frequency Modulation" at the meeting at Service House, Providence Street, at 7.30 on December 13th. Sec.: W. Farrar (G3ESP), "Holmcroft," Durkar, Wakefield.

Walworth.—Meetings of the Walworth (Men's Institute) Radio Club are being held each Wednesday and Friday from 7 to 9 at The Avenue School, John Ruskin Street, London, S.E.5. Sec.: J. Gibbs, 22, Caspian Street, Camberwell, S.E.5.

The Hall Effect

Its Application to the Measurement of the Flux Density of Magnetic Fields

IN Clerk Maxwell's time it was thought that the distribution of current in a network of wires or a fixed solid conductor was unaffected—apart from initial transient induction effects—by the application of a constant external magnetic field. Explanations of the failure of experiments to disclose any movement of the current itself, in spite of the very considerable forces experienced by the conductor, were usually sought in terms of the "incompressible fluid" theories then current. They did not entirely convince E. H. Hall,[1] working in John Hopkins' University, U.S.A., who held that even if the incompressible fluid entirely pervaded the conducting material, a lateral pressure, if not a flow, should be detectable.

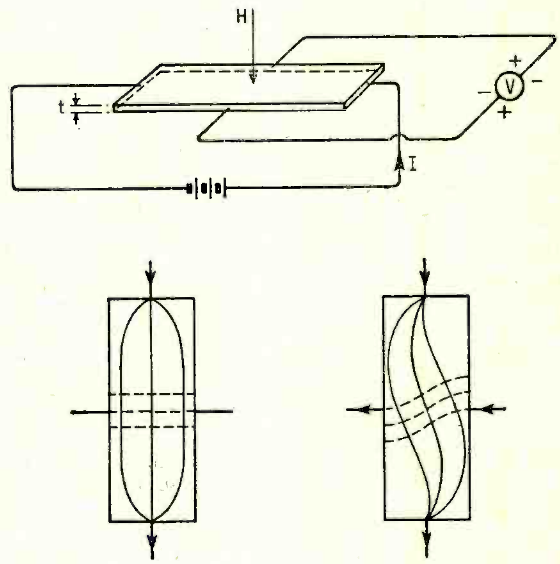
His early efforts to detect changes due to a magnetic field in the equipotential points at the sides of metal strips carrying longitudinal current (Fig. 1) were inconclusive until, at the suggestion of Prof. Rowland, he tried extremely thin conductors (gold leaf on glass). These gave positive results and he was able to show that the lateral galvanometer current was, in fact, proportional to the product of the main current strength and the magnetic field. Later the effect was shown to be inversely proportional to the thickness of the material. Thus the lateral change can be expressed $V = RIH/t$. Where R is the "Hall coefficient" of the material, I = longitudinal current in amperes, H = magnetic flux density in gauss and t = thickness of conductor in centimetres.

Theories of Conduction

According to modern theories of conduction in simple metals (e.g., copper and silver), in which the current is due to a drift of electrons from atom to atom under the influence of an external field, the effect is explained if we assume that the electrons travel in straight lines under the electric field, but describe curved paths under the influence of the perpendicular magnetic field. There is a corresponding distortion of the equipotential lines which gives rise to a potential difference at the side contacts. (Fig. 1 (b).)

In other metals and semi-conductors the polarity of the Hall voltage may be of opposite sign, indicating that the current-carrying elements have the equivalent of a positive charge. These elements are not necessarily particles, but may be "holes" in the structure of a crystal lattice which are temporarily unfilled by electrons. When an electron moves into a vacant site, a "hole" is left in an adjacent part of the structure and this vacancy can travel through the material until it reaches the negative point of connection, when it will be filled by an electron. At the other end electrons are extracted, thus keeping up the supply of "holes."

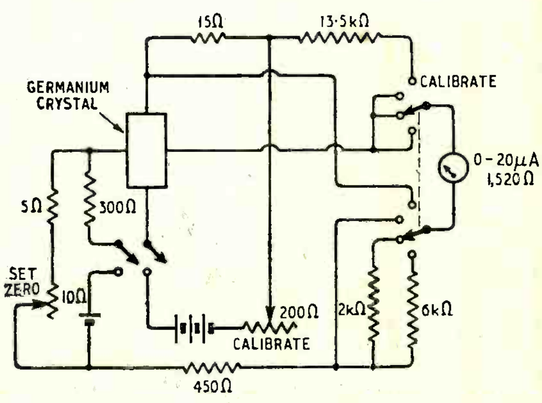
The Hall effect in germanium is very high and the ratio of Hall coefficient to specific resistance, upon which the deflection of any current-indicating meter connected to the lateral terminals will depend, is about 200 times that of copper. G. L. Pearson[2] has shown that it is suitable for the direct measurement of flux densities up to 20,000 gauss, and has described a simple instrument, involving only a $4\frac{1}{2}$-V battery, a



(a) (b)

Fig. 1. Illustrating the Hall effect. Current distribution (a) without magnetic field (b) with field perpendicular to the paper. Transverse equipotential lines are shown dotted.

Fig. 2. Typical circuit for measuring field strength by means of the Hall effect in germanium.



[1] *American Journal of Mathematics*, 1879, and *Phil. Mag.*, 1880, Series 5, Vol. 9, p. 225.

[2] *Rev. Sci. Instr.* Vol. 19, No. 4, April, 1948.

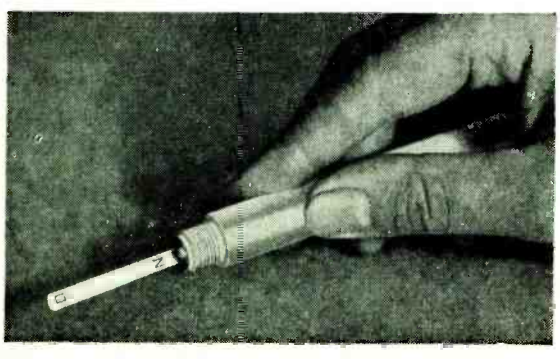
microammeter and resistances, which can be used in conjunction with a thin slip of germanium crystal for measuring, for example, the flux in loudspeaker magnet gaps.

