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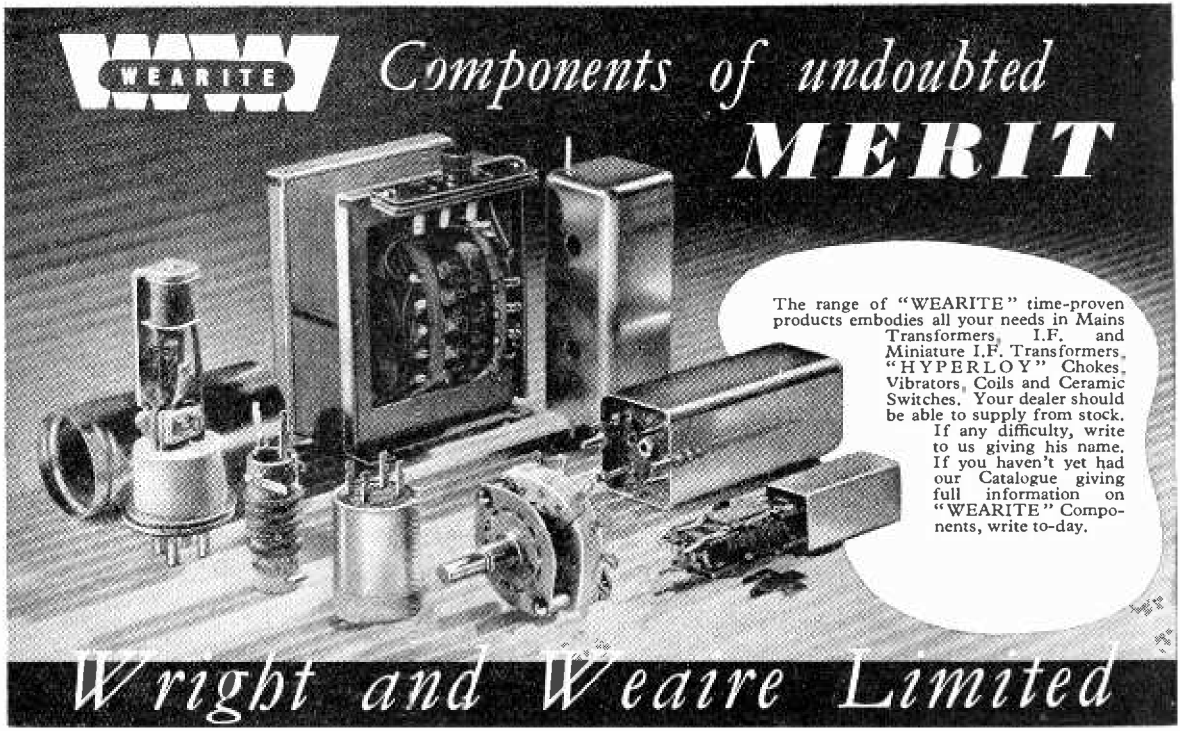

Valves and their applications

DELAYED AGC WITH E/UAF42

Receivers using AGC without delay suffer from the disadvantage that full output will only be obtained with a much larger signal input than in the case of a similar receiver with delay, and the overall amplification will appear to be less.

Delayed AGC may be obtained with various types of two-diode circuits, but modulation distortion frequently results from the loading of the primary of the IF transformer by the delayed AGC diode. This disadvantage may be overcome by the use of a three-diode circuit in which each diode performs its separate function—detection, AGC, and delay. The circuit to be described is a modification of this circuit which uses a single-diode pentode, the pentode section being the IF amplifier valve. While the advantages of coupling the AGC diode to the primary of the final IF transformer are lost, the circuit avoids modulation distortion and a very satisfactory delayed AGC characteristic results.

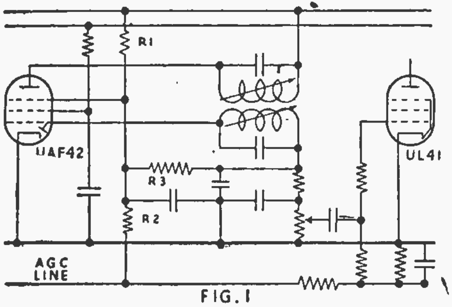

FIG. I

Fig. 1 illustrates a circuit using a UAF42 (or EAF42) diode pentode in which the main diode D1 provides the detector and AGC voltages while the suppressor is used as an auxiliary diode D2 to provide the delay which prevents operation of the AGC line until a predetermined signal level is reached.

The satisfactory operation of the circuit depends on the fact that for the E/UAF42 (a) the Ig3/Vg3 characteristic rises sharply with increasing suppressor volts and will consequently give a well defined delay voltage and (b) the internal resistance of D2 is low (50K Ohm). The suppressor is connected through a high resistance R1 to the HT supply and through R2 to the AGC line. For small signals, the suppressor will be at substantially the same voltage as cathode since the negative voltage developed by D1 will be small. D2 will conduct and the AGC line voltage will remain constant; as the input signal increases, the suppressor will be driven negative, D2 will no longer conduct and the AGC line will operate. The magnitude of the delay voltage will be determined mainly by the values of R1 and R3 : R1 = 22M Ohms, R2 = R3 = 2.2M Ohms, HT = 170 volts, the delay will be approximately 15 volts.

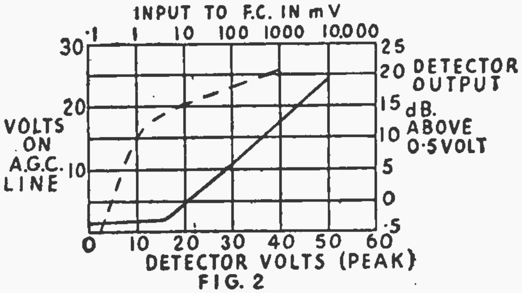

FIG. 2

The graph of volts on AGC line against peak detector volts (in full line) in Fig. 2 shows that the change in AGC line voltage over the range 0 to 15 peak detector volts is only 0.5 volts compared with 9 volts from 15 to 30 peak detector volts. The AGC characteristic for 30% modulation of a typical receiver using E/UAF42 is shown (in dotted line) in Fig. 2, the delay operates from 0.2 to 1mV and the AGC characteristic is flat to within 5db from 1 to 1000mV signal.

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Wireless World

RADIO AND ELECTRONICS

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Comments of the Month

IT is freely admitted that broadcast receivers are numbered among the very few articles of commerce of which the present supply exceeds demand by a considerable margin. The recent reduction in purchase tax has apparently done little to stimulate buying, and, indeed, the reason for reluctance on the part of the general public to do so is by no means obvious. Judging by the steadily rising licence figures, broadcasting is not losing its attraction, and new homes, presumably needing new equipment, are being set up in considerable numbers.

The price of receivers, if we deduct the unpopular purchase tax, has not risen since 1939 to as great an extent as that of most other comparable articles. In spite of that, it is widely believed in wireless circles that high cost is responsible for public apathy, and the view is often expressed that there would be a widespread demand for a really cheap set. Those who voice such opinions generally add that such a set could best be produced by abandoning continuously variable tuning in favour of switch selection of three or four stations. The advocates of this type of set contend that it would be vastly cheaper, and would satisfy the needs of the majority; even the minority who normally require continuous tuning and a good R.F. performance would buy it freely as a "second set," especially if the price were made sufficiently attractive.

This question of the cheap set raises many interesting problems, both technical and economic. In the first place we doubt very much if a switch-tuned receiver, of a design suitable for use in all areas of the country, would be appreciably cheaper than the more-or-less standardized 4+1 superheterodyne. It might well be more costly. Admittedly, a really cheap receiver for use in districts where high selectivity is not necessary for meeting the simpler requirements could easily be devised, but its retail distribution would probably introduce many commercial problems. This matter of selectivity is the fundamental problem; so far, the most economical solution has been found in the conventional superheterodyne. We think, however, that the time has come for designers of broadcast receivers to explore basically new methods of cheapening production.

Radio Equipment of Buildings

WE welcome the issue, under the ægis of the Ministry of Works, of a "Draft for Comment" of a British Standard Code of Practice* on the equipment of new buildings for broadcast sound and television reception. The recommendations relate mainly to aerial systems, the installation of which has hitherto been in the nature of an afterthought. A number of different types of aerials are treated.

On the broader issue, it is gratifying that the code is issued in the form of a "draft for comment," available to any interested member of the public who cares to buy it; comments are specifically invited, and will presumably be taken into account in the preparation of the final code. This is a procedure that might be followed much more widely. Standard specifications are being issued at a great rate and, however good the qualifications of those who prepare them, there is always the risk of some glaring error or serious omission, due, perhaps, to lack of knowledge on some highly specialized aspect of the subject by those responsible. A case arose recently where it was found that standardized symbols could not be legibly printed by ordinary type-setting methods, with the result that the wide adoption of this particular form of standardization was in jeopardy. This is a matter where a great deal of circumspection and a fine discrimination is clearly needed. "In a multitude of counsellors there is safety," though, as some cynic recently added, "there is the probability of intolerable delay."

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* *Broadcast Reception: Sound and Television by Radio* (Code 327:201). British Standards Institution; 5s.

Vibrator Power Packs

Some Notes on the Principles of Design

By

D. A. BELL, M.A., B.Sc.

LARGE numbers of vibrator power packs are now being used in mobile P.A. and V.H.F. equipments for obtaining H.T. supply from a lower-voltage D.C. source. It therefore seemed worth while to collect the results of investigations into several aspects of vibrator power packs which the author has carried out at various times. The problems can be sub-divided as follows :—

(i) The role of the "timing" or "buffer" condenser which is connected across the transformer secondary, and the choice of the correct capacitance.

(ii) Operating conditions of the transformer iron and copper with approximately square-wave currents.

(iii) Regulation.

(iv) Suppression of radio interference or "hash."

The fixed condenser which is connected across the whole of the secondary winding is sometimes called the "buffer" condenser, but in view of its true function it is better described as the "timing" condenser. The basic circuit of a transformer with a self-rectifying or synchronous vibrator is shown in Fig. 1, and both sides of the transformer are wound for double voltage and centre-tapped in the same way as the secondary of a transformer feeding a full-wave valve rectifier ; but to obtain the simplest circuit for theoretical analysis we will first replace the double-wound transformer and vibrator by a single-wound transformer and reversing switch, and then replace the transformer by the equivalent circuit viewed from the secondary side. Thus in Fig. 2 the battery is assumed to be stepped up to the secondary voltage, R is the secondary load, C the timing condenser and L and r the inductance and resistance of the transformer circuits as viewed from the secondary. The operation of the vibrator is then represented by the periodical changing over of the reversing switch, and when this opens there is a certain current, i_L say, flowing through the inductance L as well as a load current flowing through R. The inductance tends to maintain this current i_L, but the load R is disconnected by whatever rectifying system is used (since the maintenance of i_L after the battery switch is opened would require current flow through R in a sense opposite to that of the main battery current through R), and in the absence of the condenser C there would be an abrupt cessation of the current through L, i.e., a large negative value of di_L/dt and hence a high voltage. In fact there will always be some stray capacitance even if no external condenser is fitted, so the current i_L after the opening of the battery circuit flows in an oscillatory circut, L, r, C ; and if there were no losses ($r = 0$) conservation of energy would require the condenser to be charged to a peak voltage V_C such that

$$\tfrac{1}{2}CV^2_C = \tfrac{1}{2}Li^2_L \quad .. \quad ..(1)$$

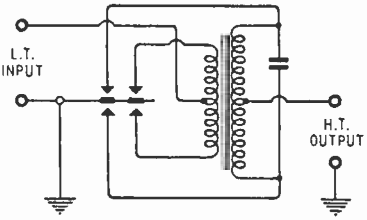

Fig. 1. Circuit of synchronous vibrator with transformer and "timing" condenser.

In the particular case of a transformer supplying a small radio set with 50 mA at 300 V, if the secondary inductance is 30 H, the stray capacitance is 0.001μF. and the "magnetizing current" $i_L = 10$ mA, equation (1) will give $V_C = 1740$ V. approx. This is the secondary voltage "spike" which in the absence of losses would occur under incorrect operating conditions and would break down any insulation designed for the normal 300 volts working.

Now suppose that the capacity across the secondary is increased by adding an external condenser. The peak voltage is reduced according to the square root of the capacitance, since from equation (1), $V_C = i_L\sqrt{L/C}$, and at the same time the period of oscillation is increased as the square root of the capacitance. Considering only a single break of the circuit, the effect of adding capacitance is to change the waveform from curve (i) to curve (ii) of Fig. 3(a). In practice the vibrator contacts re-close in the opposite polarity shortly after opening, so ideally the voltage waveform should be as shown in Fig. 3(b), and the problem is to produce a rate of voltage change during the "contacts open" part of the cycle which will fit as smoothly as possible into the "contacts closed" parts. This will occur if the point marked X in Fig. 3(a), curve (ii), which corresponds to − 300 V., also corresponds in the time scale to the instant of re-closing of the vibrator contacts.

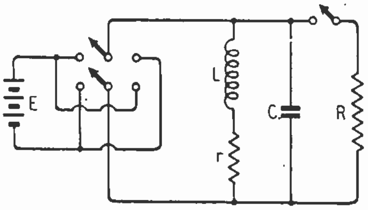

Fig. 2. Equivalent circuit of vibrator and transformer.

Fig. 4 shows idealized waveforms for limited variations of condenser capacitance about the correct value, and Fig. 5 shows tracings from oscilloscope pictures obtained in practice with different sizes of condenser. Clearly the timing conditions will be least critical if the point X in Fig. 3(a) occurs near the (negative) crest of the free oscillation of voltage, where the rate of change of voltage with time is small ; but in the absence of dissipation the reverse-voltage peak would fall to the working voltage only when the condenser was so large as to make the oscillation period of the same order as the whole period of the vibrator cycle, i.e. the transfer of the inductive energy to the condenser would take as long as its accumulation in the inductance. With the small condenser required for correct timing, therefor, the voltage is likely to be still rising at the instant of vibrator contact closure, though the presence of iron and copper losses in the circuit reduces the amplitude of free oscillation.

One firm manufacturing vibrators has suggested including a resistance in series with the timing condenser, presumably in order to provide additional damping for this purpose, but it is more usual for the damping to be light enough for the voltage to over-swing appreciably, and correct timing is relied upon to give the appropriate voltage for re-closing the contacts. For a given time of change-over of vibrator contacts, the value of capacitance C which is required is inversely proportional to the transformer inductance L.

Now in any given iron-cored transformer the inductance L will usually vary inversely with the flux density, and therefore inversely with the input voltage. It follows that if the timing capacitance is initially set to be correct at nominal input voltage (e.g. 12 volts from a 6-cell lead-acid accumulator), it will be too small when the transformer inductance falls on high input voltage (e.g. 15 volts with battery on charge) and too large on low input voltage (e.g. 10.8 volts from a discharged battery). Since too small a capacitance can give rise to dangerous over-voltages on the transformer secondary, but too large a condenser causes little more than a slight loss of efficiency the timing condenser should always be chosen of value appropriate to the highest input voltage likely to be met, not to the mean or nominal input voltage.

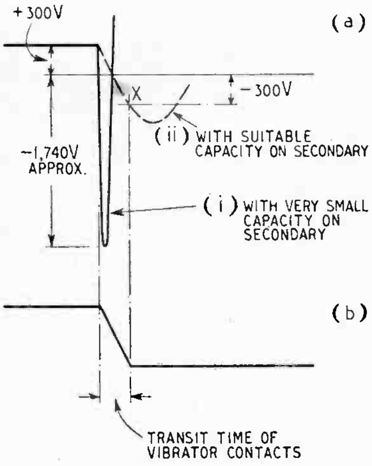

Fig. 3. (a) Effect of secondary capacitance on voltage waveform for a single break. (b) Ideal voltage waveform for break and re-make.

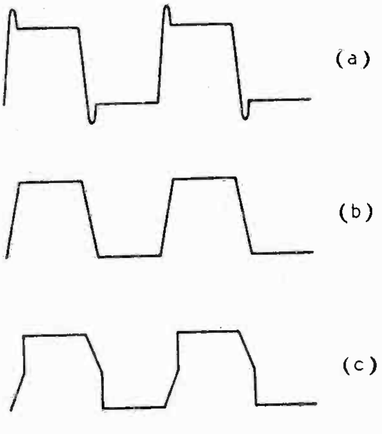

Fig. 4. Theoretical waveforms for different condenser values ; (a) too small, (b) correct, (c) too large.

If the condenser is too large, giving a waveform of the type of (c) in Figs. 4 and 5, the condenser is abruptly charged to the new voltage when the contacts re-close, but since the energy from the inductance will not all have been transferred to the condenser, the residue of the inductive energy should be transferred back to the battery. Small upward pulses of primary voltage have been detected under such conditions, but according to a moving-coil ammeter there is no saving of mean battery current. In fact, the capacitance value for minimum mean battery current corresponds very closely with the value which gives waveform (b) of Figs. 4 and 5 ; and although it is desirable to check the waveform oscillographically, the condenser size can in an emergency be adjusted for minimum input current.

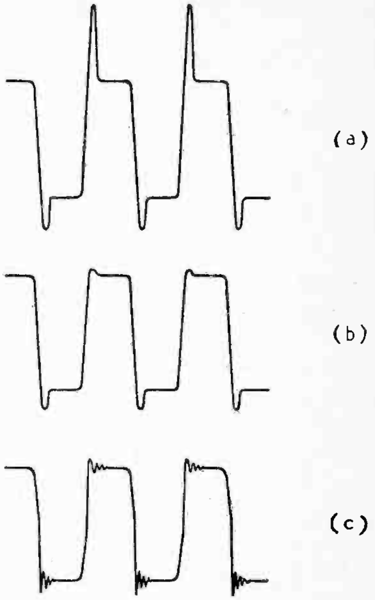

Fig. 5. Observed waveforms corresponding to Fig. 4.

An open-circuit timing condenser makes the transformer behave like a short circuit, even if no permanent damage is caused, and this is presumably due to the secondary voltage surges setting up a continuous arc across the vibrator contacts.

Provided that the timing condenser is of sufficient capacitance to give correct timing with the transformer in question at maximum input voltage, there appears to be no reason why it should have any exceptionally high voltage rating : it is never likely to receive a voltage more than 10 per cent above the amplitude of the square wave on the transformer secondary. On the other hand, it is working under A.C. conditions, and must be capable of handling a small amount of current. The change-over time of a vibrator is, in very round figures, 1 millisecond ; and if we take a condenser of 0.02 μF reversing its charge from + 300 to − 300 volts, the current can be found as the change of charge divided by the time during which it occurs, and comes out to 12 mA. This should not cause any trouble.

The simplified form of the voltage wave of a typical vibrator

Vibrator Power Packs—
transformer is illustrated at (a) in Fig. 6. This is drawn to scale for a vibrator with contact closure time of 40 per cent each way, i.e. each contacts-open period is 10 per cent of the complete cycle. Since the voltage per turn is proportional to the rate of change of flux, $E_0 = 10^{-8}. d\Phi/dt$, the flux may be determined by integrating the observed voltage:

$$\Phi = 10^8 \int E_0 dt$$

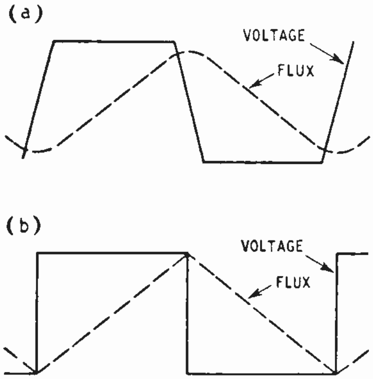

Fig. 6. Voltage and flux waveforms. (a) Vibrator, 80% time efficiency. (b) Perfect square wave.

By carrying out the integration of the voltage waveform for a vibrator-driven transformer (full line in Fig. 6a) the flux waveform is obtained, as shown dotted; and for the sake of comparison the pure square wave of equal amplitude and its integral have been plotted in Fig. 6(b). Since the flux is the integral of the voltage, the maximum flux is less in Fig. 6(a) than in Fig. 6(b) in the same ratio as the mean arithmetic value of voltage is less in Fig. 6(a) i.e. by a factor of $(1 - x/2)$ where x is the fraction of the cycle for which the vibrator contacts are open. ($x = 0.2$ in Fig. 6a).

It might be thought that since the primary circuit is broken during the period of voltage reversal, and the primary current is then zero, the magnetomotive force and the flux would also be zero. But in fact the flux is maintained, as shown, by the secondary current which is flowing into the timing condenser.

Now the flux Φ is the product of the area A of core section and the flux density B, so that

$$B = \frac{10^8}{NA} \int E dt + B_0 \quad .. \quad (2)$$

where N is the number of turns in the winding across which E is measured, and B_0 is the value of B at $t = 0$. Since a half-period of the vibrator cycle covers the reversal of the flux from a maximum in one direction to a maximum in the other, the flux change corresponding to the integration of E over half the period T of the vibrator is equal to twice the maximum flux:

$$2B_{max} = \frac{10^8}{NA} \int_0^{T/2} E dt \quad .. \quad (3)$$

E is constant over a half wave of the square waveform of Fig. 6(b), so that $2B_{max} = 10^8 ET/2NA$ and writing $T = 1/f$ where f is the vibrator frequency in c/s., and $1 - x$ is the "time efficiency."

$$B_{max} = (10^8 E/4ANf)(1 - x/2) \quad .. (4)$$

A transformer operating on a sinusoidal voltage of R.M.S. value V would have $B_{max} = 10^8 V/4.44ANf$; so that comparing D.C. input voltage with R.M.S. alternating voltage, the transformer fed through a vibrator will run at 11 per cent higher flux density than it would if fed with a sinusoidal voltage of the same nominal magnitude. (If one compared the D.C. voltage with the peak value of a sinusoidal voltage, the ratio would be increased to 1.57 : 1; and this comparison is relevant if the transformer with sinusoidal input feeds a rectifier with condenser-input filter, the D.C. output of which on no-load is equal to the peak voltage from the transformer.)

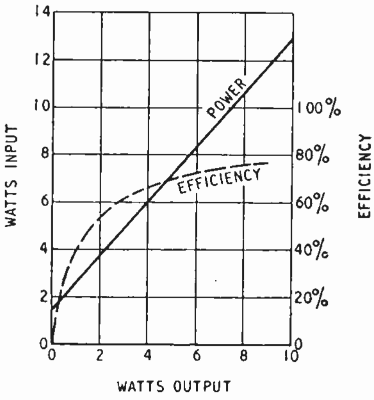

Fig. 7. Typical input-output characteristic of vibrator transformer.

Having determined the flux density, the iron loss can now be considered. It is, unfortunately, a characteristic of vibrator transformers that their efficiency is usually about 60 per cent to 70 per cent instead of the 90 per cent which one might expect from a small transformer working on sinusoidal supply. A plot of output power versus input power shows that an appreciable part of the loss is constant and may be regarded as the open-circuit or magnetising-current loss. An analysis of the power input at full load to the transformer responsible for the graph of Fig. 7 was as follows:

Output power	9.03	watts
Open-circuit losses ...	1.4	„
Vibrator contact losses ...	0.93	„
Secondary copper loss ...	0.37	„
Primary copper loss ...	0.11	„
	11.84	„
Total input power ...	12.2	„
Balance of loss unaccounted for	0.36	„

The vibrator contact losses were checked both by measuring the voltage drop across the contacts oscillographically and by observing the temperature rise of the vibrator when handling current. The temperature rise was calibrated in terms of the constant power dissipated in the vibrator driving coil, and since a vibrator with independent drive circuit was used the driving power was the same with or without load current on the contacts. The open-circuit losses are the biggest item, and since there can be little loss in the timing condenser they must be mainly iron loss. The genuineness of this dissipation is confirmed by the fact that if the timing condenser is removed the peak voltage does not rise to the extent indicated by calculations based on equation (1).

According to elementary theory, the hysteresis loss should depend only on the maximum flux density and the frequency of repetition of the hysteresis loop, and should therefore be the same for a square wave as for a sinusoidal wave of the same frequency and B_{max}. Eddy-current loss is usually assumed to be based on an expression of the type E^2/R where R is the resistance of the path round which the eddy current flows and E, the E.M.F. driving this current, is proportional to flux density and frequency, so that the loss increases as the square of the frequency. E is also assumed to be proportional to a uniform flux density, and therefore to have the same waveform as the transformer input voltage. The mean-square value averaged over a quasi-square wave such as Fig. 6(a) is nearer to the peak value than is the mean-square of a sinusoidal wave; and therefore for a given maximum flux density, E^2/R will be greater the more nearly the vibrator waveform approaches a perfect square wave. By integration of the actual trapezoidal wave, one can calculate the average value of E^2/R in terms of the proportion of the complete cycle time for which the contacts are closed on one side or the other, and compare the ratio of mean-square-voltage to maximum-voltage-squared with the similar ratio for a sinusoidal voltage, which is 0.5.