The circuit used by Pearson is given in Fig. 2. Ranges of 5, 10 and 20 kilogauss are provided and the fourth position on the range switch is used to connect the meter across a 15-ohm series resistor to check the main crystal current against a calibration mark. A potentiometer ("set zero") is used to offset any residual lateral current arising from the difficulty of soldering the leads accurately to spots of equal potential.

In Commercial Form

In this country a similar type of instrument has been produced commercially by the British Thomson Houston Company, Rugby, and is known as the Type G gauss meter. A five-way rotary switch gives ranges of 5, 10 and 25 kilogauss and has "Off" and "Calibrate" positions; there are separate calibration and zero-setting controls. The germanium crystal is in the form of a probe and is protected by a non-magnetic sheath having external dimensions of 0.14 × 0.035 × 1.25 inches; longer probes are available. The polarity of the transverse field corresponding to positive meter readings is marked on the probe.

B.T.H. gauss meter, Type G, and (below) close-up of the probe, which is protected by a non-magnetic sheath.



"RADIO LABORATORY HANDBOOK" NEW EDITION

VALUABLE information on all aspects of test and measurement is given in the fifth, revised, edition of this popular book, recently issued from our publishers at 15s. The author, who is well-known as a consulting engineer and as a contributor to *Wireless World*, writes knowledgeably from a long and varied experience of radio. He does so in a way that will appeal to the amateur and to the professional radio man alike, for he is concerned not only with commercial laboratory apparatus but with keeping down expenditure by constructing and improvising one's own equipment. After dealing with the principles of correct measurement, he goes on to describe at length the various types of instruments and how they are used, then makes helpful suggestions on the most suitable apparatus for equipping a laboratory. Considerable space is devoted to particular methods of measurement on components, amplifiers and receivers, and special attention is given to v.h.f. work. There is also a chapter of useful reference information, together with an appendix on the construction of bridges.

This edition has been revised and new material has been added. In particular, the pages on oscillators have been re-written to include the latest developments in RC oscillators, additional information is given on thermistors, valve-voltmeters and cathode-ray oscilloscopes, and the reference section is up to date.

MANUFACTURERS' LITERATURE

Microphones and associated sound equipment described in a set of leaflets from Lustraphone, Ltd., 84, Belsize Lane, London, N.W.3.

Electric Motors of the more popular ratings in an abridged list from Higgs Motors, Ltd., Witton, Birmingham, 6.

Television Aerials and accessories described in an illustrated pamphlet from Validus Aerials, 69, Hornsey Road, London, N.7.

Coilpacks are catalogued and suitable receiver circuits given in a brochure from Osmor Radio Products, Ltd., Bridge View Works, Borough Hill, Croydon, Surrey.

Midget Paper Capacitors, type W99, described in a "Hunt's News" leaflet issued by A. H. Hunt, Ltd., Garratt Lane, London. S.W.18.

Television Components illustrated catalogue, available to manufacturers from the Plessey Company, Ltd. (Components Division), Ilford, Essex.

Communications Receiver, Eddystone "740" general-purpose model described in a leaflet from Stratton & Co., Ltd., Eddystone Works, Alvechurch Road, Birmingham, 31.

"Noise and Vibration in Industry," a booklet dealing with noise-measuring instruments, from A. E. Cawkell, 7, Victory Arcade, The Broadway, Southall, Middlesex.

Sound-level Recorder, high speed, and **pH Meter,** Type 1900, described in leaflets from Dawe Instruments, Ltd., 130, Uxbridge Road, Hanwell, London, W.7.

Schering Bridge specification in a bulletin from Muirhead & Co., Ltd., Beckenham, Kent.

Intercommunication system; the Ediswan Mark II Loudspeakerphone described in a brochure from the Edison Swan Electric Co., Ltd., 155, Charing Cross Road, London, W.C.2.

Receivers and Radiograms for 1951; short specifications in a catalogue from Pye, Ltd., Radio Works, Cambridge.

Television Receiver, Model TU142; a descriptive leaflet from E. K. Cole, Ltd., Ekco Works, Southend-on-Sea, Essex.

Sound Heads for magnetic recorders; brief details in a leaflet from Bradmatic, Ltd., Station Road, Aston, Birmingham, 6.

Earth Analyser for detecting earthing faults on electrical apparatus; a leaflet from Runbaken Electrical Products, 71-73A, Oxford Road, Manchester, 1.

Dark-Screen Television

Use of Tinted Implosion Guards

IN a television picture, the "blacks" are actually the colour of the unexcited portions of the phosphors on the face of the cathode-ray tube as they appear in the particular conditions of external lighting which exist at the time of viewing. Consequently, if the external lighting is fairly high, considerable loss of contrast is noted in the picture, because the light reflected from the face of the tube gives a greyish look to the phosphors.

The obvious way of preventing this loss of contrast is to eliminate external light altogether, but this is often impracticable or undesirable. When the picture must be viewed under conditions of high external lighting it is possible to maintain an adequate degree of contrast by using a suitably tinted transparent light-filter in front of the cathode-ray tube to cut down the light reflected from the face of the tube.

Such a neutral-tinted filter in the form of acrylic sheet is now quite often used in television receivers and it fulfils a double function. In addition to improving the contrast of the picture when viewed in a room not completely blacked-out, its strength in the appropriate thickness gives adequate protection to the viewer should the tube collapse.

The increased contrast is due to the fact that external light in the room passes through the filter, strikes the face of the cathode-ray tube and is reflected back through the filter again, whereas the radiations of the tube phosphors pass through the filter once only. This considerably reduces interference by reflected light.

At first sight it would seem that to obtain a picture of comparable brightness when using a filter to that obtained on a set with the ordinary clear guard, the tube brightness would have to be turned up considerably to make up for the light absorbed in the filter. This is true to a certain extent, but in practice the actual colour of the filter is not a true "straight line" neutral and although the overall transmissions of the colours used are on the average about 50-55 per cent, their transmission curves show a considerable increase in transmission in the blue and red ranges. Transmission curves for the three "neutrals" which have been specially developed for this application are given in Fig. 1, and show that the transmission rises in the blue to about 70 per cent and in the red to over 80 per cent. As the visible light from the excited phosphors of the average cathode-ray tube also peaks in the blue and red, the filter transmits about 70 per cent of the phosphor radiations as against only about 50 per cent of daylight or other external lighting.

A further point which must be remembered is that any type of clear guard of glass or plastic transmits at the best only about 90 per cent of the light from the cathode-ray tube falling on it, so that the com-

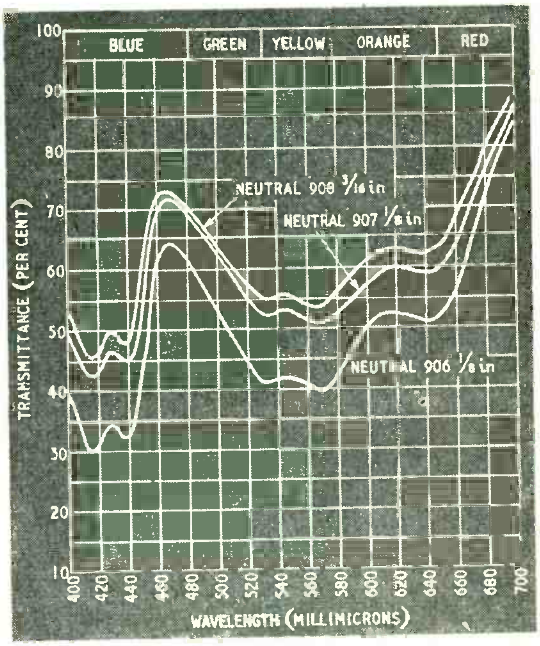
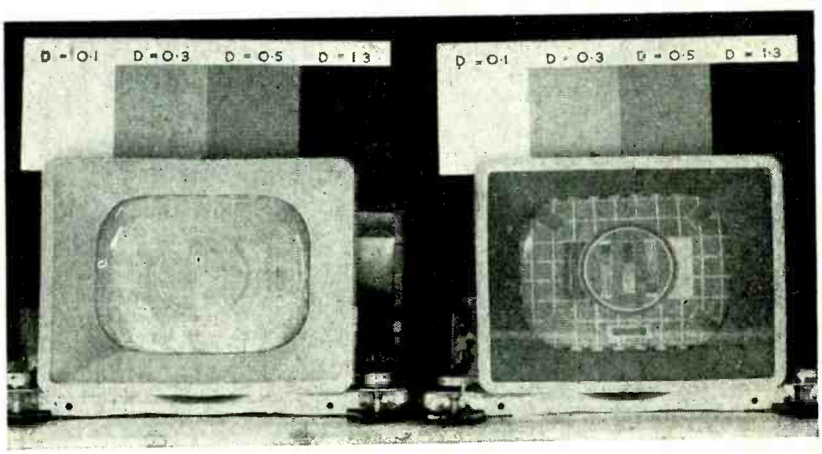


Fig. 1. Light transmission of "Perspex" acrylic sheet television implosion guards. The spectrum colours are indicated approximately against the wave-length scale.

This photograph shows identical sets under conditions of fairly high external illumination. The left-hand set has a clear guard and gives a picture of poor contrast; the right-hand set has a neutral tinted "Perspex" filter and produces a picture of good contrast.



parison of transmission of a tinted to a clear filter is about 70:90 and not 70:100.

A further effect of the coloured filter is that it completely alters the "dead pan" appearance of the cathode-ray tube and mask.

The photograph—taken in the Pye development laboratories, Cambridge—shows two identical sets operating side by side under conditions of fairly high external illumination. The left-hand set, which has an ordinary clear guard, demonstrates a picture of poor contrast. The right-hand set, which has a neutral tinted "Perspex" acrylic filter, manufactured by I.C.I. Plastics Division, England, shows good contrast. Behind the sets are exposure squares ranging in colour from white to black which demonstrate that the photograph shows the effect as nearly as possible as it is observed by the eye. These sets were, of course, individually adjusted to give as good a picture as possible under the existing circumstances.

Radio in Germany

Broadcast Receivers and Sound Reproduction at Dusseldorf

FORMING an opinion of the broadcast receivers on show at the first German post-war radio exhibition, held at Dusseldorf in August, was not made any easier by the scarcity of circuit diagrams, but in spite of this one gained the impression that modern German design techniques are much the same as ours, and no unusual principles are involved. In outward form the sets compare very favourably with models from other countries, and have neat and attractive cabinets without too much emphasis on originality of appearance. At the same time, there is a tendency in some quarters to camouflage receivers as objects of furniture. One superhet, for instance, takes the form of an easy chair, with controls fitted on the arms and a loudspeaker in the back facing outwards. The built-in frame-aerial gives somewhat directional reception, so the chair is provided with wheels to permit easy positioning. Another example is the "Straight Three Bedside Lamp," which has nothing in its outward appearance to reveal that it is a receiver, except that the station names are printed on the shade and a shadow line indicates the station to which the "lamp" is tuned.

Most of the medium-priced German receivers now have an e.h.f. band (86.5 Mc/s to 101 Mc/s approx.) incorporated in the design, and if not, arrangements are made for adding a separate e.h.f. unit by plug-and-socket connection. Some makes also provide for f.m. reception, as there are several f.m. transmitters in use now, in Bavaria and N.W. Germany.