Contacts-closed time, per cent	$\overline{E^2}/E^2_{max}$ for vibrator	$\overline{E^2}/E^2_{max}$ for vibrator / $\overline{E^2}/E^2_{max}$ for sinusoid
2 × 35	0.8	1.6
2 × 40	0.87	1.73
2 × 45	0.93	1.86
2 × 50	1.0	2.0

Thus even with a perfect vibrator having contacts-closed time of 2×50 = 100 per cent and transit time zero, the increase of eddy-current loss on this basis would be only 2 : 1 for a given maximum flux density and it would be about 1.7 : 1 for the average practical value of vibrator closure time. This is not enough to account for the observed iron loss. But it is generally known that the iron loss in a transformer increases with frequency more rapidly than can be accounted for by an increase of the measured hysteresis loss linearly with frequency and a calculated eddy-current loss. It has been suggested[1] that the additional increase of loss with frequency is due to distortion of the flux waveform within the body of the core; but whatever the cause, the increase of loss with frequency is rapid, as shown by Fig. 8 which is based on handbook[2] figures for transformer sheet of 0.014in thickness. The vibrator waveform can be approximated by the limited series

$$E = \frac{4}{\pi}E_0\left(\sin pt + \frac{1}{3}\sin 3pt + \frac{1}{5}\sin 5pt\right)$$

where E_0 is its peak amplitude. The mean-square value of the wave is equal to the sum of the mean squares of the harmonic components (since the product terms of two components of different frequency vanish when averaged over the cycle) and for this series is of magnitude 0.935 E_0. If in a particular case E_0 corresponds to the flux density for which Fig. 8 was plotted (9,000 gauss) and the vibrator frequency is 100 c/s, the total iron loss for this material should be

$$W = \frac{4}{\pi}\left(W_{100} + \frac{1}{3}W_{300} + \frac{1}{5}W_{500}\right)$$

where the W's represent the losses at the various frequencies. From Fig. 8 this leads to

$$W = \frac{4}{\pi}\left(0.85 + \frac{4.4}{3} + \frac{10}{5}\right) = 5.5 \text{ watts/lb}$$

or about six times the loss for a 100 c/s sinusoid of the same B_{max} as the square wave. This agrees qualitatively with the observed losses, but should not be regarded as quantitatively true because the loss mechanism is probably non-linear with amplitude and this will invalidate the addition of the effects of the component frequencies.

In addition to the effect of secondary copper loss, the mean output voltage is less than the product of effective primary voltage and turns ratio, because of the intervals when the vibrator contacts are open. If x is the fraction of the cycle for which the contacts are open, the mean output voltage when feeding a resistance load would be $(1 - x)E_0$; and correspondingly the current in the windings when the contacts are closed would be $i_0 /(1 - x)$ where i_0 is the mean output current. The regulation is therefore increased by a factor $1/(1 - x)$. The maximum squared current is increased by $(1 - x)^{-2}$, but it flows for a fractional time $1 - x$ only, so that the mean squared current and therefore the copper loss is increased by a factor $1/(1 - x)$ only.

In the practical case, with a reservoir condenser connected across the rectified output, the conditions are slightly less favourable, because the loss of charge during contacts-open periods tends to cause an initial peak of current when the contacts close; but this is not very serious since the variation in condenser voltage is usually less than 5 per cent.

The fraction of the cycle for which contacts are closed is commonly known as the "time efficiency" of the vibrator. It has no direct relationship to the output/input power ratio of the complete equipment, but a high "time efficiency" is useful for the following reasons:—

(i) It reduces the size of "buffer" or timing capacitor required.

(ii) By bringing the mean output voltage nearer to the peak voltage it lowers slightly the maximum flux density, so reducing

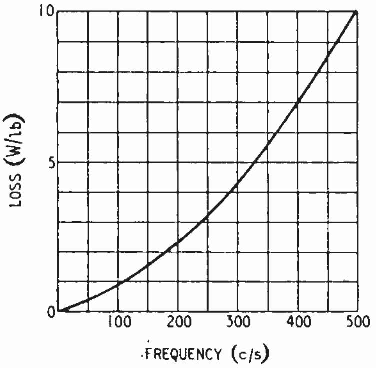

Fig. 8. Loss v. frequency for 0·014-in. transformer sheet.

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[1] F. Brailsford, "Investigation of the Eddy-Current Anomaly in Electrical Sheet Steels," *J.I.E.E.*, Part II, Feb. 1948, Vol. 95, p. 38.

[2] "Standard Handbook for Electrical Engineers," (7th Edition). Edited by A. E. Knowlton, McGraw Hill Book Co., 1941.

n losses, and at the same time reduces the ratio of R.M.S. to ean currents in the windings.

The interruption of the current om battery to transformer pri nary by the vibrator contacts produces a series of discontinuities which can be represented by Fourier series extending throughout the radio-frequency band. Assuming a periodic time of 10 milliseconds (100 c/s) the circuit is likely to be broken in a time of less than 0.1 m-sec; with a primary current of 5 amperes this phenomenon may be described as a rate of change of current of 50,000 amperes per second, which perhaps suggests some radio interference. The secondary contacts of a self-rectifying or synchronous vibrator cause relatively less interference, partly because of the smaller current and partly because the timing condenser reduces the steepness of the wave-front.

The best method of suppressing the interference depends on the particular frequency band which is to be protected. In general, suppression is more difficult at the lower frequencies, and one of the worst cases is a receiver which has to cover the long-wave broadcast band. At such frequencies it is difficult to make a choke of high R.F. impedance but low D.C. resistance, and the reactance of a condenser of reasonable dimensions is not very low. Therefore, the volt-drop limitations require that the minimum number of filter stages should be used; and by completely screening the vibrator and transformer, only two leads need be filtered, the live battery lead to the primary and the H.T. + outgoing lead, of which the battery lead will probably need a 2-stage filter but the H.T. lead only a single stage, as indicated in Fig. 9. If filament (directly-heated) types of valve are used in the equipment, care must be taken to avoid the injection of low-frequency ripple into the filament circuits via the impedance of any common battery leads, and it may even be necessary to include a further stage of low-frequency filtering in the lead to the valve filaments. Where only the higher frequencies are involved, e.g. in V.H.F. equipment, adequate attenuation can be obtained with filter coils of low D.C. resistance. It is then feasible to insert filters directly in the leads to all vibrator contacts, and so avoid the necessity for enclosing the transformer also in a screen. An arrangement of this type is illustrated in Fig. 10. The advantages of eliminating the screen round the transformer are (a) easier wiring and assembly and (b) better cooling of the transformer, but if the transformer is to be hermetically sealed for tropicalization it might as well be screened by the same enclosure.

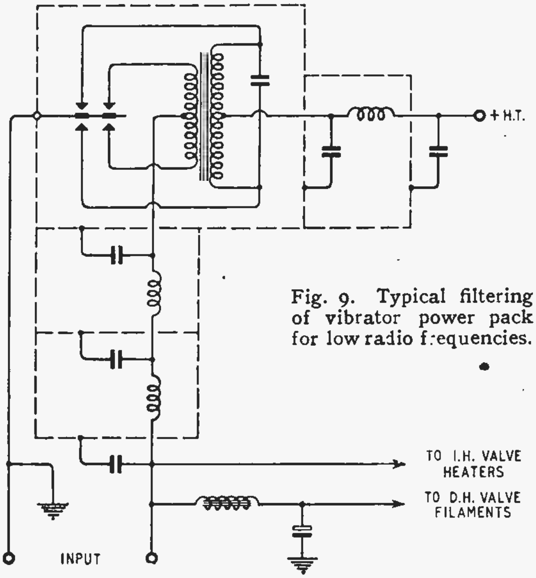


Fig. 9. Typical filtering of vibrator power pack for low radio frequencies.

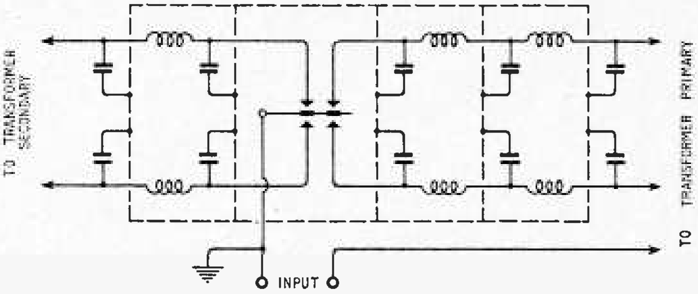


Fig. 10. Filtering of individual vibrator contacts is practicable at high radio frequencies.

This article originated in work which was carried out in the Research Laboratories of A. C. Cossor, Ltd., in 1945-6.

MANUFACTURERS' LITERATURE

Leaflet describing "Superspeed Special" cored solder for use in the radio and electrical industries, from H. J. Enthoven and Sons, 15-18, Lime Street, London, E.C.3.

Publication No. 27 dealing with "Co-ax" articulated R.F. cables, including new types for photocells and high-power transmission lines, from Transradio, Ltd., 138A, Cromwell Road, London, S.W.7.

Catalogue of T.M.C. Capacitors for telecommunications, electro-medical and industrial applications, from the Telephone Manufacturing Co., St. Mary Cray, Orpington, Kent.

Pamphlet describing a commercially built version of the "Williamson" amplifier described in *Wireless World*, April and May, 1947, from Radio Trades Mfg. Company, 141, Little Ealing Lane, London, W.5.

Leaflet describing a new range of 12- and 18-way switches from Taylor Electrical Instruments, Ltd., 419, Montrose Avenue, Slough, Bucks.

Loudspeaker Cone Assemblies

To facilitate the rapid repair of damaged loudspeakers, A. W. F. Radio Products, Sharpe Street, Bradford, can supply diaphragms, centring spiders, cardboard fixing segments, etc., to fit the principal commercial types. Diaphragms are supplied in cartons of 12 in various assortments and prices range from 48s to 96s per carton. Instructions for fitting the cones are included.

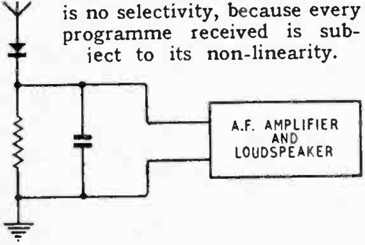
The Synchrodyne

Selectivity Without Tuned Circuits

By "CATHODE RAY"

LAST month I tried to show that modulation, frequency changing, beating, detection, rectification, etc., were all fundamentally the same—the results of alternating currents in non-linear circuit elements. Invariably there is the production of new frequencies, and the name that one calls the process depends mainly on which of these frequencies one has a use for. Admittedly there are differences in the practical details, and one of them—the difference between the so-called additive and multiplicative methods—is important. In both methods the modulating signal varies the slope of the modulator characteristic, but in the additive method it does it as a fellow passenger (not necessarily left-wing, though it often should be to avoid grid current!) and is liable to be modulated itself, whereas in the multiplicative method it does so, as it were, from its own private control room, shielded from personal risk.

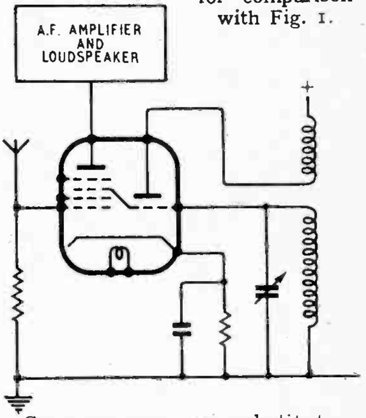
Fig. 1. With a simple additive detector and no tuning, there is no selectivity, because every programme received is subject to its non-linearity.



Where in this co-ordinated scheme of things, one may ask, fits the receiver system known as the synchrodyne,* developed mainly by Dr. D. G. Tucker of the G.P.O.? It appears in some ways to be revolutionary, notably in requiring no tuning circuits other than an oscillator, and yet providing exceptionally high selectivity.

To see how this remarkable feature is possible, consider why tuning is necessary in the ordinary receiver. Imagine an aerial connected direct or *via* an untuned amplifier to a detector of the rectifier type, such as a crystal, as in Fig. 1. All signals picked up by the aerial are applied indiscriminately to the detector. Generally they would include an assortment of broadcast transmissions. Since the sidebands constituting, say, a variety programme are excessively complicated, let us simplify matters by supposing that all the stations are doing their morning tuning notes, and that for identification these notes are all different. Then each carrier wave is escorted by two side waves differing from it in frequency by one of these audible frequencies. The top part of Fig. 2 represents the transmissions in part of the broadcast band in the form of a spectrum. Each of the upright lines represents by its position a transmitted frequency and by its height the received strength. The non-linearity of the detector will cause every frequency to modulate every other; so even with our simplifying assumption there will be a glorious mix-up. The ± frequencies due to intermodulation between different stations' transmissions will, in general, be above audibility; but every carrier wave will beat with its own side waves, so the tuning note of every station within range will be made audible. When their programmes come on, all will be heard at once; which is just what one would expect of a receiver with no selectivity.

Fig. 3. The simplest synchrodyne, for comparison with Fig. 1.



Suppose now we substitute a multiplicative detector for the additive one. Although a triode-hexode (Fig. 3) is not the best for the purpose, it is the most familiar, so will do very well for explanation. The important thing is that the hexode section should work on as nearly as possible a linear part of its control-grid characteristic, otherwise it would act more or less in the same

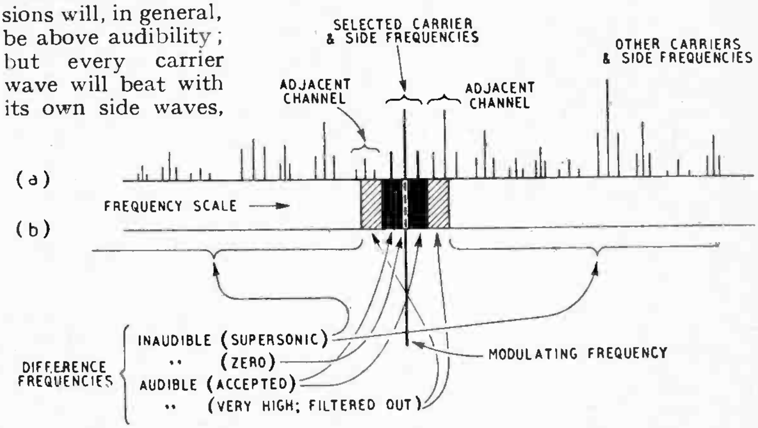


Fig. 2. Part of a broadcast frequency band. Each of the groups of three lines on level (a) represents a carrier wave and a single pair of side frequencies; the single vertical line on scale (b) (which can be shifted horizontally by the tuning control) represents the oscillator frequency in a synchrodyne. Between them is shown the various zones of difference frequencies produced when (b) modulates (a). They move along with (b).

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* *Electronic Engineering*, March, 1947.

The Synchrodyne—

way as Fig. 1. Since this is an imaginary receiver, it is as easy to imagine it to be perfectly linear as anything else. On that assumption, no new frequencies can be formed; and as all those coming in from the aerial are radio frequencies there is complete silence.

Now start the triode oscillating. It varies the slope and amplification of the hexode sinusoidally, modulating all the incoming signals and forming ± frequencies with them all, as I explained last month. Whereas the slope of the rectifier characteristic in Fig. 1 is varied at *all* the incoming frquencies, so that they all modulate one another, in Fig. 3 the right of modulation is strictly reserved to itself by the oscillator frequency.

When that frequency is adjusted to be exactly the same as the carrier frequency of one of the broadcasting stations, as shown in the lower part of Fig. 2, the difference between it and that carrier is (obviously !) zero, so is inaudible. The difference between it and the side frequencies from that station is, of course, its tuning note, so that is made audible. The difference between it and any of the other stations' carrier waves or sidebands is generally too high to be audible; except that those immediately next to it in frequency (the "adjacent channels") may be only 9 or 10 kc/s different, so if they are strong enough a heterodyne note of that frequency will be heard, together with lower but generally more transient notes due to the nearer sidebands. If these are annoying, then the low-pass filter used for disposing of the R.F. by-products must be adjusted to cut off at a lower frequency and the highest modulation frequencies of the wanted station may then suffer.

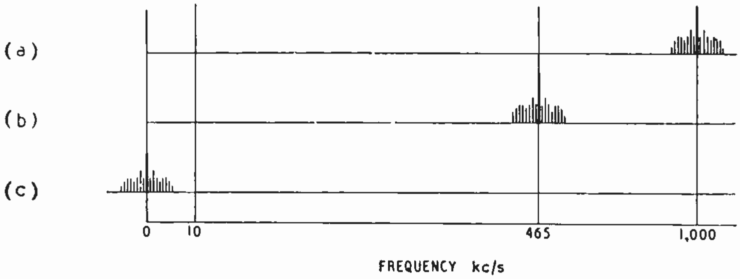

Fig. 4. Spectrum (a) represents a typical broadcast transmission as received, and as applied to the detector in a straight set ; (b) the same after the frequency-changer in a superhet ; and (c) after the modulator in a synchrodyne.

But compare that with any orthodox receiver, where to cut out this adjacent-channel interference it is necessary to use R.F. bandpass filters. Even the best designs tend to cut the wanted modulation at a considerably lower frequency than the interference, while if they are very beautifully aligned to give exceptionally good results they all the more easily drift out of adjustment. An audio filter can be made with better characteristics and has practically no tendency to lose them.

Looking at Fig. 3 you may have thought it seemed remarkably like a superhet, except for the lack of tuning. If so, it is all the easier for me to say that in principle it is a very extreme case of superhet. Only it isn't the "super" that is extreme; quite the contrary, for "super" here has no connection with the enthusiastic exclamation "It's super !" but is an abbreviation for "supersonic"—"above audibility." In Fig. 4, where again there is a horizontal scale of frequency (not very uniform this time, I'm afraid), the line (a) carries a spectrum representing an incoming broadcast on (for example) 1,000 kc/s. The more complicated sidebands show that it is transmitting something more interesting than a single note. In a straight set, all the tuning circuits have to be adjustable to select such a band, which is very narrow, anywhere out of the whole frequency scales provided. In a superhet the oscillator frequency is adjustable to make one set of difference frequencies come into line with the fixed-tuned I.F. amplifier, as indicated on line (b). The nearer the oscillator frequency is to the incoming frequency, the lower the I.F. In the synchrodyne the oscillator frequency is adjusted so near to the incoming carrier frequency that it actually coincides with it, making the "I.F." zero, as shown on line (c). The sidebands are, as before, arrayed on each side.

But how can one of them be arrayed beyond zero, in what is presumably a zone of negative frequency ? We came up against this entertaining little question last month, and once more I am going to ask you to postpone it for a while and in the meantime just to regard them as frequencies, without any + or −.

The important point is that whereas in the straight set and superhet all the frequencies are supersonic and have to be "detected" by some non-linear device which sets up audible beat notes between carrier and sidebands, in the synchrodyne they are already in the A.F. band and no detector is needed.

An interfering station with a a carrier spaced 9 kc/s from 1,000 kc/s is less than 1 per cent different in frequency, so it is difficult to make a variable-frequency filter cover the wanted sidebands evenly, and then cut off sharply to exclude such a near neighbour. In the superhet the separation is increased to 2 per cent and the filter tuning does not have to be varied, so the problem is eased. In the synchrodyne, the adjacent carrier is as much as 80 per cent higher in frequency than (say) 5 kc/s wanted sidebands; or looking at it another way, the synchrodyne filter can be made to accept wanted sidebands much closer to an interfering adjacent channel than either straight or superhet receivers.

Incidentally, what is really the same scheme has been suggested for getting round the general difficulty of making filters with very narrow pass bands.† The signals are frequency-changed to bring the desired band down to the region of zero; a simple low-pass filter is used to cut out all the others; and the remaining ones can then, if desired, be trans-

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† N. F. Barber, *Wireless Engineer*, May, 1947, p. 132.

ported back to their original frequencies. The synchrodyne is the same thing without the transporting back. Or in other words it is a "superhet" in which the frequency changer changes the frequency direct to audio instead of first to an intermediate frequency.

Fig. 3, as I implied, is a highly theoretical sort of synchrodyne, imagined solely for explaining the basic principle. To make the idea work in practice it has to be elaborated. The two main things are the oscillator and the modulator. Taking the oscillator first; it is obvious that the whole plan depends on its frequency being adjusted *and kept* exactly the same as the carrier frequency of the wanted station. The slightest difference would cause a loud heterodyne note, reminiscent of the dark ages of wireless. One possible solution is to use the carrier wave itself as the modulating oscillation. But to do that it would be necessary to have an extremely selective tuner, variable over all the reception bands, to pick the carrier out; which would destroy most of the attractiveness of the synchrodyne for broadcast reception. Something like this has been used under the name of "exalted-carrier" reception, for working on fixed commercial frequencies, to counteract distortion due to fading of the carrier wave.

A more convenient idea is to make use of the fact that an oscillator automatically falls into step with another oscillation on nearly the same frequency. This fact was more generally familiar in the days of receivers with reaction controls. If such a receiver was brought to the oscillating condition and tuned around, the heterodyne whistle due to an incoming carrier wave grew lower in pitch as exact tuning was approached, but instead of declining steadily to zero, as indicated by the dotted line in Fig. 5, it generally fell suddenly to it and remained silent over an appreciable span of the tuning control until it emerged suddenly at the other side. This "silent space" was the range of oscillator tuning within which its own free-running frequency was under the overriding influence of the carrier wave.

By having the incoming signal coupled to the oscillator, the synchrodyne is locked in synchronism against a reasonable amount of inaccurate tuning or drift. Within those limits, drift causes some variation in volume, but except at very high frequencies or with a bad oscillator that is not a very serious trouble.

The important thing is that, unlike what happens with the ordinary highly-selective receiver, slight mistuning of the synchrodyne causes no appreciable variation in *quality* of reproduction.

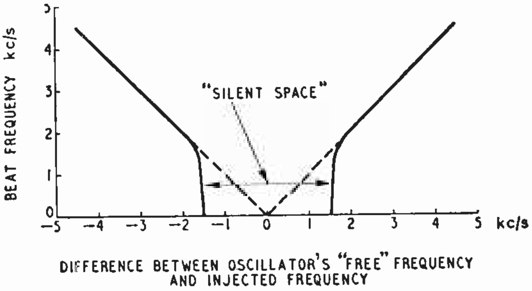


Fig. 5. The dotted line illustrates how an oscillator can be "tuned to zero beat" with another if the other is not coupled to it. When coupled it falls in step over a range of frequency (the "silent space") whose width depends on the closeness of coupling.

As Dr. Tucker has shown, the synchronized oscillator is a very selective device, for the other frequencies present in the control circuit have negligible effect unless they are very strong or very close in frequency. As regards the former, it is not much trouble to provide a moderate amount of tuned-circuit selectively as a protection against relatively strong interference. The point to notice is that this selectivity is used in the synchronizing circuit, not in the main signal circuit, so has no effect on fidelity. And the influence of very close frequencies, such as those in the sidebands of the station being received, can be minimized by reducing the coupling to the oscillator.

During the process of tuning from one station to another, the loud heterodyne whistles are an unpleasant feature. At least, they are with the continuously-variable method of tuning, which is the only one provided in most broadcast receivers, notwithstanding that it is quite unsuited to the listening habits of the vast majority of people. I estimate that in 90 per cent of homes all the time and in 99.9 per cent of homes nearly all the time, people listen to one of two or three stations. But for the sake of the small minority of ether-searchers, the patient British public are condemned to grind away at the old tuning knob every time they want to change between Home and Light, and have to carry out the skilled operation of setting the control accurately to the carrier-wave frequency. It is not surprising that the accuracy is often poor, and the quality of reproduction correspondingly poor. What nearly everybody wants most of the time is a switch or set of buttons for instantly selecting any of the usual programmes, with continuous tuning as an optional extra for those who care to pay for it.

Assuming then that tuning is carried out in what, for ordinary needs, is the common-sense way, and not the archaic way still commonly provided, the synchrodyne howl need never be heard. Although the synchrodyne is feasible for long-range reception, especially if preceded by a superhet section, it seems to me that its natural role is as a high-quality local-station receiver with switch tuning. There is then no need to spoil its sweet simplicity by having to provide elaborate R.F. amplification to bring the weaker carriers up to oscillator-control strength, or means to prevent the stronger signals from overstepping the linearity of the modulator.

That brings us to the modulator. A triode-hexode is possible, but not very suitable, because the carrier voltage needed to synchronize the oscillator section is of the order of ten times larger than the maximum that can be allowed at the control grid if perceptible intermodulation is to be avoided; which means that a carrier amplifier is desirable. Dr. Tucker favours one of the balanced rectifier types of modulator, such as the one shown in Fig. 6. The arrows show the direc-

The Synchrodyne—

tion of current during one half-cycle of the modulating signal from the synchronized oscillator. You will see that it balances out in both input and output circuits, so does not interfere directly with them.

What it does do is to make the resistance of rectifiers A and B low and C and D high, so that the output is connected one way round to the input. In the next modulating half-cycle the situation is reversed, and so are the input-to-output connections. The frequency of the carrier wave in the input is, of course, the same as that of the modulating signal. What happens to it depends on their relative phases. If it is in phase, the carrier is full-wave rectified, giving a D.C. (plus carrier harmonics) output in one direction, Fig. 7 (a); while if the phase difference is 90° the change-over in polarity of the carrier occurs half-way through each half-cycle of the modulating signal, and cancels out, giving no output.

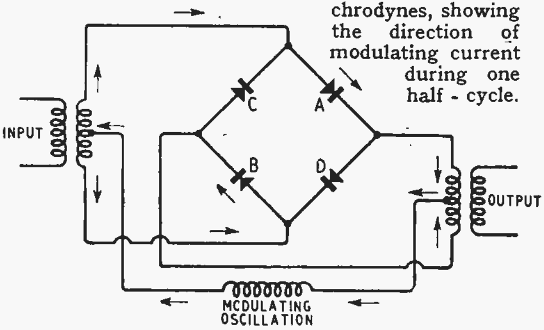


Fig. 6. One type of bridge modulator used in synchrodynes, showing the direction of modulating current during one half-cycle.