Interest in Tuned Circuits

When judging the merits of a receiver, the German public is interested not only in the number of valves that go with it (usually five or six) but in the number of tuned circuits in the r.f. stages, and this habit of counting tuned circuits (an i.f. transformer counts as two) is reflected in all the sales literature. "Seven tuned circuits" is a sales point, so that a dealer wishing to do business with only three has a difficult time. However, the importance of the properties of the tuned circuits is also appreciated, and quite a few receivers at the exhibition had resonant circuits with adjustable characteristics—variable bandwidth, for instance. With some models, the bandwidth automatically contracts on reception of a weak signal—thereby giving selectivity and an adequate signal-to-noise ratio in exchange for a loss in quality—and then expands again when a strong station is tuned in. Other sets are fitted with a manual bandwidth control, and one manufacturer has combined this with a tone control.

The average price of broadcast receivers in Germany is much the same as in this country, but the lowest prices are well below those charged here. For instance, a straight a.c./d.c. set for reception of local stations can be bought for 65 Deutsch-Marks (just over 5 guineas), whilst the "Straight Three Bedside Lamp" mentioned above costs about the same. These low prices may be partly accounted for by the fact that the number of German manufacturers producing receiving sets has greatly increased since 1939 and competition is more intense.

Unusual Recording System

Among the exhibits of the German Federal Post department, the most up-to-date equipment on show was a telephone amplifier using germanium crystal triodes, or transistors. Compared with the 8 watts of non-utilized power consumed by an equivalent valve amplifier (for heater supplies, standing anode current, etc.) this amplifier required only 0.16 watt—a saving in power or efficiency of 98 per cent.

In the acoustics section, a long-playing gramophone recording system was displayed, giving a smaller average spacing between grooves than is normally possible. With conventional systems of recording, the width of the grooves and the spacing of any two neighbouring grooves is kept large enough to accommodate any sound amplitude—that is, any lateral needle swing—that *may* be necessary in a recording, but in this new system the width and spacing are arranged to be dependent on the amplitudes which actually do occur in the individual grooves and neighbouring grooves. The result of this more economical method of "packing" is that more grooves can be got into the space available, and it is claimed that this gives an average increase in playing time of 100 per cent. Speech recordings would probably allow a greater increase in playing time than would musical performances.

M. L. T.

Manufacturers' Products

New Equipment and Accessories for Radio and Electronics

Miniature Three-Range Coil Pack

A THREE-RANGE coil pack measuring 2½in × 2¾in × 1⅝in and intended for use in small superheterodynes without r.f. stage has been introduced by British Distributing Co., 66, High Street, London, N.8. When tuned by 0.0005-mfd capacitors the three ranges available are: 16 to 50m, 190 to 550m and 1,000 to 2,000m respectively.

The six coils have dust-iron cores. The pack is inductance-trimmed in the factory, and the only adjustments needed after its assembly in a receiver will be to the six trimmer capacitors accessibly mounted on top of the unit. With the single hole fixing and simple wiring, assembly takes only a few minutes. It is designed for an i.f. of 465kc/s. The Bridisco sub-miniature coil pack is priced at 30s 6d.

Quality Amplifiers

A RANGE of quality amplifiers costing approximately £1 per watt has been introduced by the Broadcast and Acoustic Equipment Company, Tombland, Norwich. Resistance-capacity coupling is employed with a paraphase-coupled push-pull output stage.

In the 12-watt amplifier, 6V6 or 6L6 valves are used in the output stage and a 120 mV input is required for full output. Feedback is applied over three loops, and the response is flat within 2½ db between 20 c/s and 15 kc/s. Variable bass and treble boost is included with maximum lifts of 20 db. The price is £12 10s, or £8 10s without power pack.

The 15-watt model has 6L6 or 807 output valves and the overall sensitivity is higher, being suitable for use with a microphone or photo cell. The frequency range is 40 c/s to 20 kc/s within 1.8 db. Bass and treble tone controls are included and the price is £15 10s or £10 10s without power pack.

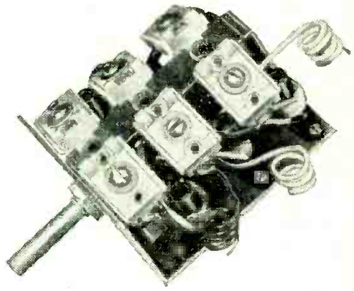
Breeze Plug and Socket for heavy-duty applications has two 100-amp pins and one 19-amp pilot pin, in a brass housing that is waterproof when screwed together. All three socket inserts and the two 100-amp pins can be removed for soldering. The makers are The Plessey Company, Ltd., of Ilford, Essex.

High-Voltage Adaptor, Model 341, has been introduced by Taylor Electrical Instruments Ltd., 419-424 Montrose Avenue, Slough, Bucks, to extend the voltage range of their Model 170A Electric Testmeter up to 10kV.

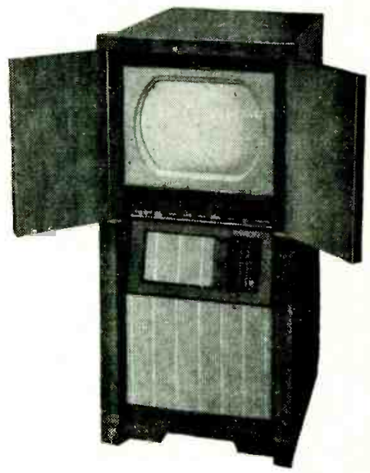
Television Receivers. Suitable for viewing in normal room lighting is the 600A table model projection television receiver produced by Philips Electrical, Ltd., of Century House, Shaftesbury Avenue, W.C.2. It has a flat screen measuring 13¾in × 10¼in with lenticular rulings on the black face to give a wide horizontal angle of view, and is fitted with safety devices to prevent damage to the projection tube should either of the deflecting circuits fail. In a walnut cabinet, the set costs £91 9s 8d with a tablestand or £88 14s 6d without.

Ferranti, Ltd., of Hollinwood, Lancs, have introduced a new range of sets by adding to their console receiver T1205 two more 12-in models, the T1405 table model, and the T1505 combined radio and television receiver. There will be two versions of each model available, and Ferranti will incorporate converter units, free of charge, in all Sutton Coldfield models which may have to be converted as a result of the forthcoming opening of the Holme Moss transmitter.

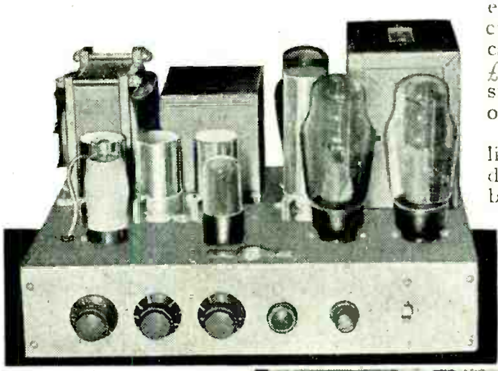
Two-speed Gram Motor. Coinciding with the recent offer to the public of long-playing records, Small Electric Motors, Ltd., Eagle Works, Churchfields Road, Beckenham, Kent, have produced a two-speed gramophone motor operating at 78 and 33⅓ r.p.m. The complete motor assembly, which is of the rim drive type, is compact and suitable for mounting direct on to a metal or wooden baseboard. Although at the moment the standard unit is for use only on 50-c/s a.c. mains, a 60-c/s unit can be offered for the export market.

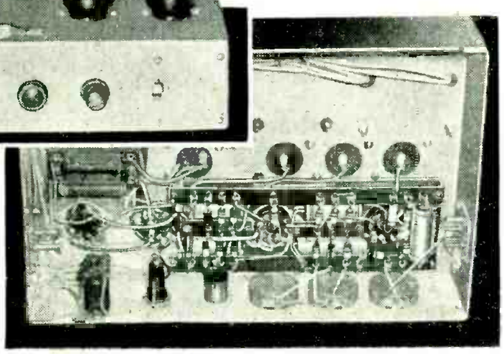


Bridisco sub-miniature coil pack.



Ferranti Model T1505 combined radio and television receiver, with self-contained radio aerials.





12-watt gramophone amplifier (Broadcast and Acoustic Equipment). The underside shows a simplified sub-assembly for coupling components.

UNBIASED

By FREE GRID

Radio and Road Hogs

RECENTLY I was telling you about a small radio transmitter installed in my car which, without infringing the law, enables me, a mile or so from home, to flood the house with light, warmth, music and the smell of sizzling kippers.

A reader who signs himself "Autophile," which, on the face of it, sounds like another name for Narcissus but probably means a car lover, has written to tell me that there is a far more necessary use for a short-range e.h.f. car transmitter than pandering to the soul-destroying sybaritism in which I indulge. He is apparently troubled by the number of inexperienced drivers and experienced road hogs who hurtle along dark country roads at night with dazzling headlamps which they haven't, respectively, the savvy or the courtesy to dip when passing other road users; in fact, according to him, night driving has become a regular battle of headlights. I cannot confirm or deny his words from my own experience as I am at the present time far too engrossed in trying to navigate my car solely by its radar screen and accordingly I leave lighting and all such matters to Mrs. Free Grid, but possibly my correspondent's information explains the presence of the ex-A.A. searchlight that I notice has recently been mounted on the car roof.

Briefly, my correspondent's idea is that headlamps should all be made illegal and the latest type of overhead lighting installed on all roads throughout the land, the capital cost being met partly by the money saved by not manufacturing headlamps and partly by one of the Chancellor of the Exchequer's once-for-all levies. Running costs, represented chiefly by the huge current consumption, could be virtually wiped out by using radio since the lights on any particular furlong of road would not come on until a radio beam from an approaching car was picked up by a simple fixed-frequency receiver which would operate the necessary switch by a relay.

Time Gentlemen, Please

NATIONALIZATION of coal is a burning topic, but, being politically controversial, is naturally barred, together with discussions of other nationalization matters, from the pages of *Wireless World*. I do think, however, that the Editor may make an exception when I call attention to the shameless manner in which the Government's own servants are deliberately sabotaging its most cherished monopolies. I refer to Time, which has had the offices of its control board at Greenwich since vesting day. Wireless, and in particular the B.B.C., has made us all conscious of the boon and blessing of this particular piece of nationalization.

Yet one need only go into any nationalized railway refreshment room to see B.P.T. (British Pub Time) still rigidly observed and the Government's wishes flouted by its own lackeys who fling thirsty electors out on to the cold hard platform five minutes before the legally appointed time. This five-minutes-fast rule must irritate teetotallers also, for after gulping down Government tea and the very aptly named rock cakes, they rush out on to the platform only to find to their chagrin that they have plenty of time to get sedately into the third-class accommodation for which they have paid instead of flinging open the door of a moving first-class compartment and collapsing breathlessly into its cushioned comfort.

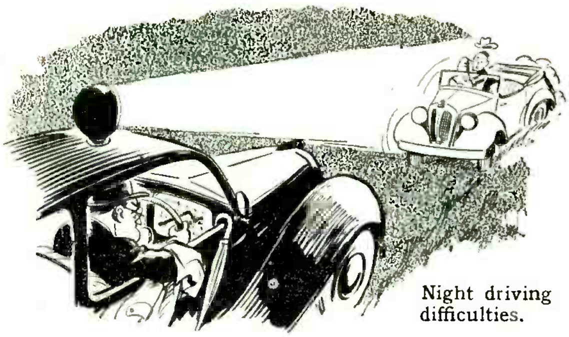
Home-bottled Programmes

I AM glad to see that more and more home recorders are coming on to the market, especially those of the self-contained type using a magnetic wire or tape from which the programme can be easily and quickly wiped out when desired. I have for a long time used a home-made one of this type and I make a regular habit of recording certain B.B.C. programmes just for the pleasure of wiping them out without listening to them.