The last point is an interesting one, because if the phase can be controlled accurately enough the synchrodyne principle can be used to *reject* a signal completely.

At intermediate phases, the D.C. attains intermediate amplitudes; which is the cause of the volume declining when the oscillator is tending to pull out of synchronism. If there are strong tendencies of this kind, as there would be when receiving short waves, it is a good thing to employ something like A.F.C. (automatic frequency correction) to keep the synchronization steady.

So much for the receiver carrier. What about the sidebands? Each frequency in these is slightly different from the carrier frequency, so there is a progressively increasing phase difference between them, amounting to one whole cycle for every cycle of the audio frequency. During that cycle the component of output due to the side frequency first adds to the carrier D.C., then declines to zero, reverses, grows to a maximum in opposition to the D.C., declines, reverses, and completes the cycle with a maximum, Fig. 7 (b). The addition of this to the D.C. due to the carrier is shown at (c). In words, the output reproduces the modulation of the received programme. This is where one can take another look at the vector diagram, Fig. 7 (d), in which the observer is supposed to be rotating with the vectors at the same speed as the carrier vector so that it appears stationary, with the sideband vectors rotating in opposite directions. In Fig. 7 the modulating signal does this slowing down for us, rather like a stroboscope, converting the R.F. carrier into D.C. and each pair of R.F. side waves into a + and – A.F. vector (that negative frequency again!).

Just one other thing about this modulator that may worry some readers. During the modulating half-cycle shown in Fig. 7 (or any other half-cycle for the matter of that) the input signal has to go through one of the rectifiers in opposition to the modulating current. This does not mean that it has to defy nature's traffic regulations by going the wrong way through a one-way street. If a cyclist on a long lorry which is proceeding in the legal direction through such a street cares to ride his machine from front to back of the vehicle he is riding in the "wrong" direction, but, assuming the speed of the lorry is greater than his, his net velocity is opposite to the way he is facing, and no offence is committed by him, at any rate in respect of the one-wayness of the street. What is thought of his conduct in other respects is not our business. The point is that the modulating current is always made much larger than the modulated current, so that to the latter the rectifiers appear to be either practically linear low resistances or very high resistances.

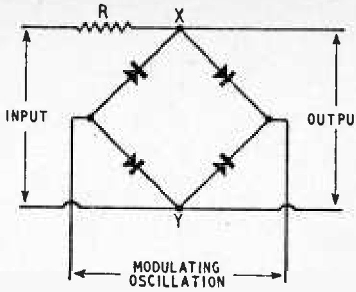


Fig. 8. An alternative synchrodyne modulator, more convenient but less efficient than Fig. 6.

A suitable input signal is 0.1 V which is just about what is needed to synchronize an oscillation of 1 V or rather more, which in turn is just about what is needed to work the modulator, if the new germanium rectifiers are used. They are more convenient than thermionic diodes; especially in

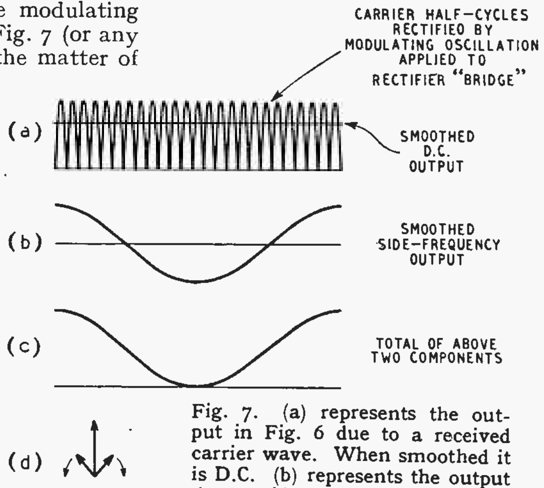


Fig. 7. (a) represents the output in Fig. 6 due to a received carrier wave. When smoothed it is D.C. (b) represents the output due to side waves, after smoothing. Added to (a), they give (c) a reproduction of the original transmitter modulation. (d) is the vector diagram; the resultant as the side-wave vectors rotate varies as at (c).

the Fig. 6 circuit, where the cathodes are all at different R.F. potentials.

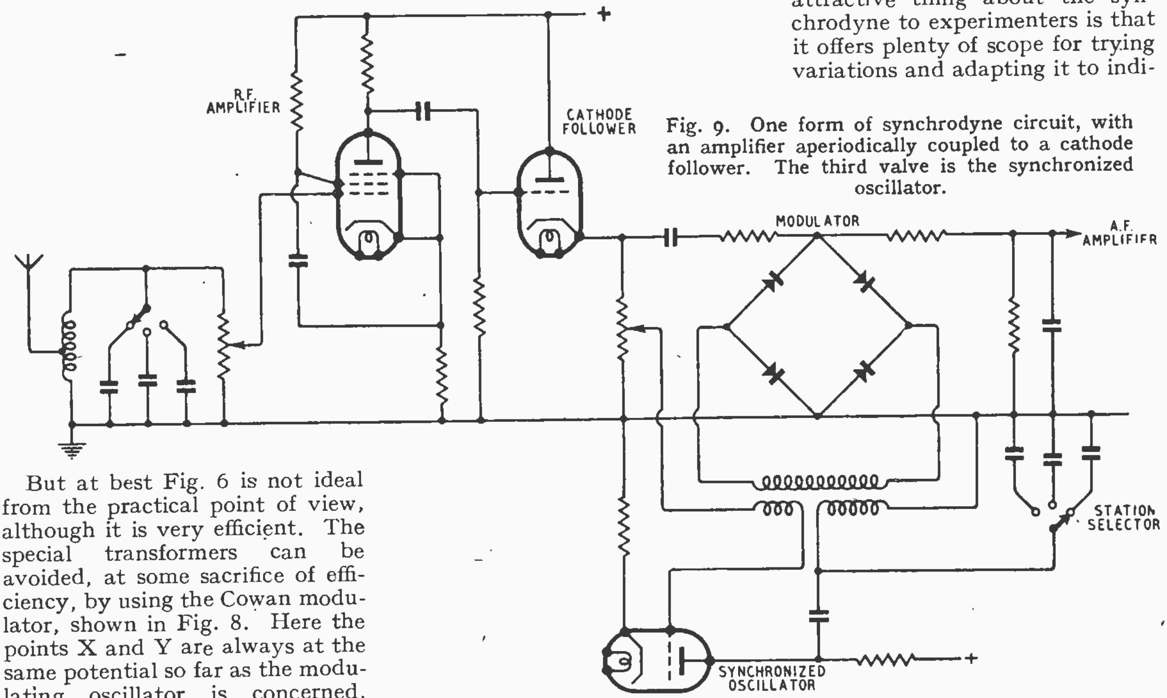


Fig. 9. One form of synchrodyne circuit, with an amplifier aperiodically coupled to a cathode follower. The third valve is the synchronized oscillator.

But at best Fig. 6 is not ideal from the practical point of view, although it is very efficient. The special transformers can be avoided, at some sacrifice of efficiency, by using the Cowan modulator, shown in Fig. 8. Here the points X and Y are always at the same potential so far as the modulating oscillator is concerned, because the current (if any, and if the rectifiers are well matched) divides equally and sets up equal potentials, as in a balanced bridge. During one half-cycle it makes all rectifiers low resistances, so that they more or less short-circuit the input-to-output path, and most of the signal is absorbed by R. During the next modulating half-cycle all rectifiers are high resistances and the signal goes through. So what we have is a half-wave modulator, and a less than perfect one at that; while twice the modulating voltage is needed, to cope with two rectifiers in series.

To supply the "signal" to either type of modulator using germanium rectifiers, a fairly low-impedance source is desirable; preferably a cathode follower. What goes before the cathode follower depends on how strong are the signals one wants to receive. Except for very strong locals, at least one stage will be needed. It can be broadly tuned, not selective enough to cause any reduction of the highest programme modulation frequencies, but enough to reduce relatively strong signals, noise, etc., to a level at which it cannot intermodulate.

The vital thing about any pre-modulator stages is that they must be very nearly linear, so negative feedback is indicated. The post-modulator stages can be on normal high-fidelity lines. Putting these parts together gives something like Fig. 9. But the attractive thing about the synchrodyne to experimenters is that it offers plenty of scope for trying variations and adapting it to individual taste and fancy. So I'll say no more.

Miniature Coil Pack and I.F.T.

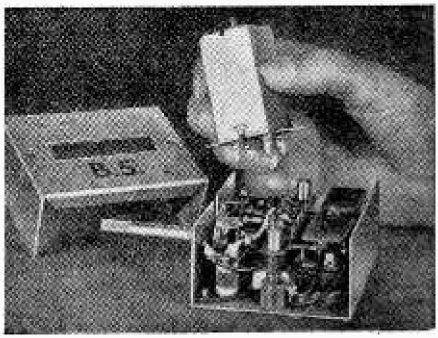
A THREE-RANGE coil pack measuring $3\frac{1}{16} \times 2\frac{1}{2} \times 1\frac{3}{8}$in overall and small permeability tuned I.F. transformers to match for use in miniature superhets have been produced by the Weymouth Radio Manufacturing Co., Ltd., Crescent Street, Weymouth, Dorset.

Three models of the coil pack are available, the type B5 (illustrated here) when used with a two-gang midget condenser having a 365-pF capacitance swing tunes over the following wavebands: 16 to 50, 200 to 550 and 800 to 2,000 metres.

There is a B6 pack designed for a standard size 483-pF tuning condenser and two export models (types B7 and B8) covering 12 to 37, 33 to 100 and 200 to 550 metres.

The coils in all these packs have adjustable dust cores and each includes all necessary trimmer and tracking capacitors. Each is fully screened and costs 35s.

The companion I.F.Ts are assembled in aluminium cans measuring 1in square and 2in. high. Primary and secondary connections are brought to the base and trimming is effected by adjustment of the cores, one on the base, the other at the top. The dynamic resistance is given as 300kΩ and the Q 110 (at 465 kc/s), so that a stage gain of about 140 is available with a normal type I.F. valve and good selectivity is assured. These transformers cost 7s 6d each.



Weymouth type B5 coil pack and miniature I.F. transformer.

Manufacturers' Products

"Cathodray" Capacitor Improvements

A SPECIALLY developed and processed mineral oil impregnant is now used by the Telegraph Condenser Company, Ltd., North Acton, London, W.3, in the manufacture of the "Cathodray" range of high voltage tubular capacitors. The resulting improvement achieved in the paper dielectric has led to a better power factor, greater ability to withstand short-time transient surges and a higher breakdown voltage for the same form of construction.

Other manufacturing modifications, not apparent in either the shape or size of the capacitors, combine to make them less affected than hitherto by changes in atmospheric humidity.

T.C.C. Cathodray capacitors with Visconol impregnated dielectric.

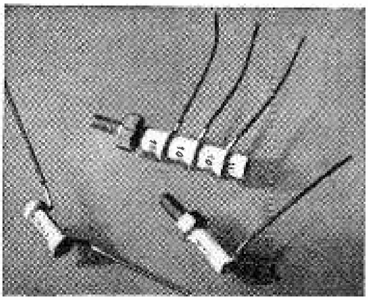
Fixing arrangements are as for existing models of the same capacitance and rating so that no replacement problems arise.

OUR COVER

A control position at the B.B.C.'s short-wave station at Skelton, Cumberland, is illustrated on our front cover. Each of the twelve 100-kW Marconi transmitters is completely controlled from an independent glass-panelled cubicle. Through the window can be seen the two valves in the final stage.

Triple Ceramic Capacitor

AMONG the latest products of United Insulators is a miniature triple capacitor of the post, or vertical mounting, type. All three sections have a common earth connection and each has a value of 1,000pF. These comparatively high values of capacitance for such small dimensions (the overall length is just over 1in and the diameter is less than ¼in) are obtained by the use of the latest type of "Hi-K" ceramic.



Some of the latest miniature ceramic capacitors, including a triple model, made by United Insulators.

The illustration also shows two other new types using this form of dielectric. Their small sizes and good dielectric characteristics make them particularly attractive for use in television and other equipments designed for operation on extra high frequencies. The makers are United Insulator Co., Ltd., Oakcroft Road, Tolworth, Surbiton, Surrey.

Pre-Amplifier Converter

THIS is a self-contained unit which can be used either as a superhet converter or as a pre-amplifier for an existing amateur communications receiver.

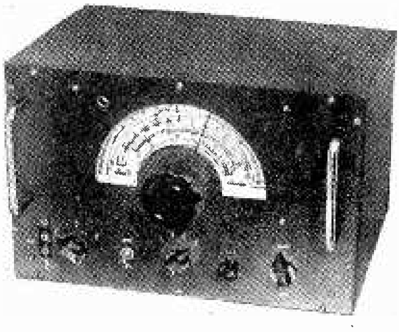
It covers the four following bands: 14 to 14.5 Mc/s, 21 to 21.5 Mc/s, 27 to 30 Mc/s and 50 to 60 Mc/s. The last-mentioned is wider than the others to take in the 6-metre band.

Special care has been taken to ensure good oscillator stability throughout, as C.W. telegraphy is now so widely used on the two highest frequency bands.

When the unit is used as a pre-amplifier it covers the three lower frequency bands only, the EF50 R.F. stage giving high amplification with a good signal-to-noise ratio and its two tuned circuits greatly improves image-signal rejection. As a converter the EF50 is followed by an ECH35 frequency changer and the two signal circuits are ganged with the oscillator.

The unit can be left permanently connected to the main receiver as all operations, such as switching on and off, range selection and aerial change over from the unit to the main set, are effected by switches neatly arranged on the front panel. There is also a transmit-receive switch. The large semi-circular dial is calibrated for each range. The I.F. is 4 Mc/s.

Made by Labgear, Ltd., Willow Place, Fair Street, Cambridge, the price for A.C. operation is £25.



Labgear optional pre-selector or convertor unit for A.C. operation.

Three-Band Scale and Drive

A CONDENSER drive giving a reduction ratio of 16 to 1 and fitted with an attractive tuning scale measuring 10in long and 4½in high has been produced by The Albert Manufacturing Company, 5, Shakespeare Road, Finchley, London, N.3.

It is intended for use in a 3-band receiver having a short-wave range of from 16 to 50 metres. Station names and tuning points, as well as wavelength scales, are included for all three ranges. The dial consists of glass and provision is made for diffused illumination from the top. Price is 22s 6d.

Electronic Circuitry

Selections from a Designer's Notebook

By J. McG. SOWERBY (*Cinema Television Ltd.*)

Negative Feedback Circuit.—Readers will be familiar with the use of negative feedback in the stabilization of amplifier gain. It is generally applied to audio amplifiers—when the stabilization of gain is a secondary effect—the aim usually being the reduction of distortion. However, in amplifiers for oscillographs and measuring instruments generally the stabilization of gain against valve and supply variations is of as much (or greater) importance as the reduction of distortion. Such amplifiers often have to operate over bandwidths of 100 kc/s upwards.

When applying feedback to a wide bandwidth amplifier it is tempting to employ circuits similar to those used in audio amplifiers, simply because the technique is familiar. Unfortunately the standard methods nearly all involve potentiometer circuits of fundamantally high impedance, and at high frequencies the effect of stray capacitances is often troublesome. A useful way of avoiding some of these troubles and of combining three stages in a negative feedback loop is given in H. W. Bode's book "Network Analysis and Feedback Amplifier Design" (Macmillan and Co.) and is shown in Fig. 1.

The figure shows only the bare bones of the circuit, without decoupling and bias arrangements. It will be seen that the feedback is applied from the cathode of the third stage back to the cathode of the first via the common cathode resistor R_c of very low resistance, and a little consideration will show that the phase relations are correct for negative feedback. The gain obtained from such an amplifier is best expressed in terms of the three individual valve gains M_1, M_2, and M_3, and the overall gain M_o when R_c is zero; i.e.

$$M_1 \, . \, M_2 \, . \, M_3 = M_o$$

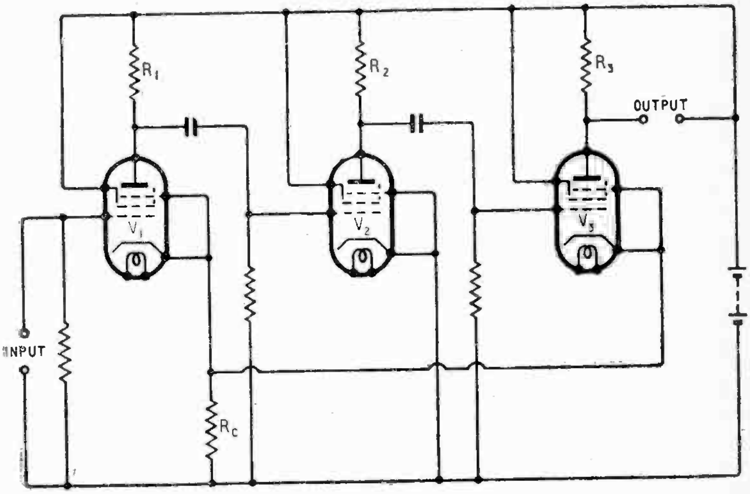


Fig. 1. Feedback circuit for wide-band amplifiers.

When R_c is inserted the overall gain becomes

$$M'_o = \frac{M_o(1 - R_c/M_oR_1)}{1 + R_c\,[M_1/R_1 + (M_o + M_3)/R_3]} \qquad (1)$$

For many practical cases the approximate simplified relation:

$$M'_o = \frac{M_o}{1 - M_oR_c/R_3} \quad .. \quad (2)$$

is quite sufficiently accurate.

Taking practical values of $M_1 = M_2 = M_3 = 20$, giving $M_o = 8{,}000$; $R_1 = R_2 = R_3 = 4$ kΩ and $R_c = 10$ ohms: $M'_o = 379$ by (1) and $M'_o = 381$ by (2). So we see that quite a low common cathode resistance reduces the gain very markedly by a factor of more than 20 in this case—thus stabilizing the gain to a great extent. Incidentally it is rather interesting to make R_c one ohm in the above example. Even this modest feedback reduces the gain by a factor of three, and it rather makes one wonder how often an unduly low gain has been ascribed to poor valves, when in fact it has been due to an unsuspected common cathode impedance in the wiring—if only of a fraction of an ohm.

Cathode-coupled Limiter.—Occasionally in electronic devices of one sort or another it is required to clip a waveform of arbitrary shape to a square or rectangular shape. For example, it is desirable to clip incoming work waveforms to a roughly square shape before using them to synchronize an oscilloscope time base, for then the sharp-fronted waveform and constant amplitude enables the time base to be synchronized more stably over a wider range of frequency than would otherwise be possible.

Various clipping devices using diodes or pentodes are well known. The double triode cathode-coupled limiter is not perhaps so well known, but has certain advantages The circuit is shown in Fig. 2. It will be seen that it consists, virtually, of a grounded-grid triode (V_2), and a cathode-follower driver (V_1), and so is a relatively wide bandwidth device, since Miller effect is absent.

On the positive half-cycle of the input, the common cathode follows the grid of V_1, and V_2 is

Electronic Circuitry—

cut off. if the input is of sufficient amplitude. On the negative half-cycle of the input, the current in V_1 is soon reduced to zero and is, in fact, transferred to V_2; thereafter V_1 is cut off and has no further effect. When V_2 is cut off, V_1 is working as a cathode follower and R_c can be chosen so that a large positive peak input voltage can be handled without grid current in V_1. This is a very real advantage if the mark/space ratio of the clipped wave must be constant with varying input amplitude. In limiters depending on grid current (such as the standard pentode type) the current charges the grid coupling condenser and imposes an undesired negative bias on the valve. This can only be eliminated by ensuring that such a limiter is driven from a low-impedance source—a requirement which is not imposed by the double triode circuit.

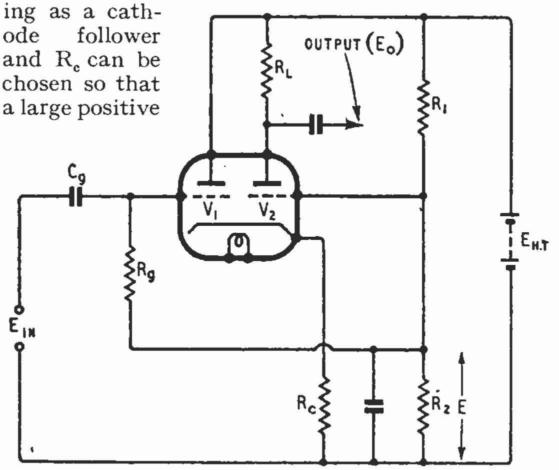


Fig. 2. Cathode-coupled limiter. Typical values are : $E_{HT} = 250$ V, $E = 50$ V, $R_c = 27$ kΩ, $R_L = 27$ kΩ, $E_p = 3.5$ V, $E_o = 50$ V, E_{in} (peak) = 50 V (approx.). V_1, V_2, ECC35.

The characteristic of the limiter of the figure is much as shown in Fig. 3, and it will be seen that limiting action does not begin to take place until the peak input amplitude is greater than E_p. A short cut-off valve such as the (Mullard) ECC35 or ECC91 should therefore be used when E_p must be small. It is obvious that separate valves may be used if a double triode of exactly the desired characteristics is not available.

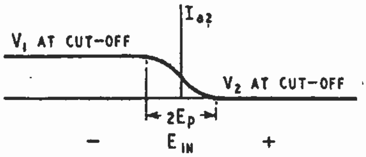


Fig. 3. Characteristics of limiter.

In design, the values of R_1 and R_2 should be chosen to permit the use of a fairly high value of R_c, and the drop, E, across R_2 should be 20 to 100 volts. The peak-to-peak amplitude of the output waveform will be $E_o = ER_L/R_c$ approximately, and the maximum permissible peak input will be that corresponding to the onset of grid current as calculated for V_1 with an anode current of $(E + E_{in})/R_c$, and an anode voltage of $(E_{HT} - E - E_{in})$, as is usual for a cathode follower.

The writer feels certain that this circuit has been published elsewhere, but has been unable to trace any reference to it. Any information on this point would be much appreciated.

New Book

Valve Technique. By D. N. Corfield and P. V. Cundy. Pp. 99; 59 figures. The Radio Society of Great Britain, New Ruskin House, Little Russell Street, London, W.C.1. Price 3s 6d.

THIS publication sets out to "present in as simple a manner as possible the calculations associated with the application of thermionic valves." It is obvious that only a part of this field can be covered in the space of 99 pages, and many omissions can be explained by the somewhat obscure line of demarcation drawn between valve and circuit technique. Subjects clearly on the "valve" side of the line, on which little or no information is given, include voltage stabilizers, crystal valves, limiters, noise diodes, and frequency drift in local oscillators. The last two of these are of particular importance to anyone concerned with communication receivers and the authors have missed an opportunity of filling some of the more serious gaps in existing amateur radio literature.

The greater part of the book is comprised of useful material. The various "Classes" of power amplification, voltage amplification (audio and video), detectors, frequency changers, frequency multipliers, power rectifiers and cathode and anode followers are treated in a simple manner adequate for most purposes, which will appeal particularly to those readers who like numerical examples.

The treatment of noise in valve amplifiers (Ch. IX) contains numerous misleading statements. Johnson noise is attributed to thermal agitation of *molecules* and described as dependent on the passage of a current, bandwidth is wrongly defined, the equivalent noise temperature of a television aerial (actually about 5,000°) is taken as 293°, and instead of obtaining the required input circuit bandwidth by proper aerial coupling a damping resistance is introduced, and with it unnecessary noise (correctly calculated) and loss of signal. The figures given for "the input impedance (R_e) of valves intended for V.H.F. operation" are only correct for valves such as the EF54, and the figure of merit for different valves is not, as stated, the noise resistance R_{eq} but for most purposes the ratio R_e/R_{eq}, both quantities being (for example) about 10 times higher for Acorns than for the EF54.

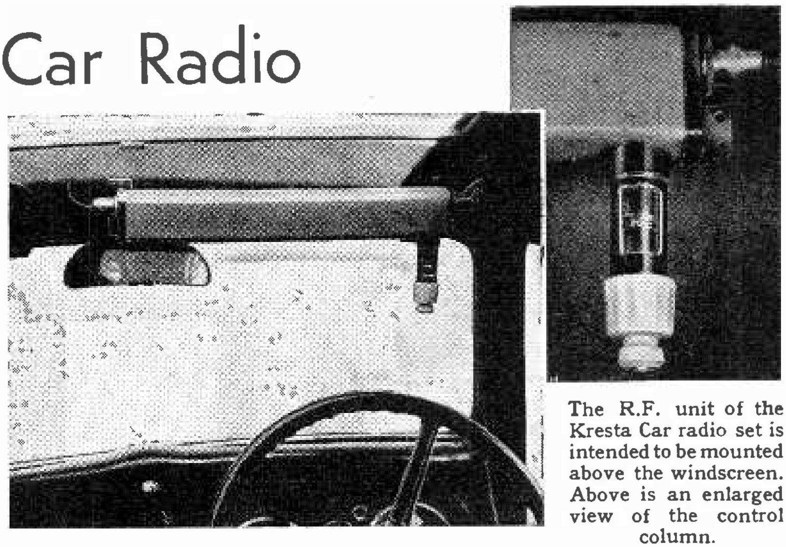
The section on wide-band amplifiers is technically correct as far as it goes, but the presentation is misleading; for example the bandwidth is expressed in the form $f\sqrt{L/C/R}$ which makes it apparently dependent on f and L, instead of in the more useful form $1/2\pi CR$. There is no mention of the valve "figure of merit," g_m/C.