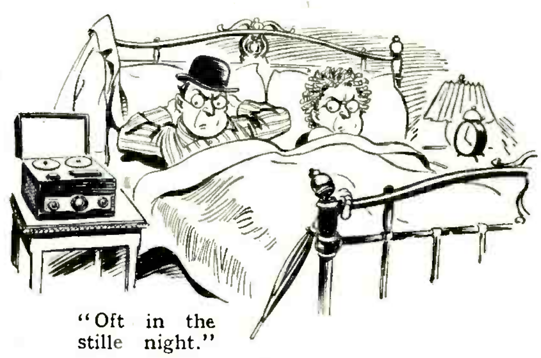
However, as I have said on a previous occasion, the real function of these instruments, in my opinion, is to record programmes which we cannot otherwise hear. Next year during the Festival of Britain when, as we have all been bidden, we are devoting all our energies to enlightening the overseas visitors on "this realm, this England," we shall have still less time to listen. We shall, in fact, have to bottle not only the B.B.C.'s day-time programmes but the evening ones as well for consumption in what we shall with literal truth be able, with apologies to Thomas Hood, to call "The Stille Night."

It is possible, of course, to bottle any programme at will by means of an ordinary receiver, a time switch and a recording unit. We can, in fact, select and bottle all our listening for a week ahead for consumption at our leisure. I am able, by this means, to keep a car full of guests cheerful and free from the vice of backseat driving when rolling home in the small hours long after the B.B.C. has closed down.

I have little doubt that by doing this I am not only infringing copyrights galore but also transgressing against the rights of innumerable recording companies; I trust they will all send along the necessary writs to the Editor who will accept service on my behalf. I can only think that it is this question of copyright and recording rights that prevents manufacturers putting forward an all-in-one receiver-cum-automatic recording unit. Can some of you legal luminaries enlighten me?



Night driving difficulties.



"Oft in the stille night."

LETTERS TO THE EDITOR

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

Resistor Colour-coding

IS it not time that the manufacturers of colour-coded resistors made up their minds as to the meanings of the colours? There is great confusion between Black for Nought and Brown for One—I have before me two resistors with orange body and tip, and brown spot; on a bridge they are 33 ohms and 330 ohms respectively! Green Black Black is shown on the bridge to be 50 ohms—how would 5 ohms be marked, then? Among a batch of 50,000-ohm resistors, the honours are about even between Black and Brown for the tip colour. Surely, if Black means Nought, when it appears as body or tip it must mean *Not Even a Nought* (a simple explantation becomes a little Irish, but you must see what I mean).

Worse is to come—with certain high-stability resistors a fourth stripe appears for the tolerance and bears its correct colour (in place of the familiar gold and silver of the humdrum resistor). Some resistors have a black moulded body; here is one with brown tip and yellow spot; it measures 100,000 ohms, using the body colour for the initial ONE. But here is one with black body and two red stripes; it measures 2,200 ohms, showing that this time the black body forms either the intermediate or final colour, according to taste; finally, a brown moulded body with three stripes, Red Red Brown; this measures 220 ohms, showing that the body colour is now disregarded—you have my sympathy if you thought that this was a 1,200-ohm 1 per cent resistor.

No wonder one manufacturer takes no chances and places round his colour-coded product a label bearing the value in clearly printed figures! PETER D. DAW.
London, S.E.1.

Stereophonic Broadcasting

IN your issue of September, 1950, I read an article about improved stereophony in which E. Aisberg started his article with the following words:

"The first broadcast of stereophony, the system in which sources of sound are restored to their relative positions in space, took place in France on June 19th, 1950."

Although I understand the feeling of stating something new, in this case there is a *deus ex machina* in Holland.

On June 15th, 1946, there was a stereophonic transmission with a specially constructed artificial head, equipped with two condenser microphones, that broadcasted a concert given by the Dutch Radio-Philharmonic Orchestra.

Also the manifold publications of our industry—Philips, Eindhoven, about stereophony (Dr. K. de Boer), were not mentioned at all in this publication.

J. J. GELUK,
Netherlands Broadcasting Union.
Hilversum, Holland.

THE article by E. Aisberg in your September number was of considerable interest to me, having had experience of an opposite problem during the earlier stages of the late war with acoustic locational apparatus for aircraft.

In his seventh paragraph he mentions the differential intensity of sound being responsible for the binaural effect. Although the intensity effect exists over short periods with human ears, it was always my experience that it was the phase differential aspect which predominated in any locational exercise or practice. To be equipped with tubes and receiving horns extending the aural sound base from 6in to 8ft and to centre these upon a stationary sound source produced a remarkable effect in that the nodal point of no phase difference travelled recognisably round the back of the cranium. This, of course, operated in one plane only for one "listener."

For perfection we will need a wall in which are positioned 5 loudspeakers (the middle one to take up slack) and two listeners, one sitting normally to recognize what is going on in the horizontal plane, and one prone to follow the vertical movements of those who climb staircases or rise upon piano wire, or to hear, for example, the gravitational descent of "Les Larmes du Diable."

M. F. L. FALKNER.
Holmes Chapel, Cheshire.

YOUR contributor's account (September issue, page 327) of the recent French broadcast over two channels does not, to my way of thinking, make a clear enough distinction between true binaural stereophony (in which two microphones mounted in an artificial head are used at the source, and headphones are used at the receiving end) and other systems which simulate directional effects.

Neither is it true to say that the appreciation of acoustic *depth* is essentially a product of binaural hearing. Distance between sound source and microphone in a studio is readily judged in a single-channel system by the ratio of direct to reverberant sound. The inclusion of a reverberation chamber in the system described suggests that the designers are well aware of these facts, and, together with two-channel control of volume, they have placed at the disposal of producers a versatile medium of expression. I believe that Bernhart and Garrett describe their work as "directed" stereophony, which seems a happy phrase. HENRY MORGAN.

Hindhead.