The glossary defines Q as the "usefulness" of a tuned circuit. If this were correct the circuits in a wide-band amplifier would be more "useful" with the damping resistances removed! The definition of "Class A" is at variance with BS204.

L. A. M.

Novel Car Radio

Two-Unit T.R.F. Receiver for Mounting Above the Windscreen

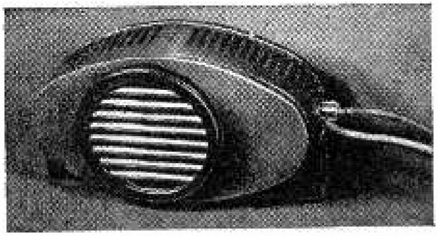


The R.F. unit of the Kresta Car radio set is intended to be mounted above the windscreen. Above is an enlarged view of the control column.

THE car radio receiver made by the Kresta Electric is quite different from any other apparatus of its kind both as regards the nature of the construction and the circuit design. It consists of two parts, the most interesting one being the receiver unit, which is assembled in a long flattened tube measuring 15 by 2¼ by 1¼in, designed for mounting along the top edge of the windscreen. Where space is available it could even be fitted between the inner fabric and the roof of the car.

A small control pillar, containing the scale, the tuning knob, on-off switch and volume control projects downwards at one end, where it is very conveniently located for the driver. In the majority of cars it will be at about eye level, but being close to the vertical screen pillar it does not impair the driver's view ahead.

The main technical feature of interest is that a T.R.F. circuit is used with permeability tuning, giving continuous coverage on the medium waveband and one spot frequency on the long waves. There are three R.F. stages, each completely screened from its neighbour, and these, in conjunction with the very efficient interstage couplings employed, give ample sensitivity for all normal requirements in a car.



Loudspeaker, power output valve and H.T. supply are contained in one unit, which is usually fitted below the instrument panel.

As only a limited amount of travel of the adjustable dust cores is possible in a set of this design, the necessary variation in coil inductance is obtained by using U-shaped cores and binocular coils. The cores are operated by a thin steel tape, the movement of which is effected by the tuning mechanism inside the control pillar. This carries a spirally engraved scale marked with the names of the principal British and European broadcast stations.

The volume control is concentric with the tuning knob and combines the function of switching on and off the set.

A separate wavechange is not employed, but it is arranged that when the tuning control reaches the end of its travel insulated tongues on the dust core carriages trip switches that bring the long-wave circuits into use. For use in this country these circuits are pre-tuned to the Light programme.

Four valves are used in the receiver unit, two being exclusively R.F. amplifiers. The third, a double-diode R.F. pentode, combines the functions of R.F. amplifier, detector and A.G.C., while the fourth is an A.F. amplifier.

The signal from the receiver is fed, via a screened cable, to the supply unit which contains a power amplifier, loudspeaker and a synchronous-type vibrator for the H.T. supply.

During the course of a brief test made in the centre of London Continental broadcast stations were well received with the car in motion and using a very short inside aerial.

Although only one suppressor was fitted to the engine, in the coil lead to the distributor, ignition noise was noticeably absent. The power unit contains filters in the input supply leads, and owing to the mounting position of the set the lead to the aerial is well removed from the worst zones of interference.

Heavy lorries, coaches and buses produced some interference when passing, but otherwise the reception of the Home and Light programmes was free from extraneous and background noise. The A.G.C. is particularly good, and the performance in general was most impressive. The quality of reproduction compared very favourably with that of the average domestic receiver operating under very much more favourable conditions.

The receiver is made by Kresta Electric, Ltd., Parkes Street, Warwick, and distribution is effected by J. H. Carvill & Co., Ltd., 5, The Vinyard, Richmond, Surrey. It costs £22 plus purchase tax, and both 6- and 12-volt models are available. The consumption on 12 volts is 2.75 amps only.

VALVE TESTING

A NEW range of valve adaptors (including types for the B9G, B8A, etc.) for use with Taylor valve testers has been introduced by Taylor Electrical Instruments, Ltd., 419, Montrose Avenue, Slough, Bucks. There is also a new issue of the firm's valve supplement.

High-stability LC

Performance Approaching Crystal Control Standards

By THOMAS RODDAM

IN recent years the growing popularity of the resistance-capacitance oscillator and the superlative performance of the best crystal oscillators have tended to divert attention from the merits of the inductance-capacitance oscillator. For many purposes the fixed-frequency LC oscillator provides a performance which is quite adequate, and which is considerably better than that obtainable from an RC oscillator. Indeed, a good LC oscillator is quite as stable as a bad crystal oscillator.

The bridge-stabilized LC oscillator, which is described in this article, has a very high short-period stability, and has the additional advantage that it works exactly as calculated. Most oscillator circuits depend to some extent on the non-linearity of the valve characteristic and their exact performance is difficult to calculate in advance. Usually they are not calculated at all exactly, but a rough calculation is followed by a series of trials of different component values until a satisfactory performance is achieved. This circuit, however, really does work exactly as predicted, and the job of prediction is no harder than that of designing a single-valve Class "A" amplifier: in fact, that is all it is. Moreover, the waveform of the oscillator is very good.

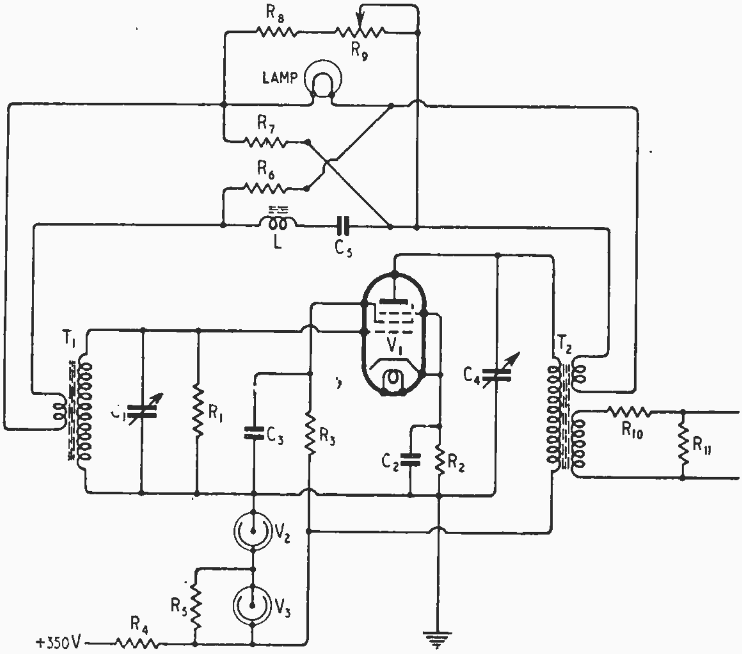


Fig. 1. Circuit diagram of high-stability LC oscillator. C_1, C_4, 950pF + 100pF variable ; C_2, 2μF ; C_3, 0·1μF ; C_5, 500pF + 10pF variable ; R_1, see text ; R_2, 82Ω ; R_3, 22,000Ω ; R_4, 1,000Ω ; R_5, 100,000Ω ; R_6, R_7, 100Ω ; R_8, 1,500Ω ; R_9, 2,000Ω variable ; R_{10}, R_{11}, 50Ω ; V_1, 6AG7 ; V_2, V_3, VR150 ; T_1, T_2, L, see text.

The oscillator described was designed to operate at a frequency of 20 kc/s to provide calibration points at 20 kc/s intervals up to 1.5 Mc/s. The actual frequencies $n \times$ 20 kc/s were obtained by means of a single-valve transitron pulse generator, locked at 20 kc/s, which will not be described here. The 20 kc/s was checked by beating the 10th harmonic with the Droitwich transmitter carrier in an ordinary broadcast receiver. If the beat is adjusted to one per second the frequency is correct to within 5 parts in a million, so that the 50th harmonic, which is 1 Mc/s, is within 5 c/s of the correct value. This was more than sufficient for the purpose for which the oscillator was constructed. Furthermore, a crystal oscillator using an X-cut crystal, without temperature control, had failed to give this accuracy, but was causing trouble owing to the trust in crystals which led the users to leave the frequency unchecked for too long. The LC oscillator gave a short-term stability of 1 in 10^5, so that the error at 1 Mc/s never exceeded 10 c/s.

All oscillators consist essentially of an amplifier and a selective feedback network. The circuit of Fig. 1 has been arranged so that the two parts of this oscillator can be seen clearly. The lower part is the amplifier, a single high-gain pentode, with tuned input and output circuits. Negative feedback is not used, for any improvement obtained by stabilizing the amplifier itself is lost as a result of the reduced gain. The feedback network is the upper part of the circuit, which is redrawn in Fig. 2. If the coil has an effective resistance R at the operating frequency and the lamp has a resistance R_0, the bridge is exactly balanced if $R_6 = R_7 = R = R_0$. This can only be true if $1/(2\pi f)^2LC = 1$: that is, if the tuned circuit is resonant at the operating frequency. Suppose now that R_0 is reduced slightly; then the bridge will give a finite output: if R_0 is increased beyond the balance

Oscillator

point, the bridge will give a finite output, but in the opposite phase. If therefore the value of R_0 is initially below that needed for balance, the feedback circuit can be connected so that it gives positive feedback. Increasing R_0 reduces the feedback until, as R_0 passes through the balance point the feedback becomes negative. If a small change of frequency is made, two things happen: there is phase shift at the output and there is also, if R_0 is less than the value for balance, a reduction in the amplitude. The operation of the oscillator depends on making R_0 self adjusting to the correct value which will just maintain oscillations at a chosen level. By using a small tungsten-filament lamp, any increase in the bridge input causes an increase in the power dissipated in the lamp, and consequently an increase in R_0. This reduces the amount of positive feedback and the amplitude is reduced accordingly. It is assumed that the amplifier is operating under Class "A" conditions and that it has zero phase shift.

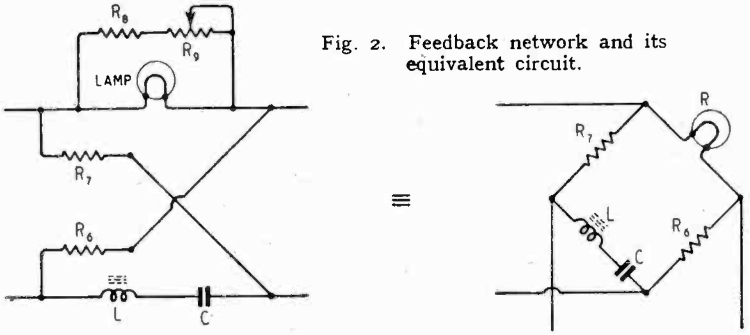


Fig. 2. Feedback network and its equivalent circuit.

The design starts with the choice of a lamp. The one actually used was a 4.5 volt torch bulb which was found to have a resistance of 100 ohms at 2 volts and a characteristic shown in Fig. 3. If approximately equal ratio arms are used in the bridge, the bridge impedance is 100 ohms and the total power dissipated is 160 milliwatts. The bridge input voltage is then 4 volts R.M.S.

It was decided to design the oscillator to give 1 watt output. This means that the amplifier must have an available output of 1160 milliwatts, of which 1000 milliwatts is useful power and 160 milliwatts is dissipated in the bridge. The valve chosen was the 6AG7, a high-slope pentode. Operated with an anode voltage of 300, and 150 volts on the screen, the anode and screen currents are 30 mA and 7 mA respectively with −3 volts on the grid. The optimum load is then 10,000 ohms, the cathode bias resistor 82 ohms and the mutual conductance 11 mA/volt. The screen dropping resistor is 22,000 ohms. In Fig. 1 it will be noted that the 150 volts for the screen could have been obtained directly from the voltage regulating tubes, but it was desired to keep the oscillator independent of the power supply arrangements.

To obtain 1160 milliwatts in 10,000 ohms we required 108 volts R.M.S., or 153 volts peak. With a mutual conductance of 11 mA/volt, the peak grid swing is seen to be 1.4 volts, which is well within the − 3 volts bias provided.

The output transformer is designed from a power point of view; this is much easier than thinking in terms of impedances. The 108 volts R.M.S. on the primary must produce 4 volts at the bridge input, so that the ratio is 27 : 1. With an output impedance at the load winding of 100 ohms, the power of 1 watt means 10 volts R.M.S., so that this ratio must be 10.8 : 1. The three windings are therefore 27 : 1 : 2½.

The input transformer should have as high a step-up ratio as possible, in order that the amplifier gain should be high. The limit is set by the stability of the input capacitance. If we assume that the valve capacitance will be stable to within ±1pF, we must be sure that this will not produce too great a frequency shift. The frequency shift produced by a detuning of 1 c/s in the transformer secondary, assumed to have a Q equal to Q_1, will be Q_1/Q_2 c/s, where Q_2 is the Q of the frequency controlling circuit. This is because the phase shift produced by detuning the transformer must be balanced by a phase shift in the feedback tuned circuit, and the oscillation frequency changes until the two phase shifts are equal and opposite.

We can probably assume a Q of 200 for the tuned circuit: for the transformer we can take a Q of 10. The effect of detuning the transformer is then to produce 1/20th c/s change in oscillation frequency for each 1 c/s detuning. We know also that if we change the tuning capacitance by x% the frequency will change by $x/2$%. Then if we change the transformer tuning capacitance by x% the operating frequency will change by $1/20 \times x/2$%. For this oscillator it was decided to keep the instability from this cause to within $\pm\frac{1}{2}$ c/s at 20,000 c/s, with an assumed change in valve capacitance of 1 pF. Immediately it can be seen that the total grid capacitance must be 1,000 pF. As the Q is to be 10, this gives a secondary impedance of $Q/2\pi fC = 80{,}000$ ohms so that a step-up of $1 : \sqrt{800}$, or 1 : 28, is used. The overall gain from bridge output to bridge input is then $28 \times 11 \times 10 \times 1/27$, or just over 40 decibels. The loss through the bridge is, of course, also 40 decibels, which is very close indeed to the balance point.

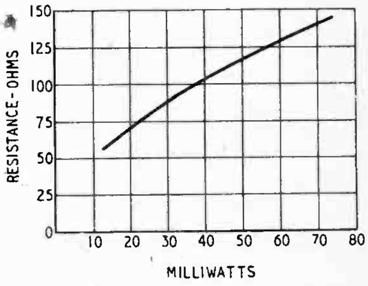


Fig. 3. Characteristic of tungsten-filament lamp used in bridge.

High-stability L.C. Oscillator—

Both anode and grid are tuned with 1,000 pF, from which the inductance at 20 kc/s is given immediately as 63.5 mH. To save a little arithmetic the grid ratio was made 1 : 27, so that both step-up at the amplifier input and step-down to the bridge are the same. The inductance of the bridge windings is then 87.2 μH. The step-down to the load is 108 : 10, which means that the load winding must have an inductance of 0.545 mH. These values are collected together in Fig. 4. The transformers were constructed on special dust cores which are not commercially available. They are quite straight forward affairs, however, though it is probably worth while making the bridge windings screened and balanced if facilities are available.

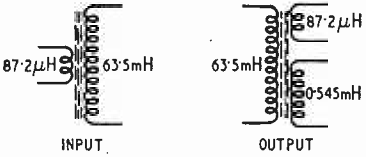


Fig. 4. Inductance values required in the dust-cored input and output transformers.

The inductance for the frequency control circuit must have a resistance of about 100 ohms at 20 kc/s. The writer used a 127 mH coil, tuned by 500 pF, which had a Q of just over 200. This gives a resistance of 80 ohms, and it was considered that this was satisfactory. The stability increases as the Q is increased, so that a good Q is desirable and the recommended procedure is to use that value of inductance which will give a resonant impedance of 80–100 ohms with the core material available. If it is impossible to get such high values with a good Q, the design must be modified to use a lower bridge impedance by the use of unequal ratio arms or a lower resistance lamp.

The actual setting up of the circuit is quite easy if a reasonable amount of test equipment is available. The amplifier is connected up and an input of about 20 millivolts at 20 kc/s applied to the input transformer. The input and output circuits are tuned for maximum gain, and the input transformer is loaded with R_1 to bring the Q down to about 10. If an oscilloscope is available the tuning can be done very exactly by collapsing the ellipse produced when the input is applied to the X plates and the output to the Y plates. This is not as easy as it looks, because the oscillograph amplifiers must have identified phase shifts at 20 kc/s if it is to be carried out successfully. When the amplifier has been adjusted the feedback circuit is connected and the resistance R_9 adjusted until the circuit oscillates and gives an output of 10 volts R.M.S. across the load winding or 306 volts peak-to-peak at the anode if an oscilloscope is to be used for the measurement. By adjusting R_9 we can control the operating level until it is equal to that assumed in the design, which we know to be well within the Class "A" limits. If no accurate way of tuning up C_1 and C_4 is available, it is possible to get the optimum values by varying the anode voltage and observing the frequency shift. C_1 and C_4 are trimmed to give the best stability. Several different anode voltages must be used, as there is a danger of passing through zero beat and getting a false value for the frequency shift.

In the circuit of Fig. 1 there are a few additional points which require mention. When first adjusting the circuit to operate at the correct level R_9 was set to its mid position and R_6 or R_7 trimmed by means of a parallel resistance to achieve an approximate balance. R_{10} and R_{11} were used simply because the following circuit requires 5 volts input in a high-impedance circuit, and it was necessary to dissipate the one watt for which the oscillator was initially designed. Voltage stabilization was included to save the trouble of checking the overall stability of the oscillator, which was needed for immediate use. Neon stabilizers were also connected across the heater supply circuits, although this precaution has now been removed. The whole oscillator, including the VR150's was mounted inside a metal box and this was enclosed by a wooden outer box. Heating lamps and a bimetallic strip maintained the internal temperature at 40° ± 1° C: this also was intended to be a time-saving feature. Other oscillators of this type now under construction will not include such elaborate precautions.

The calculation of oscillator values above really does mean something: it is as easy as that. In the writer's experience oscillator circuits are normally very stubborn brutes, if only because adequate valve data is not available to enable the amplitudes to be calculated. This circuit, operating as it does well within the linear region of the valve characteristic, behaves exactly as it should. It is well worth using when a stable fixed frequency is needed, and is probably satisfactory if modified to work over a limited band by the use of a wide-band amplifier.

News from the Clubs

Baldock.—The call sign of N. F. Wilshire, secretary of the Baldock and District Radio Club, was misquoted in our last issue; it is G3CEU.

Halifax.—Meetings of the Halifax Experimental Radio Society are held fortnightly in the Toc H Rooms, Clare Road, Halifax. Sec.: E. Allen, 13, New Road, Halifax, Yorks.

Romford.—The transmitter, G4KF/P, of the Romford and District Amateur Radio Society is now operating on 160 metres. Reports will be welcomed. Weekly meetings are held on Tuesdays at 8, at the Y.M.C.A., Western Road, Romford. Sec.: R. C. E. Beardow, G3FT, 3, Geneva Gardens, Whalebone Lane N., Chadwell Heath, Essex.

Southall.—The West Middlesex Amateur Radio Club is in need of a permanent club room where a workshop can be provided for members. Meetings are held on the second and fourth Wednesdays of the month at 7.30 at the Labour Hall, Uxbridge Road, Southall. Sec.: C. Alabaster, 34, Lothian Avenue, Hayes, Middlesex.

Stockport.—It is learned from the late secretary of the Stockport Amateur Short-Wave Radio Society that it is at present inactive owing to the lack of suitable premises.

Walworth.—The radio club associated with the Walworth Men's Institute has been reconstituted and the new secretary is B. E. Symons, 100, East Dulwich Grove, London, S.E.22.

Watford.—Monthly meetings of the Watford Radio and Television Society are held at 7.30 on the first Tuesday in each month at the Carlton Tea Rooms, Clarendon Road, Watford. Sec. S. E. Sumner, G3BGK, 48, Hilfield Lane, Aldenham, Herts.

Weston-super-Mare Group, R.S.G.B., meets at 7.30 on the first Friday of each month at the Y.M.C.A. Sec.: W. C. Holley, G5TN, 252, Locking Road, Weston-super-Mare, Som.

Frame Deflector-coil Efficiency

Conditions in Coil and Valve

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

It is well known that the back-E.M.F. across a deflector coil which is carrying a saw-tooth current consists of the sum of a pulse and a saw-tooth voltage. The pulse voltage is produced by the inductive element of the coil and the saw-tooth by the resistive element. The magnitude of the latter depends on the amplitude of the current, but the magnitude of the pulse depends on the rate of change of the current.

In the case of the line scan the inductive back-E.M.F. greatly predominates and the resistive component is often considered negligible in comparison. The frame scan is much slower, however; the inductive back-E.M.F. is only about 1/5,000th as great and it is usually small compared with the voltage drop across the resistive element. Because of this, it is sometimes thought that the inductance of a frame deflector coil is an unimportant quantity and that only the resistance is important.

This would be true if only the scan conditions had to be considered, but it is very far from being true when the fly-back is taken into account. Resistance and inductance then become of at least equal importance. In order to show this, it is necessary to examine in some detail not only the characteristics of the deflector coil but the conditions in the valve and circuit which are used to feed it.

During the scan period τ_1, which is 19 msec for the present transmissions, it is assumed that the current in the deflector coil has its ideal form and changes linearly with time in the manner shown by Eqn. (1) of the appendix. The power which must be supplied to the deflector coil is given by Eqn. (2) and, since τ_1 is a constant, it depends on two factors only—I^2L and R/L.

With a given cathode-ray tube, picture height and final anode voltage the magnitude of these factors depends only on the design of the deflector coil. Under these conditions the magnetic field required in the neck of the tube is of constant maximum amplitude. Now the term I^2L is a measure of the total field produced by the coil. Consequently, if the field in the tube neck stays constant, an alteration in the value of I^2L means a change in the ratio of the useful to the total fields. Regarding the coil in its primary function as a field-producing device, its efficiency increases as I^2L becomes less. In the design of a deflector coil, therefore, it must be a major aim to minimize the value of I^2L.

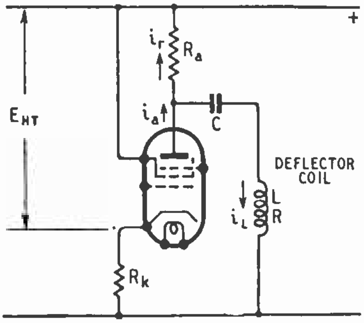


Fig. 1. Basic circuit of a resistance-capacitance fed deflector coil.

The second term, R/L, is a measure of the resistance loss and, again, it is clearly advantageous to minimize it. Its importance depends on its magnitude relative to $6/\tau_1$, however. Practical values of R/L range from about 200 to 2,000 while the value of $6/\tau_1$ is 316. In practice, therefore, the value of R/L has a considerable influence on the power needed by the coil.

It is important to note that with a deflector coil of given design the values of both I^2L and R/L are substantially independent of the number of turns, N, on the coil. It is well known that under the conditions assumed the ampere-turns NI are constant and $L \propto N^2$; therefore

$$I^2 \propto 1/N^2 \text{ and } I^2L \propto \frac{1}{N^2} \times N^2 =$$

constant. For a given wire diameter $R \propto N$, but for a constant winding area the wire area is inversely proportional to N; hence, $R \propto N^2$ and R/L is constant.

The coil power is thus independent of L. Varying the inductance does alter the ratio of voltage to current, however, and has the same effect as altering the turns ratio of a matching transformer. The inductance must be chosen to suit the valve and its supply voltage, and its choice becomes a form of impedance matching.

The foregoing remarks about the constancy of I^2L and R/L are true only for a coil of given design. By changing the physical shape of the coil and the winding area, large changes in their values can be obtained. Not a great deal of information about their possible values is available, but there is some evidence to indicate that R/L tends to increase as I^2L decreases.

So far only the question of the coil power has been considered. The magnitude of this is not a matter of very much interest in itself, however, for the factor of real importance is the power drawn from the H.T. supply. This must be greater than the coil power but does not necessarily bear any direct relation to it.

Two methods of coupling a valve and a deflector coil are available—transformer and resistance-capacitance coupling. Both are commonly used, but there is an increasing tendency towards the use of the latter because it permits an appreciable saving of wire and laminations to be made. In view of this, only resistance-capacitance coupling will be considered here, and the circuit is shown in Fig. 1.

Frame Deflector-coil Efficiency—

It will be assumed that the valve characteristics are linear and that the capacitance of C is large enough for any voltage change across it to be negligible. In practice neither assumption is strictly true, and a finite capacitance is used to compensate for non-linearity of the valve characteristic.[1] However, the voltage changes across C are normally sufficiently small to have an unimportant effect on the power calculations.