WITH reference to the article in the September *Wireless World*, I note that there is no reference to the effect of phase displacement in the location of a source of sound.

I had understood that whereas amplitude formed the chief discriminating factor in the case of the high notes, phase discrimination was important in the lower register where amplitude differences are less marked.

(This is physiologically possible since at low frequency the nerve impulses are synchronous with the sound waves. Note that this does not involve phase discrimination between waves of different frequency.)

If this is so Fig. 1 (a and b at least) will preserve the original phase relations intact, provided the channels are balanced, but Fig. 2 ought to introduce a certain amount of distortion unless the faders can be made to introduce the correct phase displacement, a problem of no small magnitude in an electrical circuit.

H. R. A. TOWNSEND.

South Cerney, Glos.

Hint to Manufacturers

WHEN buying a television set its position in the home should be in a room different from that in which a wireless set is kept. This is obviously desirable when only one wireless set is available, as a member of a family may well wish to hear a particular sound programme during television transmitting hours. It is also desirable in these days of flats and small rooms which quickly tend to become overcrowded. At the same time sound broadcasting is sometimes required in the room used for television. The answer, of course, is an extension speaker, but this not only adds to the overcrowding, but is an additional expense. In the television set, however, there is a loudspeaker which is idle for a large part of the day. May it be suggested to television manufacturers that a simple switching apparatus be incorporated in television sets (other than combined sound models, of course) so that the speaker may be used as an extension speaker from a wireless set. The speaker could be wired for use when the television set is installed. D. R. BRAY.

London, N.22.

Raising E.H.T. Voltage

I FEEL the greatly improved brightness and focus of modern receivers is due to using voltages of 6 to 10 kV whereas it was quite common in older types of receiver to use from 3 to 4 kV.

The obvious method of changing the e.h.t. transformer for one of higher voltage might be considered too costly in an old receiver. The only alternative is to use line flyback e.h.t. but it will usually be found that the line output transformer is unsuitable for this purpose and with a simple half-wave system would only provide about 2 to 3 kV. But if this voltage could be added to the existing system the e.h.t. could then be 6 to 7 kV or more. Unfortunately, however, the straightforward connection of a rectifier and condenser would not work as the cathode of the rectifier would be at a higher positive potential than the flyback pulse feeding the anode. The best way of adding the voltages is as shown in my diagram. This circuit might seem a bit puzzling until it is realized that the extra components $V_2C_2C_3R$ are really the top half components of the usual voltage doubler system sometimes used in flyback e.h.t. systems.

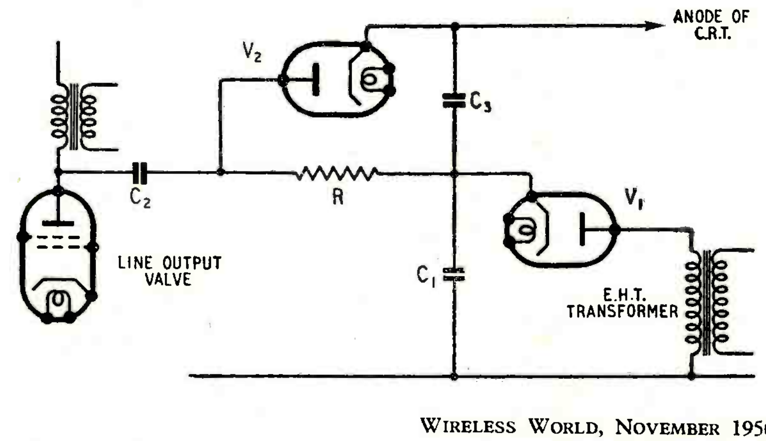
During the forward scan C_2 will be charged up through R to the same potential as C_1. When the flyback pulse comes along these two voltages will be added and will be applied to the anode of V_2, thereby charging C_3 and C_1 to the combined voltage. So therefore with the simple addition of two condensers, a resistor, and a rectifier, almost double the e.h.t. voltage could be obtained. This would naturally mean that increased scanning power would be required and whether this is within the capability of the set is another matter, although I have found this just possible in most cases.

It would be rather more difficult using the voltage doubler system with the existing mains transformer as one side is usually earthed and must remain so. In any case, much larger capacitors would be required whereas with the above method C_2 and C_3 need only be 0.0003 μF; R is 2 MΩ.

It would be better to use a metal rectifier for V_2 and no heater voltage would then be required.

L. J. HILLS.

Belvedere, Kent.



American Insularity

HAVING read with interest the correspondence on the above subject in your journal, I felt it would be interesting to analyse the footnotes and references in a typical American publication. This I have done for the excellent collection of articles entitled "Electronics Manual for Radio Engineers" (Zeluff and Markus; Pub. McGraw-Hill). This book contains 872 pages of text, covering 289 "all-time-great articles" from *Electronics* 1940-48.

The total numbers of separate references are as follows: American, 466; British, 38; others (mainly German), 14; (A few references are of doubtful origin and may have been added to the wrong list). Of the 38 British references, 6 are to O. S. Puckle's "Time Bases," 5 to *Wireless World* and 3 to *Electronic Engineering*, leaving a paltry 24 to represent the remainder of British brains.

A further analysis shows that of 77 pages of microwaves (did we do any radar work in this country?) there are 3 British references, and of 75 pages on television, only 1! In an article on the "Phantastron," although it is admitted that the circuit originated at T.R.E., there are no British references and 3 American references.

It is important to realize that these figures are not taken from one isolated case, but represent the attitude of 270 different authors to the efforts of workers outside their own country.

Although I have not made a similar count in any British publications, a quick check through 3 copies of *Wireless World* and 3 of *Electronic Engineering* shows that more than 50 per cent of references are to American literature.

A. T. COLBECK.
Talgarth, Brecon.

Names and Titles

AS an "old timer" in the world of wireless I have been giving some thought to nomenclature and titles.