The conditions existing in the valve are sketched in Fig. 2, for a pentode (a) and for a triode (b). The D.C. load line is R_a and the mean voltage drop across this resistance is i_oR_a, where i_o is the mean anode current. Ignoring for the moment the effect of the inductance, the A.C. load line is for $RR_a/(R + R_a)$ and is drawn through the intersection of the R_a-line with the i_o-current ordinate. During the scan there is a constant back E.M.F. of magnitude LI/τ_1 across the inductance, however, and so the actual load line is displaced to the left on the diagram by this amount.

The relations involved are developed in the Appendix and Eqns. (5), (6), (7) and (8) summarize everything of importance during the scan.

From the point of view of power efficiency there is an optimum relation between the coupling resistance R_a and the coil resistance R which is given by Eqn. (9). Provided that this relation can be adopted there is a direct relation between the input power P_{in} and the coil power P_L, and a reduction of the latter involves a reduction of P_{in} of the same order of magnitude. No such relation necessarily exists if the optimum value of R_a/R is not used.

In practice, it is common to find that the optimum value cannot be used, for the attainment of proper fly-back conditions sets a minimum value to R_a. It is usually permissible to ignore shunt-capacitance effects on the frame fly-back. If, also, the fly-back of the grid-voltage waveform is more rapid than that of the anode, the conditions are approximately those of a current-carrying coil L shunted by a resistance R_f comprising R in series with the parallel value of R_a and r_a, the effective A.C. resistance of the valve.

The current has changed by 98 per cent of its total value when $\tau_2R_f/L = 4$, where τ_2 is the fly-back time; this is 1 msec for the present transmissions. This leads to Eqn. (10) which gives the smallest value of R_a/R which is permissible if an adequately rapid fly-back is to be secured. When the A.C. resistance of the valve is high, as it usually is with a pentode, the simpler Eqn. (11) can be used.

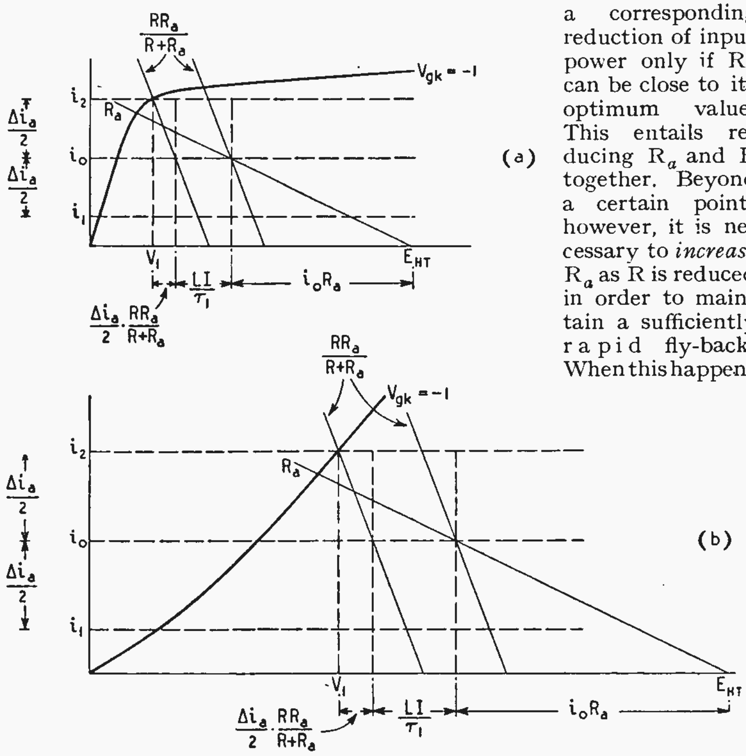


Fig. 2. The operating conditions of the valve are shown here (a) for a pentode and (b) for a triode.

When R/L is fairly large (say above 1,500) $R_{a(OPT)}$ is usually larger than $R_{a(MIN)}$. The optimum condition can be adopted and P_{in} is usually proportional to P_L; the fly-back time may be less than the maximum allowable value, but there is no harm in this. With smaller values of R/L, however, $R_{a(OPT)}$ will be less than $R_{a(MIN)}$, and it is necessary to adopt the minimum permissible value in order to obtain a sufficiently rapid fly-back. It is found that under this condition, which is a common practical one, P_{in} does not depend nearly so much on P_L. In particular, P_{in} becomes insensitive to changes of R/L.

Expressed somewhat more fully, the input power is always reduced if the coil power is lessened by a reduction of I^2L. If the reduction is achieved by altering R/L, however, it entails a corresponding reduction of input power only if R_a can be close to its optimum value. This entails reducing R_a and R together. Beyond a certain point, however, it is necessary to *increase* R_a as R is reduced in order to maintain a sufficiently rapid fly-back. When this happens the efficiency of the coupling falls off rapidly as the efficiency of the coil increases and the net result is only a small change of input power. As a consequence, there is usually little to be gained by reducing R/L beyond a certain point.

Before giving an example of this it is necessary to consider the valve. There are three important factors—the values of V_1, i_1 and r_a.

The value of i_1, the minimum permissible anode current is set chiefly by the amount of non-linearity which can be allowed, and it varies somewhat with different

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[1] "Deflector Coil Coupling," by W. T. Cocking, *Wireless World*, November 1946, Vol. 52, p. 360.

valves. It is not possible to assign any exact value to i_1 without rather lengthy and laborious calculation. With the sort of values usually adopted, however, it is generally satisfactory to take i_1 as about 5 mA—of the order of 10–20 per cent of the mean anode current. The main effect of choosing a low value of i_1 is to increase efficiency and valve distortion; the latter makes it more difficult to secure a linear scan. The value of i_1 is usually much the same for both triode and pentode.

The value of V_1, the minimum permissible anode voltage, varies much more. With a triode it is set quite definitely by the intersection of the i_2-ordinate (i_2=peak current = $i_1 + \Delta i_a$) with the grid-volts curve for a grid-cathode voltage which is just sufficiently negative to avoid grid current—about −1V. The working A.C. load line must be arranged to pass through this point, as shown in Fig. 2 (b). It is only necessary to inspect a number of valve curves to see that V_1 increases markedly with an increase of i_2. V_1 depends also on the A.C. resistance of the valve and increases with it. With a valve of under 1-kΩ resistance V_1 is likely to be around 50–100 V with one of 3-kΩ resistance it is of the order of 100–150 V, and still more with a higher resistance valve.

In the case of a pentode, V_1 is again set by the intersection of the i_2-ordinate with a grid-volts curve. This curve is not now necessarily the one which just avoids grid current, although this still sets one limit; it may be one more negative than this. It is set chiefly by the knee of the curve and does not vary with current nearly as much as with a triode. It nearly always lies between 50 V and 100 V, and in most cases is around 70 V.

It is clear from Fig. 2 that V_1 reduces the effective H.T. voltage. Consequently its practical importance depends on its value relative to E_{HT}. If E_{HT} is very large compared with V_1, a change in the latter will affect the input power very little, whereas if the two are of comparable magnitude an increase of V_1, say, will entail a reduction of L and an increase in I and i_o, and hence, quite a large increase of P_{in}.

If the A.C. resistance of the valve is below a certain value it is not possible with any value of R_a to obtain a quick enough fly-back in the absence of negative current feedback. With a higher value an adequate fly-back is possible, but entails the use of a much higher value of R_a than would be needed for a pentode. This results in some improvement of current efficiency but a considerable reduction of voltage efficiency, and the power efficiency is nearly always lower.

However, it is always possible to make the effective valve resistance as high as with a pentode by using sufficient negative current feedback. The A.C. resistance does not then affect the power efficiency. It is usually found, however, that the input voltage to the grid becomes inconveniently large when this is attempted, and it is rarely practicable to use as much feedback as this.

It is also desirable to consider the power loss in cathode-bias and screen-feed circuits. A triode tends to need more bias than a pentode, although not all types do, and so the power loss in the cathode resistor tends to be greater. There is, however, no screen-grid to supply.

It is not possible to draw any general conclusion about the superiority of either type of valve. In some cases there is not a great deal to choose between the two. However, it will nearly always be found that the pentode is better than the triode when the H.T. supply voltage is under about 250 V, for then the lower value of V_1 obtained with this valve has a considerable influence and there will also be no loss in a dropping resistor for the screen supply—only the actual screen loss of the valve itself. At higher voltages V_1 becomes less important, and as few pentodes can be operated with the screen at more than 250 V, a dropping resistor becomes necessary and causes an extra power loss. The triode may then become the more efficient of the two, but it may still be the less convenient on account of the large amount of negative feedback required. In addition, the high-voltage low-current conditions suited to a triode demand a high value of inductance in the deflector coil, and it may prove impracticable to wind a suitable coil.

TABLE I

		Coil A	Coil B
L	(H)	1	1
R	(Ω)	1,700	208
I	(mA)	40	58
I^2L		0.0016	0.0034
R/L		1,700	208
P_L	(W)	0.269	0.149

In order to illustrate these effects two deflector coils of very different design will be considered. Both are of 1-H inductance, but whereas one—coil A—has R = 1,700 Ω and I = 40 mA, the other—coil B—has R = 208 Ω and I = 58 mA. The values of I^2L are thus respectively 0.0016 and 0.0034, while R/L has the values 1,700 and 208. Coil A is the more efficient of the two in producing a magnetic field where it is needed for deflecting the beam of the C.R. tube, but coil B has a much lower resistance loss in its windings. As far as the coil power is concerned the resistance loss outweighs the field loss and coil B needs little more than one-half the power of coil A. For convenience of reference the relevant figures are collected in Table I.

Now consider the use of these coils with a pentode valve of high A.C. resistance for which $V_1 = 70$ V and i_1 = 5 mA. The first step is to apply Eqns. (9) and (10). As shown in Table II, the optimum values of R_a for coils A and B are 2,760 Ω and 670 Ω, whereas the minimum permissible values are 2,300 Ω and 3,800 Ω respectively. In the case of coil A the optimum value is higher than the minimum, and it can be adopted. With coil B, however, the minimum value is much higher than the

TABLE II

V_1 = 70 V ; i_1 = 5 mA ; $r_a \to \infty$

		Coil A	Coil B
$R_{a(OPT)}$	(Ω)	2,760	670
$R_{a(MIN)}$	(Ω)	2,300	3,800
i_o	(mA)	37.3	35.5
i_2	(mA)	69.5	66
E_{HT}	(V)	210	215
P_{in}	(W)	7.85	7.65

Frame Deflector-coil Efficiency—

optimum, and it is necessary to adopt this minimum value. In what follows, therefore, the values of R_a for coils A and B are respectively 2,760 Ω and 3,800 Ω.

The application of Eqns. (5), (6), (7) and (8) leads to the remaining figures of Table II, and it is interesting to see that the powers drawn from the H.T. supply are almost the same—7.85 W and 7.65 W. Practically speaking, the difference is negligible. Although one coil needs only about one-half the power of the other, because of the fly-back requirement it can only be coupled so much less efficiently to the valve that there is virtually no difference in the demands on the H.T. supply.

Now with a valve such as the EL33 with a screen-cathode potential of 215 V the grid bias needed is approximately − 4.25 V and the grid saw-tooth voltage input some 7 V p-p. The screen current is some 4 mA. For coil B, therefore, there is a screen power loss of 215 × 0.004 = 0.86 W and a cathode bias-resistor loss of 4.25 × 0.0395 = 0.168 W. The total power drawn from the H.T. supply system thus becomes 7.65 + 0.86 + 0.168 = 8.078 W.

If the same valve is connected as a triode it has an A.C. resistance of about 3,000 Ω, and so a large amount of negative feedback must be used. Suppose R_a is made arbitrarily 4,500 Ω, then r_a must be 24,500 Ω and sufficient feedback must be employed to increase the effective A.C. resistance from 3,000 Ω to 24,500 Ω.

With this value of R_a, i_0 and i_2 are negligibly different from their previous values. Inspection of the valve curves for $i_2 = 66$ mA and − 1 V between grid and cathode shows V_1 to be 180 V. The grid bias needed is about − 3.7 V and the bias power loss is some 3.7 × 0.0355 = 0.13 W. Application of Eqn. (7) gives $E_{HT} = 350$V and so $P_{in} = 12.4$ W and the total power becomes 12.4 + 0.13 = 12.53 W as compared with 8.08 W for the pentode. Taking feedback into account the input grid voltage needed will be about 5.4 × 24,500/3,000 = 44 V p-p. The pentode input of 7 V p-p will, in practice, be greater rather because it is usually desirable to employ some feedback even with this type of valve in order to linearize the characteristic. The difference of input grid voltage is not, therefore, a very important one.

In this instance the pentode is very considerably superior to the triode on a power basis. This superiority is due almost entirely to the lower value of V_1 obtainable with it. It is obvious from first principles that the advantage of the pentode will decrease if L is made larger, for this will decrease the current needed and V_1 will fall more for the triode than for the pentode. Such a change will increase E_{HT}, however, and this may be undesirable; in addition, with some designs of deflector coil it is inconvenient to make L much over 1 H, for it entails the use of very fine wire, and there is an increased risk of fracture during the construction.

It thus becomes clear that the pentode usually leads to higher power efficiency than the triode, and this is especially the case when the H.T. supply voltage is limited and it is necessary to use a deflector coil of moderate inductance and needing a fairly large current. In seeking to improve efficiency it is much more important to reduce I^2L than R/L as long as the latter is not of such a value that $R_{a(OPT)}$ is much less than $R_{a(MIN)}$.

Appendix

Let the current through the deflection coil have the ideal form

$$i_L = I\left(\frac{t}{\tau_1} - \frac{1}{2}\right) \quad .. \quad .. \quad .. \quad (1)$$

during the period τ_1 of the scan.

The power loss in the resistance is $I^2R/12$. The energy stored in the inductance once each cycle is $LI^2/2$ and this is dissipated in the resistance elements during the following fly-back. The total power supplied to the deflector coil is thus :—

$$P_L = \frac{I^2L}{12}\left(\frac{R}{L} + \frac{6}{\tau_1}\right) \quad .. \quad .. \quad (2)$$

The back E.M.F. across the deflector coil during the scan is,

$$-\left(i_L R + L\frac{di_L}{dt}\right)$$

$$= -\left\{IR\left(\frac{t}{\tau_1} - \frac{1}{2}\right) + \frac{LI}{\tau_1}\right\} \quad .. \quad (3)$$

the minus sign indicating that it acts in opposition to the E.M.F., which drives the current through the **circuit.**

When the change of voltage across C can be considered negligible, this is also the back E.M.F. on the anode of the valve additional to the mean voltage drop in R_a.

Referring to Fig. 2 the D.C. load line for R_a is drawn from E_{HT} in the usual way and the mean drop across it is i_0R_a. The A.C. load line for $RR_a/(R + R_a)$ is drawn through its intersection with the i_0-current ordinate. On account of the back E.M.F. across L, the actual working line during the scan is displaced by the amount LI/τ_1.

The change of voltage during the scan is clearly $\Delta i_a \dfrac{RR_a}{R + R_a}$ and this must be equal to the change of voltage across the coil resistance IR. Hence,

$$\Delta i_a = I\left(1 + \frac{R}{R_a}\right) \quad .. \quad .. \quad (4)$$

By inspection of Fig. 2,

$$i_0 = i_1 + \Delta i_a/2$$

$$= i_1 + \frac{I}{2}\left(1 + \frac{R}{R_a}\right) \quad .. \quad .. \quad (5)$$

$$i_2 = i_1 + \Delta i_a$$

$$= i_1 + I\left(1 + \frac{R}{R_a}\right) \quad .. \quad .. \quad (6)$$

and

$$E_{HT} = V_1 + \frac{\Delta i_a}{2}\cdot\frac{RR_a}{R + R_a} + \frac{LI}{\tau_1} + i_0 R_a$$

$$= V_1 + i_1R_a + IR\left(1 + \frac{R_a}{2R} + \frac{L}{\tau_1 R}\right) \quad .. \quad .. \quad (7)$$

The power drawn from the H.T. supply is clearly,

$$P_{in} = E_{HT}i_0 \quad .. \quad .. \quad (8)$$

Differentiating (7) with respect to R_a/R and equating to zero gives for the optimum value,

$$\boxed{\left(\frac{R_a}{R}\right)_{OPT} = \frac{\sqrt{2}}{1 + 2i_1/I}\sqrt{1 + \frac{L}{\tau_1 R} + \frac{V_1}{IR}}} \quad .. \quad .. \quad (9)$$

During fly-back the coil current is approximately of the form,

$$i_L = I\left(e^{-tR_f/L} - \frac{1}{2}\right)$$

assuming shunt capacitance effects to be negligible and the fly-back time of the grid voltage to be less than that of the anode. The change of voltage is 98 per cent complete when $tR_f/L = 4$ where $R_f = R + \dfrac{R_a r_a}{R_a + r_a}$, and so the minimum permissible value of R_a/R is,

$$\left(\frac{R_a}{R}\right)_{MIN} = \frac{1}{\dfrac{1}{\dfrac{4L}{\tau_2 R} - 1} - \dfrac{R}{r_a}} \quad .. \quad (10)$$

and when r_a is large this reduces to,

$$\left(\frac{R_a}{R}\right)_{MIN} \approx \frac{4L}{\tau_2 R} - 1 \quad .. \quad .. \quad (11)$$

WORLD OF WIRELESS

Developments at N.P.L. ◆ Birmingham Television ◆ WWV Schedule

N.P.L. DEMONSTRATIONS

THIS year the annual exhibition of the N.P.L. was held on June 21st and 22nd, when representatives of industrial organizations, the universities, Government departments and the Press were invited to meet the Laboratory staff and discuss the work in hand.

In the Radio Division the cathode-ray direction finder for locating thunderstorms was demonstrated in conjunction with a continuously recording camera, now in course of development. Standard 35mm film is used and the linear speed is just sufficient to give resolution between flashes. After development the film is optically projected on a large screen for measurement of bearings. Synchronizing signals for correlating the observations with other stations are photographed on the edge of the film.

A technique for extending the range of quartz-crystal controlled oscillations to centimetre wavelengths was demonstrated by the Electricity Division. By the use of frequency multiplication, mixing and amplification, controlled frequencies at powers of the order of 3 watts are obtained at fixed intervals between 33.6 and 220.8 Mc/s. Harmonics up to the 36th of these frequencies give calibration points at intervals of about 1 per cent throughout the range 350—8,000 Mc/s. A variable frequency oscillator is provided for interpolation and two further stages are being added to extend the range to 50,000 Mc/s. The apparatus will be used for the investigation of molecular absorption spectra as well as for the calibration of wavelengths.

MIDLAND TELEVISION

IN reply to a question in the House the Asst. P.M.G. stated that the B.B.C. hoped to have the Midland television station, now being built at Sutton Coldfield, in operation by the autumn of next year.

On enquiry from the secretary of the Television Advisory Committee it was learned that the frequencies for the sound and vision transmitters had not yet been decided upon. It is, however, understood that they will be at the top of the television band, which extends from 41 to 66 Mc/s. The frequencies of the London and Birmingham stations will therefore be as widely separated as possible. The frequencies quoted in some quarters are 63.45 and 59.95 Mc/s.

The Asst. P.M.G. also stated that one of the next stations will be in the north of England.

STANDARD FREQUENCIES

A CONTINUOUS twenty-four-hour service on each of eight frequencies is now provided by the radio station WWV of the U.S. National Bureau of Standards. This arrangement ensures reliable coverage of the U.S. and extensive coverage of other quarters of the globe.

The services provided are: (1) standard radio frequencies, (2) time announcements (E.S.T.) in morse, (3) standard time intervals, (4) standard audio frequencies, (5) standard musical pitch, 440 c/s, and (6) radio propagation disturbance warning notices.

The carrier frequencies—accurate to one part in 50,000,000—and the audio frequencies radiated are:—

Mc/s	kW	c/s
2.5	0.7	440
5	8	
10	9	440 and 4,000
15	9	
20	8.5*	
25	0.1	
30	0.1	
35	0.1	

(* Power reduced to 0.1 kW for short period at beginning of each month.)

A pulse of 0.005 second duration is radiated at intervals of precisely one second, providing a standard time interval on all carrier frequencies.

A warning of radio propagation conditions is broadcast in code on each of the carrier frequencies at nineteen and forty-nine minutes past the hour. If a warning is in operation a series of "Ws" (in morse) follow the time announcement; if there is no warning, a series of "Ns" are transmitted.

Warnings indicate that radio propagation disturbances of the ionosphere storm type are anticipated within 12 hours, or are in progress, with their most severe effects on radio transmission paths crossing the North Atlantic. Sudden ionosphere disturbances characterized by simultaneous fade-outs in the entire high-frequency spectrum are not covered by this warning.

Full details of the services provided are given in a bulletin, "Technical Radio Broadcast Services," issued by the Central Radio Propagation Laboratory, National Bureau of Standards, Washington, D.C.

PAYING FOR TELEVISION

IN America, as in this country, a governing factor in the progress of television is the cost of supplying first-rate programmes — especially films. A system has, therefore, been devised in the U.S. whereby a "television equivalent for the box office" is provided.

The system, developed by the Zenith Radio Corp. and called Phonevision, employs standard transmitters and receivers, but in addition to the normal "broadcast" method of operation the transmissions can, when desired, be confined to reception by viewers paying a special fee.

The operation of the system is outlined in our American contemporary *F.M. & Television.* The

A RADAR REFLECTOR, to facilitate location by searching ships and aircraft, is fitted to the latest type of life-float to be used by the Navy.

World of Wireless—

writer states that the only additional equipment is an extra modulator at the transmitter—which is connected to a telephone line—and at the receiving end a unit connected to the telephone and an additional three-valve unit in the receiver.

The picture is given a flicker which cannot be steadied unless the viewer asks the local telephone operator to connect him to the television station, whereupon the beam becomes steady. The telephone operator records the period during which the viewer was connected to the station and the charge for the P.V. service is added to the telephone bill.

It is pointed out that the use of P.V. does not interfere with incoming and outgoing telephone calls.

L.C.C. RADIO COURSES

IN addition to the full range of courses in electrical and telecommunication engineering and applied physics for the National Certificate and City and Guilds exams, the South-East London Technical College is providing a number of special day and evening courses for the next session which commences in September.

Among these are the following, each of which will be held on one evening per week:—

Television—Two courses, one of about 12 lectures and one of about 30 lectures and practical work.

Industrial Electronics—about 25 lectures.

Communication Networks (Theory and Design)—about 30 lectures.

Communication Engineering Economics—about 30 lectures.

Applications of the C.R.T. to Industrial Problems—about 6 lectures.

Radio-Frequency Measurements—about 10 evenings, including practical work.

High-Vacuum Technique—about 6 lectures.

Electronic Equipment and Instrumentation—about 6 lectures.

The printed prospectus for the 1948-49 session will be available in August from the College, Lewisham Way, London, S.E.4.

RESEARCH FOR INDUSTRY

THE firm of Mactaggart & Evans has opened a Research Institute at Sondes Place, Dorking, Surrey, for general investigations into the problems of industrial production. The services of the institute are available to small firms who may not be in a position to maintain research departments of their own. Work is undertaken for an agreed fee, and any patents arising from the research become the property of the client.

The laboratories are equipped for chemical, physical, biological and metallurgical research and there is an electronics laboratory dealing primarily with problems of servo-control in industrial processes. Other work for which this section is equipped includes ultrasonics, electro-biological research and the development of electro-mechanical computing methods.

TELEVISION CONSTRUCTION

A NEW printing of the booklet "Television Receiver Construction" (consisting of reprints of a series of *Wireless World* articles) is now available: price 2s 6d from booksellers or 2s 9d by post from our Publishers.

The Mullard MW22-7 C.R. tube used in the set as described is tending towards obsolescence and the makers have introduced a new type to replace it. This is the MW22-14C and is identical except for a heater-current rating of 0.3A instead of 0.6A. The new tube can be used, therefore, without any alteration to the equipment.

PERSONALITIES

Sir Edward Appleton, secretary of D.S.I.R., has recently been honoured by two foreign academies. He has been elected a Foreign Member of the Royal Swedish Academy of Science and a Member of the Pontifical Academy of Sciences. The latter has only seventy members, who are nominated by the Pope.

L. H. Bedford has been awarded the Fellowship of the American I.R.E. "for his development of special circuits, particularly those used for scanning purposes, in television." As Cossor's director of research he was one of the first two industrial engineers to be taken into the confidence of the Government on radar. He is now with Marconi's.

T. E. Goldup celebrated on July 2nd twenty-five years' service with Mullards, of which he is now a director. For some years he was in charge of the Technical Service Dept. and in 1938 was made a director of the subsidiary company, Radio Transmission Equipment, Ltd., at Balham.

T. E. GOLDUP.

C. R. Nortcliffe has resigned from the Boards of British Rola and Celestion but is maintaining his export connections. His address is "Riverhome," The Green, Hampton Court, Middx. (Tel.: Molesey 3795).

IN BRIEF

Television Licences have increased nearly threefold during the past twelve months. The number in force at the end of May, 1947, when it was for the first time possible to know the number of viewers, as all the old 10s sound-and-vision licences had expired, was 18,850. At the end of May this year the total reached 52,500, an increase of 3,300 in a month.

Broadcast Licences in force at the end of May totalled 11,235,700. This number includes television licences.

P.T. on Pickups.—It has been ruled by H.M. Customs and Excise that where a matching transformer is sold with a pickup, but not as an integral part of the pickup, the transformer shall not, in future, be subject to Purchase Tax, which is now 66⅔% on gramophone equipment. In consequence of this decision, the following price revision for the Marconiphone Type 14 lightweight pickup and transformer is announced: Pickup £2 10s, P.T. £1 1s 8d; transformer £1 5s.

"Cast out the beam. . . ."—B.B.C. staff will not in future be permitted to use their private cars on Corporation business unless interference suppressors have been fitted. "Suppression" is now a prerequisite for car allowances. The cost of fitting the suppressor will be borne by the Corporation.

Olympic Games.—Television receivers are being installed by the Radio Industry Council in all the Embassies for the duration of the Olympic Games, many events of which will be televised by the B.B.C. Extensive arrangements are being made by the B.B.C. to facilitate the coverage of the Games by reporters from overseas.

Scientific Films.—The second congress of the International Scientific Film Association will be held in London from October 4th-11th. The primary aim of the Association, which was founded by twenty-two countries last year, is "to raise the standard and to promote the use of the scientific film . . . in order to achieve the widest possible understanding of scientific method and outlook. . . ." Details of the congress are available from the Scientific Film Association, 34, Soho Square, London, W.1.

Record Library.—A choice of more than 2,000 records, including frequency test discs, is available to subscribers to the Yorkshire Gramophone Library, 166, Briggate, Leeds, 1. The postal service provides a parcel of ten records per month and subscriptions range from £1 15s 6d for three months, to £6 5s 6d for a year. There is a returnable deposit and subscribers undertake to use thorn or fibre needles except where express permission is given to use an approved lightweight pickup.

Frequency allocations to all services in the entire telecommunication spectrum—10 kc/s to 10,500 Mc/s—as agreed at the Atlantic City conference, are given on a sixteen-colour chart, measuring 54in by 30in, issued by Mullards. The vertical columns are divided into three—one for each of the three Regions. It is available from the Communications Division, Mullard Electronic Products, Ltd., Century House, Shaftesbury Avenue, London, W.C.2, price 30s. A smaller six-colour edition will be available later.

Television Demonstrations are now given every afternoon from 3 to 4 at the Science Museum, South Kensington. Admission to the Museum, which is open from 10 a.m. to 6 p.m. weekdays and from 2.30 to 6 p.m. on Sundays, is free.

Aids to Production.—Although the first national mechanical handling exhibition, held at Olympia in July, was mainly concerned with the handling of heavier products than those generally associated with the radio industry, there were some examples of mechanical aids to light production engineering. A full report of the show will be given in the August issue of our associated journal *Mechanical Handling.*

Brazil.—The new broadcasting station in Recife, Brazil, equipped by Marconi's for the Radio Jornal do Commercio, was inaugurated on July 3rd. The installation includes a 20-kW M.W. transmitter and two 25-kW S.W. transmitters.

Television and the Cinema.—A convention is being organized by the Société de Radioélectriciens of France on the question of the relationship between television and the cinema. It will be held in Paris in the autumn and invitations have been sent to other countries for contributions. Full details are obtainable from the society, 10, Avenue Pierre Larousse, Malakoff (Seine), France.

N. American F.M.—Agreement has been reached between the U.S. and Canada regarding the allocation of frequencies for F.M. stations, their power and height of aerial. Eighty-one frequencies have been distributed among Canada's nine provinces.

Royal Yacht Radio.—Broadcast receivers and radio-gramophones for the King of Norway's yacht "Norge" were supplied by Golden Voice Radio, Ltd., 25, Haymarket, London, S.W.1. Special superheterodyne receiver chassis were designed to work from the ship's mains and the cabinet work of the seventeen pieces was varied to blend with furniture and panelling.

I.P.R.E.—A Midlands Section of the Institute of Practical Radio Engineers has now been formed. The secretary is F. Prosser, 27, Duncroft Road, Yardley, Birmingham, 26.

Amateur Radio Exhibition.—The second annual exhibition of amateur radio equipment is being organized by the R.S.G.B. and will be held in London from November 17th to 20th.

I.E.E. Council.—Among the new members of the Council of the I.E.E. to fill the vacancies which occur on Sept. 30th are A. J. Gill, B.Sc. (Eng.), who is appointed a vice-president, and Dr. W. G. Radley, C.B.E., from the Radio Section.

FREDERICK SMITH, O.B.E.

I.E.E. Radio Section.—The new chairman of the I.E.E. Radio Section Committee is Frederick Smith, O.B.E., who is general manager of the M.O. Valve Co. There are two vice-chairmen this year; they are R. T. B. Wynn, M.A., B.B.C. asst. chief engineer, and C. F. Booth, O.B.E., staff engineer in charge of the Post Office Radio Development Branch. The following have been elected to fill the four vacancies occurring on the committee on Sept. 30th: Dr. H. G. Booker, M.A. (Cavendish Laboratory, Cambridge); Dr. L. F. Broadway, B.Sc. (E.M.I. Research Laboratories); E. Fennessy, O.B.E., B.Sc. (Decca); and F. R. Willis, B.Sc. (Eng.) (Sir Alexander Gibb & Partners).

INDUSTRIAL NEWS

Magnetic Disc Recorder.—A portable recording machine, the "Recordon," using paper or plastic discs coated with powdered magnetic material, is to be manufactured under licence in this country by Thermionic Products, Ltd., Pratt Walk, London, S.E.11. The machine, which is intended primarily for office dictation, weighs about 11 lb and gives a playing time of 3 minutes (approx. 450 words) per disc. The design is based on the "Mail-a-Voice" recorder of the Brush Development Co., of America.

"Better Listening."—Plans have been made by B.R.E.M.A. to launch a "Better Listening" campaign in the autumn to encourage the replacement of old receivers and, in the London area, the purchase of television sets. The campaign will be run from September 26th to October 9th.

Radio Ball.—The second annual Radio Industries Club Ball will be held at Grosvenor House, Park Lane, on September 30th.

Philips Electrical has installed two 50-watt amplifiers and over fifty loudspeakers at Lord's Cricket Ground.

Mullard-Hallicrafter Agreement provides for Hallicrafter-designed communication transmitters and receivers to be manufactured by Mullards, who will also represent Hallicrafters in the U.K., Eire and Australasia.

Marconi E.H.F. radiotelephone equipment was installed in each of the six tugs used during the launching of the whale-tanker "Kosmos V," at Middlesbrough, on July 8th. The equipment, together with a seventh set temporarily fitted in the "Kosmos V," will facilitate the handling of the ship, the longest—675ft—launched at this port.

British Rola, Ltd.—At the request of the company a receiver has been appointed to go into its affairs with a view to reconstruction. A net loss of over £10,000 was incurred last year compared with the previous year's profit of over £13,000.

E.M.I.—The Service Division of E.M.I. Sales and Service, Ltd., has been transferred from Hayes to the recently acquired Sheraton Works, Wadsworth Road, Greenford, Middx. (Tel.: Perivale 3344), to which all enquiries regarding servicing should be addressed. The E.M.I. London depot, previously at Clerkenwell Road, has also been transferred to Greenford, where all orders for gramophone records and accessories should be sent.

Philco.—In addition to the reduction in price of Philco sets consequent upon the decrease in Purchase Tax the Philco Radio and Television Corp. is adjusting the prices of receivers so that the selling price will be reduced by about 25 per cent.

Partridge.—The new factory for Partridge Transformers, Ltd., on the Kingston By-pass, Tolworth, Surrey, is nearing completion and it is hoped to start production in August. Enquiries should continue to be sent to the new offices in Peckford Place, London, S.W.9. (Tel.: Brixton 6506.)

S. G. Brown, Ltd., who manufacture headphones and precision instruments, have moved from North Acton to a larger factory in Shakespeare Street, Watford, Herts. (Tel.: Watford 7241).

Goodmans.—The telephone number of the registered offices and works of Goodmans Industries, Ltd., at Lancelot Road, Wembley, has been changed to Wembley 1200.

Melton Metallurgical Laboratories, Ltd., manufacturers of "liquid silver" for capacitors, have moved from Slough to 42, Towngate Street, Poole, Dorset (Tel.: Poole 872-3).

Wolsey Television has moved to 75, Gresham Road, Brixton, London, S.W.9. (Factory: 102. Barrington Road, S.W.9.)

Tannoy.—Guy R. Fountain, Ltd., who manufactures Tannoy equipment, has gone into compulsory liquidation.

Advert. Corrections.—In the advertisement of Reproducers and Amplifiers, Ltd., in our June issue, the tolerance should have been given as ±0.0005in—not 0.005in as printed. Purchase tax on the Collaro Microgram de Luxe equipment, incorrectly given in the July issue advertisement, should be £8 12s 11d.

More Cathode-ray Tube Data

Further Notes on Ex-service Types

Compiled by
D. W. THOMASSON

THE following list has been compiled in response to a number of requests for an extension of the original list given in the December, 1947, issue.

A number of correspondents were anxious to have details of C.R. tubes suitable for use in television receivers, but a careful search has revealed only one type with white trace, large screen (12in) and magnetic deflection. This tube, the the CV274, has not been seen in the surplus market as yet, and it seems that television experimenters must either put up with a green or blue trace and electrostatic deflection or buy in the civilian market.

There are a good many tubes for magnetic deflection, but they are mostly of the "afterglow" type, and useless for television. It is useful to note that such screens can generally be identified by the greenish tint of the screen caused by

Type	Screen	Base	Size		Operating Conditions					Sensitivity		Remarks
			L	D	V_1	V_2	V_3	V_{max}	I_b	X	Y	
ACR1	W	—	495	136	3	0.6	3	4	15	600	675	
ACR2	As ACR1, but less stringent specification.											
ACR8	W or G	—	—	136	0.15	0.56	3	3	20	870	500	
ACR10	G	12.4	205	70	0.45	0.07	0.45	1	2	170	170	=VCR139A
ACR11		As ACR8, but with metallized outer coating.										
ACR12	G	—	620	295	4	0.8	4	5	—	650	650	
ACR13	G	—	431	160	2	0.48	3	5	15	620	1160	
NC2	G	8.1	414	136	Gas Focus		—	1.5	—	450	450	0.6 V Htr.
NC3	G	9.1	203	71	—	—	—	0.8	—	120	150	
NC4	B/G	Otherwise as NC2.										0.6 V Htr.
NC5	W	6.1	495	136	3	0.55	3	4	—	600	675	
NC8	Red	—	—	Gas focus		—	1.5	—	—	—	—	=32E
NC9	B	12.5	380	114	—	—	—	2	—	490	490	
NC10	W	6.1	495	136	3	0.55	3	4	—	600	675	
NC11	G	12.3	420	160	1.8	0.8	5	6	3	550	1000	Obsolete.
NC13	G	12.3	495	175	0.45	0.44	2.2	4	—	520	520	
NC15	G	12.6	380	116	1.2	0.35	1.2	2	—	530	370	=VCR518
NC17	D	8.2	393	90	Mag. Focus		—	15	—	Mag.	Defl.	Skiatron
NC18	Y	12.3	431	160	2	0.8	5	6	—	620	1160	=CV966
NC20	G	12.5	585	300	4	0.8	4	5	20	900	900	
VCR84	A	12.7	685	305	1.8	0.65	3.5	4	—	1175	550	Obsolete.
VCR85	A	12.7	660	300	1.8	1.6	6	7	—	1345	1300	
VCR86	A	12.7	570	160	1.8	0.97	5	5.5	—	900	700	Obsolete.
VCR87	A	12.7	512	160	3	0.7	3	5.5	—	700	750	
VCR112	G or W	—	495	135	0.2	0.56	3	3.5	—	870	500	
VCR131	G	12.7	585	300	4	0.8	4	5	—	900	900	
VCR138	G	12.3	340	90	1.2	0.2	1.2	2.5	—	357	780	
VCR138A	G	12.3	340	90	1.2	0.2	1.2	5	—	357	780	Larger screen than VCR138
VCR139A	G	12.4	205	70	0.8	0.135	0.8	1	3	170	170	
VCR140	A	8.2	587	306	Mag. Focus		5.5	6.5	—	Mag. Defl.		
VCR511	A	12.7	585	300	4	0.8	4	6.5	—	1000	1000	2 screen variants A & B.
VCR514	G	12.3	370	90	0.8	0.28	2	2.5	—	380	580	
VCR515	B or G	—	384	90	0.2	1.2	—	1.5	—	480	400	2 anodes
VCR516	A	8.2	452	230	Mag. Focus		4	5	—	Mag.	Defl.	
VCR517	A	12.3	431	160	2	0.5	3	6	—	720	880	5 screen variants A-E
VCR518 VCR518A	B G	12.6	380	116	1.2	0.35	1.2	2	—	530	370	Double Beam.
VCR519	G	—	640	312	0.5	0.5	2.2	4	—	720	720	Compass.
VCR520	A	8.2	393	885	Mag. Focus		10	15	—	Mag. Defl.		
VCR521	A	12.3	340	92	1.8	0.7	4	5	—	357	780	
VCR522A	G	9.1	145	39	0.8	0.135	0.8	1	—	90	90	
VCR523	G	12.7	660	295	1.8	1.6	6	7	—	1345	1300	Similar to VCR85.

NOTES: The screen type is given by the following symbols: A = Afterglow; (long persistence); B = Blue; B/G = Blue-Green; D = Dark Trace; G = Green; W = White; Y = Yellow.

The size is given in mm, L being the overall length, and D the diameter. The operating voltages are given in kilovolts, and the beam current in μA.

V_1 = 1st anode; V_2 = 2nd anode voltage; V = 3rd anode voltage;
V_{max} = maximum final anode voltage; I_b = beam current. The sensitivities are given in mm/V/V.

More Cathode-ray Tube Data— phosphorescence. After exposure to sunlight, the screen glows plainly when shaded again. This will not, of course, identify a tube with a "dark-trace" screen.

All but two of the tubes listed are 4-V heater types, the current drawn being of the order of 1 A. The deflection and focus are generally electrostatic, the exceptions being noted.

BASE TYPES

There are a large number of variations between tubes of a given type, but the connection lists are framed to cover these as far as possible.

	1	2	3	4	5	6	7	8	9	10	11	12	Side Caps					
6.1	K	G	H	H	A_2	A_1	—	—	—	—	—	—	A_3 ;	Y_1 ;	Y_2 ;	X_1 ;	X_2.	6-clip type.
8.1	A	Y_1	F	X_1	G	Y_2	F	X_2	—	—	—	—	—	—	—	—	—	8-pin spigot.
8.2	—	H	—	—	G	—	H	K	—	—	—	—	A	—	—	—	—	Int. Octal.
9.1	X_1	Y_1	A_2	H,K	H	G	$A_{1,3}$	X_2	Y_2	—	—	—	—	—	—	—	—	Brit. 9-pin.
12.1	G	—	H,K	H	A_1	A_2	Coa	X_2	—	A_3	—	X_1	Y_1 ;	Y_2.	—	—	—	12-way S.C.
12.2	G	—	H,K	H	A_1	A_2	Coa	Y_2	X_2	A_3	X_1	Y_1	—	—	—	—	—	12-way S.C.
12.3	G	K	H	H	A_1	A_2	Coa	Y_2	X_2	A_3	X_1	Y_1	—	—	—	—	—	12-way S.C.
12.4	K	G	H	H	A_2	—	Y_2	X_2	A_3	X_1	Y_1	—	—	—	—	—	—	12-pin Spigot.
12.5	K	G	H	H	—	A_2	—	Y_2	X_2	A_3	X_1	Y_1	—	—	—	—	—	12-pin Spigot.
12.6	K	G	H	H	—	A_2	A_4	Y_2	X_2	A_3	X_1	Y_1	—	—	—	—	—	12-pin Spigot.
12.7	K	G	H	H	A_1	A_2	Coa	Y_2	X_2	A_3	X_1	Y_1	—	—	—	—	—	12-way S.C.

SYMBOLS: G = Grid (Modulator); H = Heater; K = Cathode; Coa = Coating (Internal); X_1, X_2, Y_1, Y_2 = X- and Y-axis deflector plates A_1 = 1st anode; A_2 = 2nd anode; A_3 = 3rd anode; A_4 = Splitter plate in double-beam tubes.

The probable variations are: Coating and A_1 to A_3, K to H, and X_1, Y_1 to A_3.

HIFAM

E.H.F. Amplitude-modulated Broadcasting in U.S.A.

By SARKES TARZIAN

IN common with a large number of radio engineers, it has been the writer's opinion that the extra high frequencies could be utilized more economically by using A.M. than F.M. In order to study the radio service possibilities, particularly for small communities, of A.M., an experimental station, W9XHZ, was constructed in Bloomington, Indiana. W9XHZ operates on a frequency of 87.75 megacycles with radiated power into the aerial of 200 watts. The word "HIFAM" (high-fidelity A.M.) has been coined to describe the service.

In the area covered by W9XHZ, the terrain is very hilly, some of the hills around the transmitter being as high as 900 feet above sea level. The aerial, which is non-directional, is 795 feet above sea level. It consists of eight co-axial units mounted vertically and hanging down from the tower platform, and has a power gain of about 10. This is a very inexpensive type of aerial to construct. It gives vertical polarization, which has advantages when small vertical aerials are used for reception.

In all urban districts of Bloomington, the field strength is high, ranging from 250,000 to 5,000 µV/metre. The 50-µV per metre contour is about 25 miles with 200 watts of radiated power. The maximum power output of the transmitter is 500 watts. The fidelity characteristic of all components was specified as ±3 db from 30 to 10,000 c/s. A compression amplifier is used in order to maintain a relatively high modulation level. The fidelity characteristic of the studio equipment is ±1 db from 30 to 15,000 c/s.

Amplitude modulation permits the use of inexpensive converters

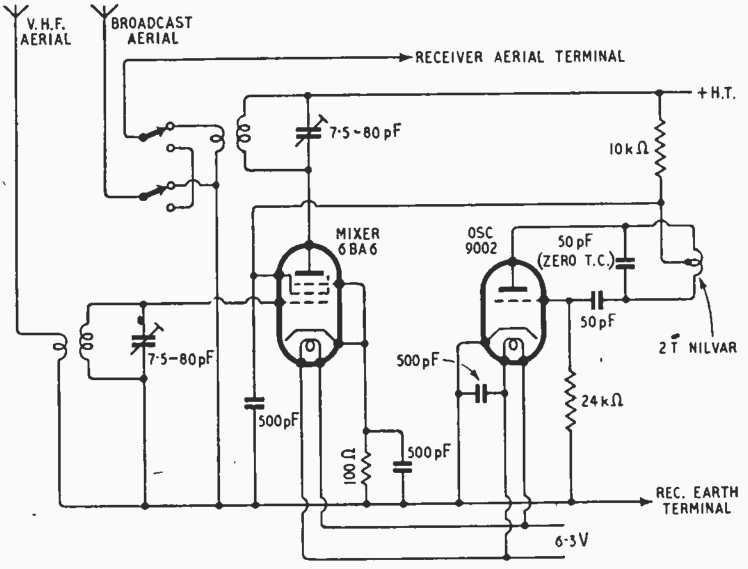
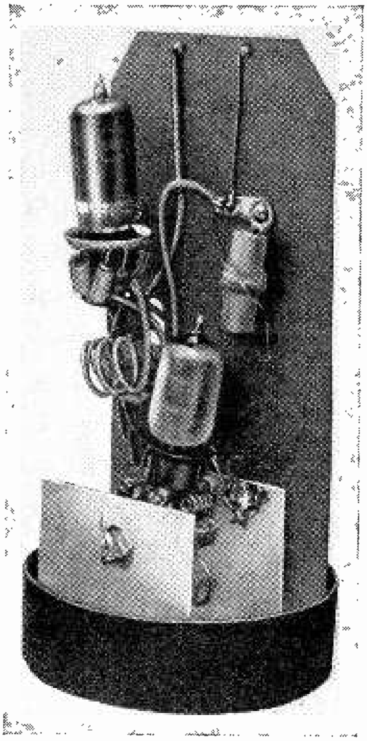


Fig. 1. Circuit diagram of the converter unit described. The input frequency is 87·75 Mc/s and the output 1,500 kc/s.

HIFAM—

with standard broadcast band receivers which are already in use in thousands of homes. A great deal of development work was done in the design of an inexpensive converter to be sold at $5.95; the circuit arrangement is shown in Fig. 1. The problem was to build a highly stable oscillator with a frequency stability of 0.002%. It is essential to have high signal/noise ratio in the mixer stage. This was achieved by using a high g_m tube as mixer (6BA6 and 12BA6). The frequency stability was obtained by using a "chimney" type of construction which maintains a flow of cool air at room temperature past the oscillator components. An Invar oscillator coil and zero-coefficient capacitors are used in the oscillator tank circuit. In all cases the oscillator stabilizes after ten minutes. In many cases it is stable after five minutes. Fig. 2 shows the drift characteristic in production units. The overall gain of the converter is 25. The average broadcast band receiver with 5 or 6 tubes has a signal/noise ratio of about 25 to 1. Production converter units have a signal/noise ratio of over 110 to 1. Converters that have been in operation since July, 1946, have fulfilled the designers' expectations.



The inexpensive converter used for the American experiments in A.M. broadcasting to small communities on 87·75 Mc/s.

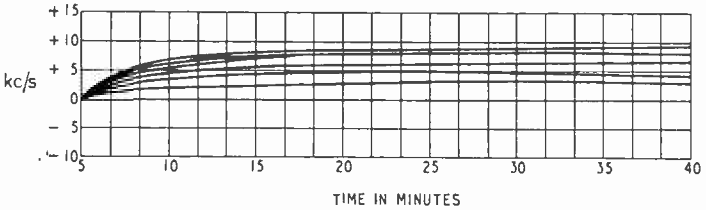


Fig. 2. Frequency stability curves of production models of the converter shown in Fig. 1.

We have also developed small converters with an R.F. stage. These have been used in the 50 to 100-μV field strength areas and have given excellent results. These units can be sold for $9.95 to the public.

Several combined broadcast-band and E.H.F. receivers were developed. A low-cost 6-tube receiver was designed which is no more complicated than any standard-band receiver with a simple short-wave band added. Common broadcast components can be used throughout. The band width of the IF system, which is tuned to 460 kc/s, is broadened for HIFAM use. The HIFAM-AM receiver can be sold at a profit for $29.95. Receivers for the AM system will always be simpler and cheaper than those for F.M.

In larger console type HIFAM-AM receivers, it is possible to eliminate all oscillator drift. This is accomplished by using a crystal (cost $1.20) to obtain a double superheterodyne. In addition to a standard broadcast band receiver, a crystal and two tubes are used for HIFAM reception.

Very satisfactory radio service has been given to the small community of Bloomington with a radiated power of 200 watts, and there has been no trouble from atmospheric interference, because the frequency use is inherently immune. Man-made electrical disturbances cause very little interference at 88 Mc/s and higher.

HIFAM receivers are very stable and any change in alignment with age will not cause such serious distortion as in E.M. receivers. In all our tests since May, 1946, we have encountered no multipath distortion. The country is very hilly and multipath distortion would be easily detected if present. This is another decided advantage of HIFAM over F.M.

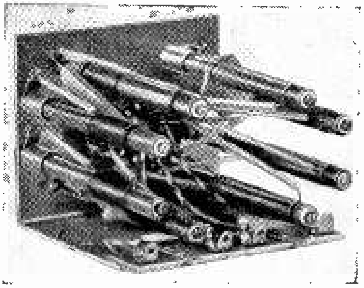
Due to its nature HIFAM needs a much narrower band of frequencies than F.M. This permits the assignment of a greater number of stations on a given frequency spectrum. The number assigned will depend, of course, on the highest modulation frequency.

Pre-set Tuner Unit

THE tuner illustrated has been produced to simplify the construction of small superhet broadcast sets. Ganging and alignment of circuits are avoided by using pre-set tuning and a selector switch giving the choice of three stations in the medium waveband and one in the long.

Efficient dust iron coils with adjustable cores are used and the sensitivity and selectivity should compare favourable with the more usual capacitor tuning.

The unit measures 3 × 2½ × 3in and costs 33s. Makers are Electro Technical Assemblies, Eta Works, West Hill, St. Leonards-on-Sea.



Eta switch-selected four-station tuner.

Quality in the Home

Are High-Powered Amplifiers Necessary ?

By H. S. CASEY

SO much has been written on the design of high-quality amplifiers that it may appear to readers, especially after the recent articles by D. T. N. Williamson and P. J. Baxandall, that the subject is played out, and that there can be little justification for monopolizing the time of readers by a further article. Yet despite this I humbly submit that much that has been written is inconsistent, and that the underlying basic data of many amplifiers is based on false premises:

In *Wireless World*, March 10th, 1938, "Cathode Ray" had been advocating remedies for "scale-distortion" as he called it, and the climax came when he visited the Queen's Hall, London, with "loudness" measuring equipment to prove that there was such a difference between the actual and reproduced levels of sound that a "weighting" network was necessary at the reproducing end to restore the bass response to the same level as the middle register.