The first refers to v.h.f. radiotelephony between private vehicles, tugs and the like, offices, etc., with, at present, the unwieldy designation of "Business Radio." It is extraordinary how difficult it is to arrive at a suitable name covering this application of the art. Of course there is R/T, but this encroaches upon service terminology and in any case is still not a word. RADIOPHONY appears to cover it, but it would be interesting to have opinions of your many readers.

My second search has been for a suitable title covering the 1951 Radio Exhibition, observing it cannot be held at Olympia. RADIOSHOW is what it is, but RADIOBRITAIN seems to cover the special occasion. Again, what do your readers think?

H. ANTHONY HANKEY.
London, W.4.

"Television In Your Home," a new booklet written for the layman by W. E. Miller in clear non-technical language, provides all the information a viewer needs to know before and after purchasing a receiver. The confirmed televiewer also will find here answers to some of the questions which may have cropped up during his viewing experience. After describing the television service and sketching the basic principles of television, the booklet gives useful advice on the choice, installation and correct operation of a receiver, and ends with a comprehensive list of questions and answers. Copies can be obtained from all bookstalls, price 2s, or direct from our Publishers, price 2s 2d.

RANDOM RADIATIONS

By "DIALLIST"

Big Tube or Projection?

INTERESTING TO NOTICE that television receivers seem to be developing along quite different lines in this country and in the United States. Viewers in both countries want big images: here the tendency is to provide them by projection methods; on the other side of the Pond they are all in favour of the monster c.r.t. I don't know of any model amongst this year's British receivers with a tube bigger than 15 inches, nor are there many such; but in America there are quite a few with 19-inch tubes and for all I know some may use even larger ones. One reason, I suppose, for our different approaches to the problem of the big image is that America, with an output that runs into quasi-astronomical figures, can turn out c.r.t.s a good deal more cheaply than we can. We, on the other hand, seem to have advanced rather further in the technique of making reasonably long-lived, small, super-brilliant projection-type tubes.

Direct Comparison

Not all comparisons are odious, despite the old saying. I recently had the opportunity of making one that can't have been possible to any vast number of people, and, far from being odious, it was surprisingly interesting and instructive. Briefly, I watched the simultaneous display of a whole television programme by projection and big-tube methods. The images were of the same size—about 16 by 12 inches—and the two screens were side by side. The big tube was provided with optional spot-wobble; that is, the "spot-wobbulator" could be switched on or off at will. The first thing to strike one was that, even at short range, no lininess was apparent in the projected image, though it was very much in evidence in that on the large tube when the spot-wobble was not applied. The reason, presumably, is that in small high-voltage tubes one cannot obtain a focus that is relatively as sharp as that of a high quality tube of large diameter. In other words, the spot on the small tube has sufficient spread to cover up the effects of lininess. One might expect this to lead to a rather poorly-defined image; but I cannot honestly say that it had this effect. My general impression was that though the projected image might be a little lacking in depth when directly compared with the other, it was distinctly more pleasing (and less tiring) to the eyes than an unwobbled image on the big c.r.t.

Passing Thought

It must be no mean job to design and manufacture very large cathode-ray tubes. It wouldn't be so bad if the business end could have a pronounced convex curve, for this would have a much better chance of standing up to the strains resulting from a vacuum within and an outside atmospheric pressure of getting on for 15 lb to the square inch, but the end of the television c.r.t. must be as nearly flat as possible. Take a 20-inch tube to make calculations nice and easy, and you have a surface area for the screen of 314 square inches. That multiplied by 14.5 gives a total air pressure on the screen of 4,553 lb, or a little over 2 tons—the combined weight of 32 average men and women.

Nomenclature

SOMEHOW, I am not attracted by F. B. Rudd's suggestion in the September *Wireless World* that what we now know as the intermediate frequency should be styled henceforward the resultant frequency. For one thing, you could not abbreviate it to r.f., for that is already in use for radio frequency. Our frequency designations are a pretty bad muddle, anyhow. The main reason is that so many of the terms are used sometimes with a relative and sometimes with an absolute meaning. What, for instance, is a high frequency or a low frequency? Glance through disquisitions by various writers on the amplification problems in different parts of the receiving set and you will see what I am driving at. Myself, I would like to see a standardization on the following lines. Let the three main classes of frequency met with in a receiver be named respectively signal, intermediate and audio frequencies—s.f., i.f., and a.f.; divide each of these into three degrees: upper, middle and lower. All the three class terms are relative, for s.f.s may be anything from a few kilocycles to thousands of megacycles, i.f.s have a smaller but similar possible range and a.f.s run from frequencies below the limits of human hearing to those a long way above those limits, but, as applied to the receiving set they are perfectly clear.

Still They Come

THERE CAN BE no doubt that television has caught on as a national hobby. By the time that this is printed the number of licences will probably have passed the half-million mark, which means that, despite raw material shortages and production difficulties, a very considerable proportion of the homes in which reception is possible will have television sets. Between them the London and Birmingham service areas have a population of some 18 millions. Allowing an average of four persons to each household gives a figure of 4.5 million homes in the areas. For one reason or another television reception is probably impossible in at least half-a-million of these. Hence, just about one home in every eight in which reception is possible now has the necessary equipment. What will the saturation figure be? Higher costs—initial, maintenance, running and replacement—will naturally make it much lower than the figure for sound broadcast receivers, which are now part of almost every home. For television I predict it will turn out to be somewhere between one home in four and one home in five.

Terminals

THE TERMINAL (*Americè*: binding post) as we know it to-day and have known it for umpteen years is definitely not a satisfactory electrical device. There are only two main types. In one of these a nut clamps the wire or wires to a non-moving base. In the other the base is again fixed, but the clamping is done by the point of a screw. The trouble in either case is that the moving part of the clamping system rotates and in so doing grinds, bruises and even cuts the wires. We're all only too familiar with defects due to the eventual breaking of wires—particularly flex—at the point of compression in the terminal. What is urgently wanted is a terminal in which a straight push, without any twisting action, is exercised on the wires.