The loudest playing of the B.B.C. Symphony Orchestra in peaks was 105 phons, the softest 55 phons. The sustained climaxes of loud playing were 90 phons. In measurements in a small room furnished in the customary style the power needed for a similar level was only 1½ watts. The extreme contrasts were perhaps 10 phons less. I take this to mean the range in the Hall 55-105 phons was compressed to 60-100 phons in the room. This is borne out by his other measurements with a commercial receiver, nominal output 3½W (actual about 2), which gave 110 phons close to the speaker and less than 100 some distance away. Assuming that the power ouput in the distorted condition was 3½ W I deduce a mean level of 103 phons. Taking the 1½ watts and adding 5 db (to restore the peaks) we have an output of 5 W for a peak intensity of 105 phons which is in close agreement with the 3½ W-103 phons deduction. Or again, take the third statement that 1 W pure tone gave 110 phons in the mouth of the speaker and considerably less elsewhere, a figure of 5 W for peaks of 105 phons is not unreasonable. Finally the formula he quoted gave 0.57 W for 100 db or 1.6W for 105 db. He expressed doubts about the formula and thought it was a little on the low side.

Summing up I deduce that, with a baffle-loaded moving coil loudspeaker, an output of 5 W is all that is necessary at home to secure maximum ear-drum pressure comparable with that at the Queen's Hall.

While not being entirely convinced by all the arguments adduced by the writer, we print this article as a salutory reminder of the incontestable fact that equipment for high-quality reproduction should be treated as a whole, and not as a collection of detached pieces.

It is relevant, I suggest, at this point to ask whether this level is necessary for the complete and full enjoyment of serious music. I am aware I am treading on dangerous ground, but it is necessary to go wherever the pursuit leads. I have a number of friends and acquaintances whose radio knowledge is practically nil, but who express keen interest in serious music. They have never suggested that the B.B.C. Symphony Orchestra was itself not powerful enough to fill the Albert Hall, although this hall is considerably larger than the Queen's Hall and must therefore have a lower average "phon" level than the old home of the Promenade Concerts. Such criticism has been made about solo voices and instruments but never, to my knowledge, about the whole orchestra. From this I deduce that there is a fair margin in the ear-drum pressures permissible for the complete enjoyment of orchestral works. The figure of 5 W may therefore be regarded as a "peak of peaks," and a figure of 1½ W maximum is not unreasonable. Remembering that these figures assume expansion by 5 phons, a figure for normal peak output for B.B.C. reproduction would be ½ to 1½ watts. In case these figures may appear absurdly small I would add that the 600-milliwatt power output of an AC/P valve proved quite satisfactory in my own case for seven years with an efficient 12in energized moving coil speaker.

There is another aspect of this problem which tends to be overlooked — interference with one's neighbours. For this reason we should aim at the lowest peak level consistent with the full enjoyment of the music and this level is something lower than was experienced at the old Queen's Hall.

I submit, therefore, that our amplifier need not exceed 5 W for high fidelity reproduction in the average home.

The next consideration is frequency response. The limits are variously placed from, say, 50-8,000 c/s to 10-20,000 c/s. "Cathode Ray," in his article, said that with a pure tone the output varied widely over the room. So far as the listener with normal hearing is concerned binaural listening eliminates to a considerable degree the presence of standing waves produced by reflection, so long as the wavelength of the note is not too great compared with the distance between the ears. This difficulty becomes worse as the frequency decreases and when the wavelength approaches that of the principal measurements of the room, regions of maximum and minimum sound intensity become very marked indeed and their location varies with the wavelength. Realistic reproduction in an average living room is therefore, I suggest, impracticable for notes whose wavelengths are greater than the physical dimensions of the room. Taking the greatest measurement as 15 feet this limits the reproduction to 80 c/s. I submit on this basis that it is impracticable to reproduce in an average living room the sound heard in, say, the nave of Westminster Abbey when an organist is sounding his pedal notes going down to a fundamental frequency of 16 c/s.

So far as I have been able to read there is no equivalent upper limit to the frequency range. Accordingly we need an amplifier with a range from, say, 50 c/s (to be on the safe

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side) to 20,000 c/s with a power output of 5 W.

The instrument we shall use for reproduction will be a baffle-loaded moving coil loudspeaker. First the loudspeaker: the average 12in "high fidelity" speaker will handle 12 W at 400 c/s, and this limit on power input is normally dictated by consideration of heat dissipation. I deduce, I hope correctly, from elementary dynamics that the limit on power input based on the amplitude of vibration of the voice coil will be greater at low frequencies. Thus, supposing the 12 W at 400 c/s was the maximum input before the voice coil travelled outside the zone of uniform magnetic field then the power input at 200 c/s would be 3 W, at 100 c/s ¾ W, at 50 c/s $\frac{3}{16}$ W, etc. In practice the power-handling capabilities of a loudspeaker are governed by consideration of amplitudes of vibration at the lowest frequencies and heat dissipation at the middle frequencies. There are at least two methods of ensuring a wide excursion of diaphragm movement with freedom from intermodulation difficulties caused by variations in magnetic field. The first, by using a thicker "top-plate" than the length of the voice coil, and the second, converse of the first, by using a longer voice coil than the thickness of the top plate. The objection to the first method is the impracticability of obtaining a high flux density with a thick top plate, and to the second, the loss of sensitivity and increase in mass of the voice coil. To take a practical example, one manufacturer uses a $\frac{3}{16}$in top plate with a ¼in voice coil. This limits the travel to $\frac{1}{32}$in and theoretically the maximum input before frequency doubling occurs at 50 cycles to ¼ W. Another speaker with a 12in diaphragm can handle 1½ W at 50 cycles before difficulties ensue. It has a ¼in top plate. For a 12in speaker with a top plate of ½in thickness a reasonable figure for the power handling capacity at 50 cycles would be 4 W.

Bass Resonance

Our troubles with the loudspeaker are not yet over, for there are at least two more considerations. First, the frequency of resonance in the extreme bass—I believe it is true to say that the movement of the loudspeaker above this frequency is substantially inertia controlled, i.e., the stiffness of the surround and suspension do not constitute the major factor governing the amplitude of the diaphragm movement. Below this frequency, however, the audio output falls off sharply. For practical purposes it can be said that the linear range of the acoustic output of a loudspeaker starts from just beyond the frequency of major resonance in the bass. If the reader is interested he is recommended to study the curves of loudspeakers published in *Wireless World* since 1935 to appreciate this assertion. Let there be no mistake; I am not saying; there is no output below this point, but I am emphasizing the fact that the output is no longer linear with frequency. The fundamental frequency is usually about 60-70 c/s for the average 12in speaker. If, therefore, this type of speaker is chosen for high quality reproduction in the average small room there is another reason why we need not bother to go below 50 cycles.

The second difficulty with conventional loudspeakers is the production of spurious notes by a development of the Doppler principle. Take, for example, a speaker reproducing a "pedal" note of an organ at 50 c/s with a displacement of its diaphragm of ½ cm each way from the position at rest and also reproducing a flute note of 1,500 cycles. To the listener the diaphragm will approach and recede 100 times per second with a peak velocity of 50 cm/s, assuming a sine wave motion. When the diaphragm is approaching the 1,500 c/s note will rise in pitch and become 1,565 c/s and when it is receding will fall to 1,431 c/s. This is almost a variation of a semitone. The aural result is a harshness of tone as of, say, many flutes playing some half a tone flat and some half a tone sharp with others in between. The smaller the amplitude of the pedal note the less the displacement of tone. The amplitude of ½ cm is certainly the maximum likely to be experienced without frequency doubling, but the aural effect is noticeable with much less than this input.

Recapitulating, it is not practicable to aim at a reproduction below 50 cycles because of acoustic limitations of a small room, and because of limitation in loudspeaker performance.

We will proceed to the placing of the loudspeaker on a baffle and point out that the power radiated depends on the size of the baffle. A baffle 6ft square will result in 16 per cent efficiency or 8 db loss at 50 cycles, and many baffles are less than this in size. The difficulty in the production of long waves in small rooms is still further increased by the impracticability of housing large baffles. The use of a dividing wall between rooms as a baffle does not seem to be an unqualified success for various reasons.

The Output Stage

Proceeding now to the examination of the output valve, we must bear in mind that with the application of negative feedback the characteristics of the tetrode can be made similar to those of the triode in output impedance, distortion, etc. A. W. Stanley in the August, 1946, *Wireless World* produced curves for constant current and constant voltage input to a particular loudspeaker. The former rose 20db at the bass resonance frequency; the latter was level at this point. Translating these extreme cases into those of the KT41 tetrode and PX4 triode without feedback, the gain will be reduced from 20db to 14db for the tetrode and increased from zero to 1.7db for the triode. The result for the tetrode is excessive boom and over-accentuation of the range 1,000 c/s to 5,000 c/s. Filters are required to tune at the bass resonance, to reduce the gain by 10-14db, and again progressively between 1,000 c/s to 5,000 c/s by a similar amount but to restore the full output by 10,000 c/s, as the total spherical power radiated between 5,000 c/s to 10,000 c/s is much less than would be inferred from the axial response curve.

The use of negative feedback will not alter the response to these requirements and S. W. Amos in an article in *Wireless World*, Dec., 1944, stated that if too much feedback were used the top response sounded dead, and he proposed restoring some of the loss of "top" due to feedback. Feedback applied to triodes is open to this objection.

This leads on to the amount of distortion which can be tolerated before a detectable difference in quality is apparent. I would refer readers here to an article in the *Post Office Electrical Engineers'*

Journal, April, 1939, "Non-Linear Distortion of Music Channels with Particular Reference to the Bristol-Plymouth System." The findings of this study were for non-linear distortion with single- and two-tone inputs to be just audible by direct comparison, and the percentages were:

2nd harmonic (a) up to 25 per cent at 100 c/s
(b) up to 3 per cent higher than 200 c/s
(c) up to 1 per cent higher than 400 c/s
3rd harmonic (a) up to 5 per cent at 100 c/s
(b) up to 1 per cent higher than 400 c/s

Quadratic Distortion
(a) up to 15 per cent at 100 c/s
(b) up to 7.5 per cent higher than 200 c/s
(c) up to 1.5 per cent higher than 400 c/s

Cubic Distortion
(a) up to 30 per cent at 100 c/s
(b) up to 10 per cent higher than 200 c/s
(c) up to 5 per cent higher than 400 c/s
(d) up to 1 per cent higher than 800 c/s

Quadratic or cubic difference tones
(a) at any frequency between 100–200 c/s, 20 per cent
(b) at any frequency between 200–400 c/s, 5 per cent
(c) at any frequency between 400–800 c/s, 2 per cent
(d) at any frequency between 800–6,400 c/s, 1 per cent

From this article there is abundant evidence to show that it is unnecessary to worry about small percentages of distortion at low frequencies and it would appear that distortion percentages to which the average radio engineer would hold up his hands in horror would pass unnoticed to the human ear if the frequency is low enough. Consider 25 per cent 2nd harmonic at 100 c/s; at 30 c/s a figure of 50 per cent would not be out of place. "Iron" distortion in transformers does not therefore appear important.

Adding all our deliberations together we need an amplifier which has not more than 1 per cent distortion over the middle register and the rest of the scale will in all probability be satisfactory if standard components are used. Mr. Williamson in his articles in the April and May issues of *Wireless World* last year showed that the output for 1 per cent distortion without feedback is not much less than the nominal output for the valves in push-pull. The rated output of one KT66, triode-connected, is 5.8W; of a PX4, 3.5W. Two PX4s in push-pull will give 7W with 1 per cent distortion total, and I contend that a satisfactory output can be obtained without feedback with distortion less than is audible by direct comparison. There are thus no major reasons why negative feedback should be used with triodes.

On the subject of tetrodes without feedback, two KT41s in push-pull, 250 V screen, 250 V anode, will give 4 W with 1 per cent third harmonic, zero second; or 9 W with 3½ per cent third harmonic, zero second.

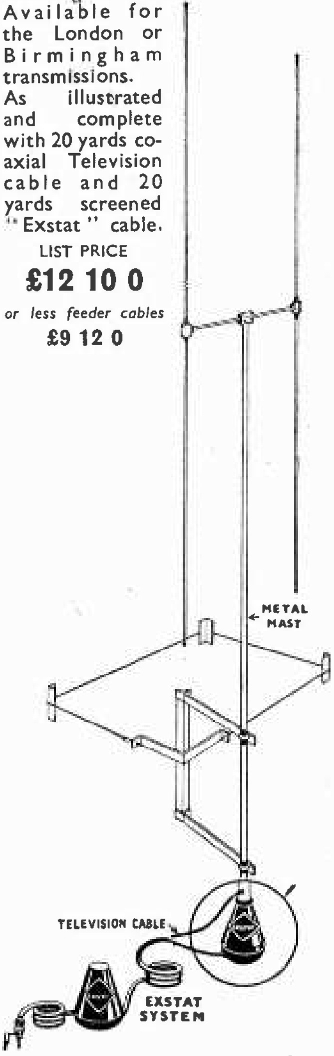
There remain at least two further considerations; the type of output valve, whether directly or indirectly heated, and the type of bias, whether fixed or cathode.

Normally a directly heated valve should always be chosen, as the control influence exercised by the grid at low anode current levels is greater than that of an indirectly heated valve. It is for this reason among others that manufacturers list their output triodes as directly heated: *vide* "Introduction to Valves" by F. E. Henderson. This superiority of the directly heated valve is reflected in the power output for a given degree of distortion. It is observed that the makers claim a greater output for the KT66, triode-connected, than the PX25, but this is most unusual. A comparison of other valves is given in the Table below.

Type of Valve		Efficiency per cent (Power output) / (Power input)	Distortion per cent
Indirectly heated	6L6 (triode-connected) ..	12.5	6
	6F6 (triode-connected) ..	10.0	6.5
	ML4	17.0	5
	ACP	20.0	5
	ACP1	19.0	5
Directly heated ..	PX4	23.0	5
	2A3	23.0	5
	PX25	22.0	5
	DO30	27.5	5

A further advantage of directly heated valves is their superior life; it is generally admitted by manufacturers that this is so.

The American valve handbooks



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make a point of the superiority of fixed bias over cathode bias in reducing distortion, so far as triode valves are concerned. The details in the Table below have been extracted from the "R.C.A. Handbook."

I have no literature for B.V.A. valves with fixed bias, but no doubt the distortion would be reduced in like fashion. In the American cases cited above I observe that the load resistance chosen produces considerable variations in anode current under working conditions, and I assume that fixed bias is helpful only where the power output is such as to cause these variations. These variations are not confined to the Class "AB1" and "AB2" conditions, but occur in simple Class "A." Thus a PX4 with −42 V bias and 300 V on the anode takes 50 mA, but when a grid swing of 42 V peak is applied the current varies between 95 mA and 12 mA giving a mean of 53.5 mA; i.e., a rise of 3.5 mA.

	2A3	2A3	6F6	6F6	6L6	6L6
Conditions	Fixed Bias Push pull	Cathode Bias Push pull	Fixed Bias Triode connected and push pull	Cathode Bias	Fixed Bias Triode Connected	Cathode Bias Single Valve
Power output Watts ..	15	10	13	9	1.4	1.3
Distortion per cent ..	2.5	.5	2	3	5	6

With cathode bias this means an alteration of grid voltage tending to reduce the output of the extreme peaks of the wave applied to the grid, producing in turn added distortion. There is an added advantage of fixed bias, inasmuch as the potential for the anode need not now exceed the required value by the amount of the bias voltage. A separate metal rectifier can supply the bias and the total heat dissipation in the output stage can be reduced by something like 10 per cent. As usual, however, there is a snag. American valve manufacturers specify a grid-cathode resistance, under fixed bias conditions, of a fifth to a tenth of the normal value. The B.V.A. do not normally list the grid-cathode resistance of 15-watt dissipation triodes under fixed and cathode bias. One value only is usually given—around ½ megohm. The American 2A3 valve is limited to 50,000 ohms with fixed bias and the conventional resistance-capacity coupling values will not fit such a low resistance.

Recourse can be made to transformer coupling, but my experience in this direction has not been entirely satisfactory. Although the transformer used was rated to have an adequate primary inductance with a particular value of D.C. flowing in its primary winding I found that fairly heavy A.C. voltage input was necessary to secure this inductance. The normal values of applied A.C. are between 3½ and 5 volts. With a transformer of 1:2 ratio feeding two PX4s the input to the primary would need to be 42 volts for 7 W output. Allowing our programme level of 105 phons corresponding to 5 W, the average level is 80 phons and this corresponds to 2 V. The softest passages, 55 phons, correspond to a level of 0.11 V. It is essential therefore that the primary inductance of any inter-valve transformer should remain adequate at these low input voltages and I fear this does not happen, especially when the transformer is directly fed. If the transformer is parallel-fed the presence of the resistance in the anode circuit of the "driving" valve limits the voltage output with any specified degree of distortion. The best valve I can find for transformer coupling is the American 6P5. The use of a centre-tapped primary and push-pull input valves overcomes this trouble, but a phase inverter will be necessary.

The performance in the extreme bass of a transformer coupling is usually criticised on the grounds of "iron" distortion, but, as I have shown, the Post Office experts do not consider distortion as audible at low frequencies until it is very excessive.

Recapitulating, the amount of distortion can be reduced by the use of fixed bias, but this involves unusually low grid-cathode resistors and the penultimate stage requires special care if use is made of the resistance-capacity type of coupling. Transformer coupling is satisfactory provided steps are taken to see that the primary inductance is adequate at low signal inputs, and that the circuit arrangement does not prejudice the delivery of the required peak voltage output.

Summing up, a pair of PX4s in push-pull without feedback should provide all that is necessary for home use under normal conditions with a baffle-loaded speaker.

Short-wave Conditions

June in Retrospect : Forecast for August

By T. W. Bennington and L. J. Prechner (Engineering Division, B.B.C.),

DURING June the average maximum usable frequencies for these latitudes decreased during the day in accordance with the seasonal trend, but during the night they increased rather more than was expected, possibly because of the still considerable sunspot activity. Consequently there was very little difference between the day and night M.U.F.s.

Communication on frequencies higher than 35-Mc/s was very infrequent, although contact was maintained with South and Central Africa on the 28-Mc/s band. Conditions on the lower frequencies were poor, and frequencies below 14 Mc/s for distances exceeding 3,000 miles were not practicable at night.

In accordance with the seasonal trend the rate of incidence of Sporadic E was very high and many contacts were made with the Continent by this medium. Very occasionally frequencies as high as 58-Mc/s came through. Long-range tropospheric propagation was again observed in June. Thus, the Paris television transmissions (sound 42 Mc/s, vision 46 Mc/s) were received in southern England on a number of occasions, but not as frequently as in May.

Although sunspot activity in June was about the same as in May, June was a very quiet month. Ionosphere storms occurred on 19th, 22nd, 26th/27th, none of them being very severe. There may have been some connection with the sunspots, as four fairly large groups were observed in June, which crossed the central meridian on 2nd, 18th, 25th and 29th respectively.

Many "Dellinger" fadeouts have been recorded, although fewer in number than in May. Those on 3rd, 18th, 20th and 21st were particularly severe.

Forecast. — During August the working frequencies for long-distance transmission should, generally speaking, be much the same as during July, although the day-time usable frequencies may tend to be a little higher and the night-time usable frequencies a little lower.

Working frequencies for *long-distance* transmission should, therefore, continue to be relatively low by day and high by night. As in July, day-time communication on very high frequencies—like the 28-Mc/s band—is not likely to be very frequent, although near the end of the month they may begin to become more useful, particularly towards the south of this country. Over many circuits fairly high frequencies—like 17 Mc/s—will remain regularly usable till midnight. Frequencies like 15 Mc/s may remain of use throughout the night on many circuits, but frequencies lower than 11 Mc/s will be seldom required.

For medium distances up to about 1,800 miles the E and F_1 layers will control transmission for considerable periods during the day.

Sporadic E is usually somewhat less prevalent than during July, and so on many occasions (which it is, however, impossible to predict) communications over distances up to 1,400 miles may be possible by way of this medium on frequencies greatly in excess of the M.U.F.s for the regular E and F layers. For example, frequencies as high as 60 Mc/s may be occasionally reached for a very short time.

Below are given, in terms of the broadcast bands, the working frequencies which should be regularly usable during August for four long-distance circuits running in different directions from this country (All times G.M.T.) In addition, a figure in brackets is given for the use of those whose primary interest is the exploitation of certain frequency bands, and this indicates the highest frequency likely to be usable for about 25 per cent of the time.

Montreal :	0000	11 Mc/s	(16 Mc/s)
	0300	9 ,,	(15 ,,)
	0800	11 ,,	(15 ,,)
	1000	15 ,,	(19 ,,)
	1400	17 ,,	(21 ,,)
	2000	15 ,,	(19 ,,)
	2300	11 ,,	(16 ,,)
Buenos Aires :	0000	15 Mc/s	(19 Mc/s)
	0400	11 ,,	(16 ,,)
	1000	17 ,,	(23 ,,)
	1110	21 ,,	(27 ,,)
	2100	17 ,,	(22 ,,)
Cape Town :	0000	17 Mc/s	(22 Mc/s)
	0100	15 ,,	(19 ,,)
	0300	11 ,,	(18 ,,)
	0500	15 ,,	(20 ,,)
	0600	17 ,,	(23 ,,)
	0700	21 ,,	(26 ,,)
	1000	26 ,,	(32 ,,)
	1700	21 ,,	(26 ,,)
	2100	17 ,,	(22 ,,)
Chungking :	0000	11 Mc/s	(16 Mc/s)
	0500	15 ,,	(19 ,,)
	0800	17 ,,	(22 ,,)
	1700	15 ,,	(19 ,,)
	2000	11 ,,	(16 ,,)

Ionosphere storms are not usually very prevalent during August, but at the time of writing it would appear that the most likely periods during which disturbances may occur are 3rd/6th, 9th/10th, 14th/15th, 21st/23rd, 25th/27th and 30th/31st.

Unbiased

By FREE GRID

Glass Houses and All That

THE suggestion that it should be made illegal for anybody to own or drive an unsuppressed motor vehicle has been made on more than one occasion and I am glad to see that "Diallist," writing in the July issue, lends it the weight of his advocacy. No doubt the critics will say that the idea smacks somewhat of totalitarianism, but I think none the less of it for that. Totalitarianism in moderate doses and in the proper place has much to commend it, more especially in the family circle. In Queen Victoria's day the head of the family might truly say, as was said of another potentate, that "all the Earth trembled before him." This is certainly more than he has been able to say since 1918 when Lloyd George, playing Delilah to his Samson sheared of his locks by extending the franchise to women.

Totalitarianism in the family circle.

Although, therefore, I am on the whole, in favour of legislation to "suppress" motor vehicles and all other interference-producing apparatus ranging from trams to electric razors, I cannot consent to something which would, metaphorically speaking, hand me over, bound hand and foot, to the perpetrators of a far greater nuisance, the noisy-loudspeaker brigade. At present whenever I hear the loudspeaker in a neighbouring garden bellowing out a futile appeal by the B.B.C. to people to moderate the volume, I can secure almost instant compliance by switching on Mrs. Free Grid's so-called violet-ray beautifier. This is, of course, nothing more than a dolled-up version of a ship's plain aerial spark transmitter of bygone days. This always has a far more salutary effect than all the B.B.C.'s plaintive appeals. Moreover it causes no harsh words among neighbours who, under my guidance, imagine the din to be caused deliberately by an omniscient and omnipotent B.B.C. to secure compliance with its request.

Now if an anti-electrical-interference law were passed my exercise of the functions of a benevolent totalitariocrat would come to an end—as I could not think of breaking the law. My neighbourhood would, therefore, cease to be the peaceful and law-abiding one that it is and would at once become a bedlam of babbling loudspeakers. Frayed tempers and ill-feeling between neighbours would be prevalent as in most other districts during the summer months.

I think, therefore, that the wireless-using community—which means virtually everybody—ought to put their own house in order before expecting motorists and others to bother about the particular type of interference caused by them.

Meaningless Misnomers

I THOUGHT that in the statement of my views in the June issue I had effectively scotched the attempt that is being made in various quarters to foist on us strange-sounding units to denote thousands and millions of megacycles. Apparently it is not so, however, and I cannot allow to pass unchallenged a bid which is being made to get us to adopt an uncouth word like gigacycles to denote 10^9 cycles.

This numerically meaningless term can do nothing but hold us radio men up to public ridicule, as it is at once suggestive of the unit which a schoolgirl might properly use to define the degree of her risibility (giggles to you). What is still more surprising, however, is one of the reasons which a correspondent in the July issue of *Wireless Engineer* — that most sternly puritanical of journals in technical matters—appears to advance in its favour, namely that it is in use on the Continent. To my mind this is strangely reminiscent of the "I've-seen-it-in-print" method of reasoning.

A correspondent in a recent issue of *Electronics*, who has also "seen it in print," goes even further as, in addition to wishing us to perpetuate the Greek prefix "giga" (giant) for 10^9 cycles, he wants us to follow certain textbooks and indicate 10^{12} cycles by using the prefix "tera." This is of course derived from a Greek word which, appropriately enough, means "a strange thing" or "a monster"!

He also delves into the question of the nomenclature of sub-units which we use for measurements of capacitance and upholds "nano" (dwarf) as a prefix for 10^{-9} and "pico" for 10^{-12}. The correspondent of *Electronics* supposes the latter term to be of Latin origin. I can at least assure him that he is correct in his supposition. It is a direct descendant of the *litera picata*, or large black letter, which the monastic scribes employed to commence a fresh section of the Church liturgy long before the followers of Caxton adopted it as part of their jargon.

I still maintain that every prefix, whether intended to indicate multiples or sub-units, should possess a definite numerical meaning, as in the case of the metric system, which would itself be greatly improved by adopting my logarithmic method of nomenclature. I could, however, go even further and sweep away all existing prefixes and, starting off with a cycle as the logical unit, would use hexacycle (10^6 cycles) for megacycle, and so on. 10^3 cycles would not, of course, become a tricycle but a treiscycle, as we do not want to use the Greek adverbial prefix which the muddle-headed makers of three-wheeled velocipedes adopted merely because it rhymed with the Latin prefix "bi" used for two-wheeled machines whereas the Latin prefix "ter" did not.

10^3 Treis	**10^{-3} Tres**
10^6 Hex	**10^{-6} Sex**
10^9 Ennea	**10^{-9} Novem**
10^{12} Dodeka	**10^{-12} Duodecim**

Prefixes for cycles, metres, farads or what have you? Words can be amended for the sake of euphony by omitting final letter, if a consonant, adding a vowel or in other ways as is freely done in the metric system.

LETTERS TO THE EDITOR

High-quality Broadcasting ◆ Renaming Printed Circuits ◆ Future of Television ◆ Full-wave Detection

Is High-quality Broadcasting Wanted ?

THE discussion on the E.H.F. broadcasting service in your recent issues is very interesting, but seems to be mainly academic. An essential question which has not been asked is: "Are there enough listeners interested in high quality, and prepared to pay for it, to justify such a scheme?"

Present receiver sales suggest that the answer is "No." Most listeners are content with "Home" and "Light," and show no inclination to wander farther afield. They like the bass well boosted, and the top severely cut, in spite of the best efforts which have been made to persuade them that the resulting quality is very bad.

These people will have little interest in a high-quality service, and will not be prepared to pay large sums for new F.M. receivers. It is doubtful if the converter method would attract them much more. The service will therefore be of interest only to those few who appreciate quality and can pay for it.

In these circumstances it seems absurd to proceed with a scheme whose success is in any doubt, and there seems to be considerable doubt regarding the value of F.M. Even Thomas Roddam, who calls A.M. "cheap and nasty," has listed some very nasty features of F.M. (*Wireless World*, Feb., 1947, p. 70).

In the same article, he says that the cost of an F.M. receiver will be "rather higher" than that of a normal broadcast receiver. Manufacturers estimate that the cost will be at least double, if not more. This assumes that proper advantage is taken of the possible quality of reproduction.

America has produced an object lesson and a warning. Unable to sell high-quality receivers for F.M. in sufficient quantity, the manufacturers over there have devised a small set whose quality is comparable with that of an average A.M. midget set. The main advantage of the E.H.F. service is thus sacrificed.

These points have been made without reference to the technical matters affecting the case: difficulty of tuning, maintenance of alignment, and all the others. These are well known, and have been discussed at length. Add them to the case given here, and it appears that the B.B.C. would be well advised to delay the introduction of F.M. until the economic health of the country is in a better state. Any losses incurred would then be less important, and the public would be more prepared to buy quality.

Exeter. D. W. THOMASSON.

Onlaying

PLEASE save us from this "applique" business (July issue, p. 260). It is surely unnecessary to maul both the French and English languages to find a name for sprayed-on or printed-on electronic circuit manufacture. Let us coin new words for the new things—SPRON and PRON—and see the result:

"A factory spronning radio chassis can spron 5,000 a day, but, using the pronning process, hundreds can be pronned every hour."

Yes . . . ? I don't like it much either.

But there is already a word "inlay" in our language; why not coin a word "onlay" to describe the manufacture of a unit having its wiring onlaid by a spraying or printing process?

I rather care for that.

W. IRE LESS.

Planless Television

IT is understandable that Britain has not been able to extend her television service at a rate commensurate with the promise of 1937, when the service started; since then she has suffered from the effects of a crippling war. But I think we are entitled to protest against the lack of any long-term plans for future extension of the service.

We read that America proposes to make television programmes available to nearly 67 million listeners by the end of 1948. Many will have alternative programmes. Nobody would suggest, while we are feeling the economic after-effects of war, that anything approaching equivalent growth can be planned here, but we should at least have some kind of declared aim, if only for the remote future.

Our distribution of population and the shorter distances for radio and cable links, as compared with America, should help us to make up leeway with reasonable speed as soon as the economic conditions of the country permit.

H. T. STOTT.
Chadwell Heath, Essex.

Aircraft and Television Reception

CAN any of your readers suggest a remedy for the complete break-up of a raster which occurs when low-flying aircraft are in the vicinity of a vision receiver.

This interference is quite common in this area and appears to be a greater menace than the increased interference created by the return of the basic petrol ration.

The interference is comparatively negligible in the sound channel and appears to be associated with the actual audible note and has what I term a "Doppler Effect." In less severe cases the interference is manifest in the form of fluctuating light density without affecting sync to any extent.

R. M. STAUNTON-LAMBERT.
London, N.W.6.

Full-wave Detection

THE renewed interest shown in the Cockcroft-Walton multiplier circuits for H.T. and E.H.T. supplies prompts me to report that the circuit can be used with advantage also at the detector stage in a straight set, the principal advantage being that the use of an R.F. choke is avoided.

The circuit values I have chosen are shown in Fig. 1, and although it can be seen that the detector will give a damping across the tuned circuit of about 25 or 30 kΩ, a typical R.F. valve (EF39) passing 6 or 8 mA will still be able to develop plenty of signal across it without distortion. Readers may ask, of course, why I prefer this circuit to the "infinite-impedance" detector; the answer is twofold. First, A.V.C. can be obtained in the usual way. Secondly, measurements I have made on typical valves in the "infinite-impedance" circuit (6C5, 6J5) do not confirm the popular view that the circuit provides linear detection; diodes on the other hand do. At low frequencies a diode circuit can be given a high input impedance by putting in front of it a cathode follower, and for L.F. work I have found the single-valve circuit of Fig. 2 quite useful, since an almost linear scale is obtained.

Malvern, Worcs. E. F. GOOD.

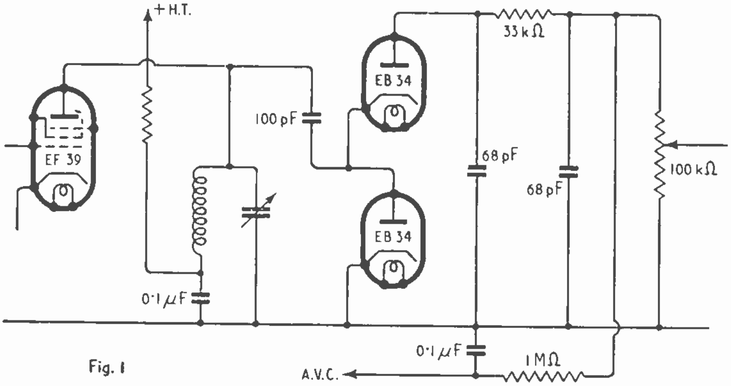


Fig. 1

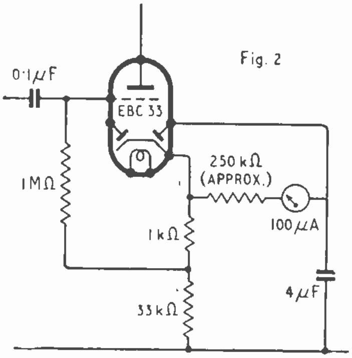


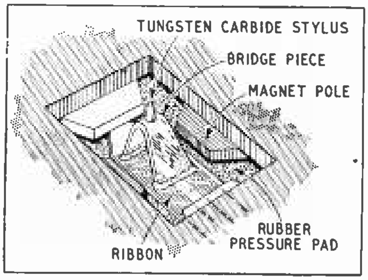
Fig. 2

Ribbon Pickup

New Equipment Demonstrated

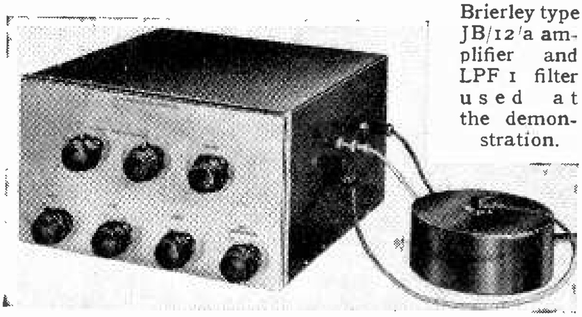
AT a recent joint meeting of the City and Guilds Radio Society and Imperial College Musical Society, J. H. Brierley, gave a demonstration of reproduction from commercial gramophone records, using one of his latest designs of ribbon pickup.

Essentially this pickup consists of a U-shaped foil strip folded so that the plane of the foil lies parallel to the magnetic field. A bridge-piece of light plastic material is attached to both limbs of the ribbon and carries a tungsten carbide stylus which is cemented in position. A special grade of carbide, which does not flake, has been chosen and is stated to have a hardness six times greater than sapphire. The mass of the moving parts is about 1/25th of that of a standard needle so that record and stylus wear is very small. The top resonance has been measured by harmonic methods and is stated to be in the region of 40 kc/s.



Ribbon and stylus assembly in the Brierley pickup.

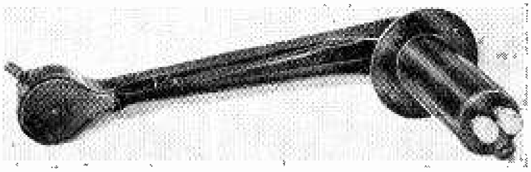
Demonstrations given with the full frequency response were remarkable for the excellent transient response and attack, but surface noise on standard commercial pressings was also faithfully reproduced. With a low-pass filter cutting off at 8,000 c/s the difference in quality of reproduction was easily discernible, but there was less scratch. Musical critics in the audience called for the



Brierley type JB/12 a amplifier and LPF 1 filter used at the demonstration.

8,000 filter at the beginning of the recital, but after hearing recordings with and without the filter, preferred the improvement in quality resulting from an extended H.F. response and agreed to tolerate the surface noise.

The electrical output from the pickup is small and care is necessary in the design of the amplifier if mains hum is to be avoided. The Brierley amplifier equipment showed no trace of hum pick-up when demonstrated in conjunction with a wide-range loudspeaker reproducing down to at least 40 c/s.



The tone arm bearing in the Brierley pickup consists of widely spaced, spring load ball races in a dust-proof housing.

New Domestic Receivers

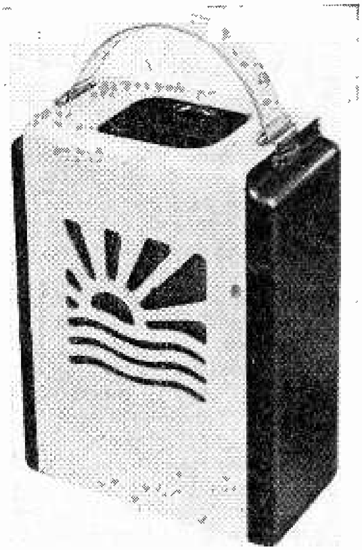
DESIGNED with an eye to the export market as well as for home consumption, the Model 600 console receiver, made by Ace Radio, Tower Road, Willesden, London, N.W.10, employs an R.F. stage before the frequency changer and covers seven short-wave bands between 13 and 55 metres in addition to the usual long- and medium-wave ranges. A resistance-coupled push-pull amplifier provides an output of 10 watts and the bandwidth of the I.F. amplifier can be expanded to 20 kc/s for high-quality reception of local stations. The price is £54 12s 6d, including purchase tax.

A 14-inch glass scale with a separate pointer for short-wave stations is a feature of the Model U75 made by E. K. Cole, Southend-on-Sea. Suitable for operation from A.C. or D.C. mains, 200-250 volts this receiver employs a four-valve plus rectifier superheterodyne circuit with a high-gain output pentode used with negative feedback. The price is £22 19s 11d, including purchase tax.

The Philips Model 474B is a six-valve, three-waveband superheterodyne for battery operation. There are two I.F. stages and the output stage employs two pentodes in quiescent push-pull. The normal consumption is 0.4 amp L.T. and 9.5 mA H.T., but an economy switch is fitted which reduces these figures to 0.3 amp and 5.5 mA for a slight reduction in sensitivity and power output. Battery connections are provided for combined H.T. and L.T. dry battery blocks, or separate batteries and the L.T. can be supplied from either a 1.5V dry cell or a 2V accumulator. A rubber accumulator tray is provided to isolate acid leakages and prevent damage to the interior of the set. The makers are Philips Electrical, Century House, Shaftesbury Avenue, London, W.C.2, and the price is £22 18s 11d, including tax.

The Mullard Model MBS147 has a similar technical specification but a different style of cabinet; the price is the same and the makers are Mullard Electronic Products, Century House, Shaftesbury Avenue, London, W.C.2.

An attractive plastic case with detachable carrying handle has been designed for the Pye Model M78F miniature receiver. This is a four-valve two-waveband superhet running from dry batteries and measures 7½in × 5⅝in × 3¼in; the weight is 4¼lb. Made by Pye Ltd., Radio Works, Cambridge, the price is £12 12s (excluding purchase tax).



Pye miniature portable. Model M78F

The chassis design is unconventional and permits the use of a 5in loudspeaker—a notable achievement in a set of this size.

Random Radiations

By "DIALLIST"

Superlatives

IT IS REFRESHING to learn that in future *Wireless World* will have no truck with the wild welter of superlatives which often make it difficult to gather exactly what class of frequencies is under discussion when they are described as super, extra, very or ultra high. For readers E.H.F. will in future mean all frequencies above 30 Mc/s, except that V.H.F. may be used when it relates beyond question to the 30-300 Mc/s band only. Excellent, so far as it goes; but are we yet quite out of the wood? I hardly think so, for we really do seem to need some separate terms for the 3,000-30,000 Mc/s and the above-30,000 Mc/s bands. The corresponding wavelengths are nicely taken care of by calling them centimetric and millimetric; how would it be to adopt the same terms for the frequencies? If it were understood that the term "centimetric frequency" was a portmanteau expression standing for "Frequency corresponding to a centimetric wavelength," there couldn't be much objection to its use. An extension to metric, decametric, hectometric and kilometric frequencies would enable us to be just as precise in talking or writing of radio frequencies as we can now be in talking or writing of radio wavelengths. One can't, unfortunately, evolve a precise classification on the same lines based on the cycles-per-second. The wavelength classes are all simple tenfold multiples or sub-multiples of the metre; but the cycles-per-second classes involve 3, 30, 300 and so on, and the corresponding terms would be over-large mouthfuls to receive any kind of welcome.

Radar and Cable Faults

AN INTERESTING application of radar technique for the location of faults in cables is now coming into use. When a discontinuity occurs in one of the leads a short pulse is injected into the line. The pulse is reflected back at the point of discontinuity and the time for the out-and-home journey is measured by means of an oscilloscope. I'm told that results are exceedingly good. There are, of course, a good many snags; but means of overcoming most of them have been worked out and any that still remain will no doubt be dealt with in due course. Any reader who recalls the positive shambles that was apt to result in wartime, when breaks in radar, searchlight, predictor and other heavy multi-core cables had to be located without proper instruments and repaired in the shortest possible time, will realize what a packet of money such fault locators would have saved. In everyday life they should, if they give accurate information (as I am told they do), play an even more valuable part in assisting the maintenance of the vast and growing network of cables that now lies over and under so much of the world's surface.

French Television

THE FRENCH P.T.T. authorities, I hear, have decided to adopt an 819-line system for the high-definition television service of the near future. The Paris station already possesses two cameras and a small transmitter designed for 819 lines, and experimental transmissions are being made. Like ourselves, the French have decided that their present lower-definition system with 455 lines is to be extended. A guarantee has been given that it will be continued for at least another ten years. Transmitters relaying the 455-line Paris programmes and probably sending out some items of their own are likely to be in operation before very long in Lille, Lyons, Toulouse, Marseilles and probably Bordeaux. Both in Paris and in these towns 819-line transmitters are to be installed to send out the same programmes. Television will thus be available both for those who install simple, moderately priced 455-line receivers and for those whose purses can run to the more elaborate 819-line sets. It is also intended to erect television theatres in certain towns. In these, large audiences will be able to see big-screen reproduction of the 819-line transmissions. Success has already been obtained by using the intermediate film method, in which a film is made of the images on the C.R.T. screen and then developed, fixed and passed through a projector, all in less than 60 seconds. A friend who has seen projection on to a 12ft × 10ft screen describes the images as being as good as those of the 16 mm cine.

Battery Set Indicators

D. A. BELL'S SUGGESTION of the use of a flashing neon lamp as an indicator that a battery set is switched on is an interesting one. The snag, as he says, is that it is difficult to get neons to strike at much below 90 volts. Or, perhaps, it might be put in another way: there are small neons that strike at considerably less, but it's almost impossible to get hold of them. The kind I have in mind are not much bigger than peas and they're used in neon voltage testers. I've been trying ever since the end of the war to find one or two of them, but so far I haven't managed to do so. Used with a capacitor-and-resistor circuit with a time constant of a second or so, they'd be ideal for the job.

Vision Only

A READER takes me to task for having written recently that the vision-only receivers seen at Radiolympia before the war didn't catch on because people were not attracted by the tiny images on their 2½in or 3in tubes. He reminds me that there was at least one model with a 7-inch tube. He tells me that he bought one of these and is still getting good service from it. I'd forgotten that there were any vision-only sets with screens of this size—I'm sure, anyhow, that there can't have been many of them. But I do feel that any manufacturer who cares to try a modern version of the vision-only set with a 6-inch or 7-inch tube might find that it was just what a good many people wanted. What happened in pre-war years is really nothing to go by. Television of any kind was very "sticky" then, and there was only a feeble demand for receivers. To-day people are becoming more and more television-minded, as the continuing rapid increase in television receiving licences shows. Many who feel that they can't afford even the lowest-priced sound-and-vision table model might jump at a small vision-only set, if it cost appreciably less.

Tail-piece

You, I expect, get as bored as I do by the Old-Uncle-Tom-Cobbley-and-all lists of "those taking part" in broadcast programmes. I thought that bottom had been touched when the fellow whose sole contribution to the entertainment was "Your coffee, sir," was listed as "The butler, played by so-and-so." But I was wrong, quite wrong. The other night we had: "The part of the deaf mute was played by. . . ." They'll never beat that one, unless they name the player of the part of The Man Who Was Not There in some whimsey piece.

BOOKS RECEIVED

Fundamental Principles of Ionosphere Transmission.—Radio Research Special Report No. 17, issued by the Department of Scientific and Industrial Research. Written to provide background knowledge on short-wave propagation, particularly for those engaged in applying the results of ionosphere measurements to the organization of communication services. Pp. 82; figs. 69. H.M. Stationery Office, Kingsway, London, W.C.2. Price 1s 6d.

Loudspeakers: The Way and How of Sound Reproduction, by G. A. Briggs. A collection of data gathered during 15 years of loudspeaker manufacture, including notes on the design of cabinets. Pp. 85, with numerous illustrations. Wharfedale Wireless Works, Bradford Road, Idle, Yorks. Price 5s.

Microwave Transmission Design Data, by Theodore Moreno. An advanced textbook giving basic formulæ and design data for the "plumbing" in microwave equipment. Is limited to problems arising in the propagation of energy in transmission lines and waveguides at frequencies above 300 Mc/s Pp. 241, with numerous illustrations, tables and graphs. McGraw Hill Publishing Co., Aldwych House, London, W.C.2. Price 24s in U.K.

Applied Electronics. By D. Hylton Thomas. Fundamental principles and description of valves, cathode-ray tubes, photocells and other electronic devices, with their applications. Pp. 131; 90 figures. Blackie and Son, 66, Chandos Place, London, W.C.2. Price 7s 6d.

Photoelectric Cells in Industry. By R. C. Walker. A comparatively brief exposition of the theory of operation, followed by detailed information on the practical industrial uses of the cells in relay circuits and for such uses as measurement, control, reproduction of sound, facsimile and television. Pp. 500; 241 figures. Pitman and Sons, Parker Street, Kingsway, London, W.C.2. Price 40s.

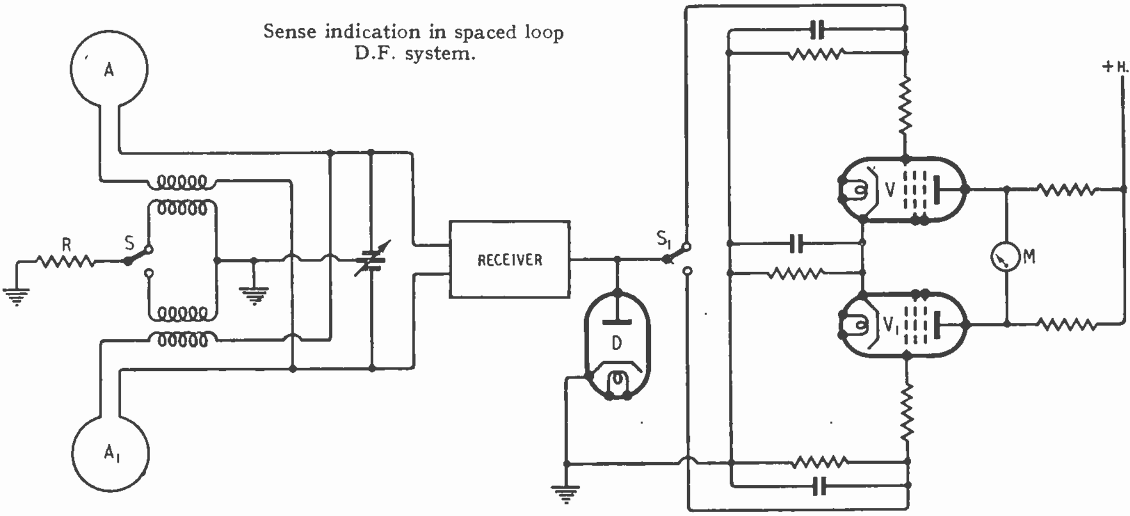
RECENT INVENTIONS

A Selection of the More Interesting Radio Developments

DIRECTION FINDING

RELATES to a direction finder of the kind in which two parallel loop aerials, spaced apart, are rotated about a point halfway between them. The polar diagram of such a system is free from polarization errors, but includes four different directions of zero signal strength.

The diagram shows an arrangement for resolving this ambiguity. Each of the aerials A, A1 is coupled, in rapid alternation, through a switch S, to an earthed resistance R. A second switch S1, driven synchronously with the first, feeds the output from the receiver to an indicating meter M, through a pair of amplifiers V, V1, the effect of the switching frequency being smoothed out by the circuits associated with the second detector D. The periodic inclusion of the resistance R in the aerial circuits creates a different sequence of deflections, to right and left, in the centre-zero meter M, as the aerial system is rotated clockwise. This allows the directional sense of each of the four zero channels to be distinguished and identified.


Sense indication in spaced loop D.F. system.

F. Chaplin and J. H. Bagley. Application date, June 7th, 1945. *No.* 593063.

FLUORESCENT SCREENS

THE sensitive screen of a cathode ray tube is coated by electrostatic attraction from a suspension of fluorescent particles, in such a way as to ensure a uniform layer of very fine grain.

The screen is placed, face downwards, in a chamber containing a fine spray or mist of zinc silicate or sulphide, or other suitable material, and is connected to one pole of a 50-kV supply, the other pole being earthed. Only the finer particles of the suspension are attracted upwards, against gravity, to form a deposit on the screen. When the layer is sufficiently thick, usually after two or three minutes, the screen is removed and exposed to a gaseous suspension of phosphoric acid, which settles uniformly on it, and binds the fluorescent coating firmly in position.

To reduce the risk of subsequent damage, the coating process can be carried out on the screen after it has been mounted inside the bulb of the cathode ray tube.

Cinema-Television, Ltd., and R. B. Head. Application date, Feb. 1st, 1945. *No.* 592860.

RADAR INTERROGATOR

A SMALL self-contained unit is designed to radiate a characteristic series of pulses in response to a definite calling or triggering signal. If one or more of these devices are placed surreptitiously near an enemy post they can subsequently be interrogated, say by a radar set for controlling artillery fire. Their useful life is, however, limited to a few hours or days, at most.

The receiving valve must be kept constantly active, but in order to make the most of the battery power available, the transmitting circuits are only brought into action as and when the unit is interrogated. The calling signal takes the form of equally spaced pulses which are passed through two parallel circuits, one including a time-delay network equal to the pulse interval. Each circuit feeds one of the grids of a two-grid relay valve, which is normally non-conductive, until "unblocked" by the coincidence of the two impulses. An oscillation generator of the multivibrator type is thereupon triggered and the response signal is radiated.

Standard Telephones and Cables, Ltd. (assignees of H. G. Busignies). Convention date (U.S.A.) October 26th, 1943. *No.* 588777.

The British abstracts published here are prepared with the permission of the Controller of H.M. Stationery Office, from specifications obtainable at the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1/- each.

RADIO ALTIMETERS

IN a radar set of the pulsed echo type, auxiliary indications are provided to show when the measured range falls short of, or exceeds certain predetermined limits. In the case of a radio altimeter, for instance, one lamp lights automatically when the aircraft is flying too low, whilst a second lamp may similarly indicate, either too high an altitude, or the presence of a mountain or other obstacle in the path of the machine.

The incoming echo signals are fed in parallel to the indicator lamps through two separate amplifiers, which are normally biased to cut-off, but are periodically "unblocked" by two positive voltage waves which are generated at different times relatively to the master frequency control of the set. One positive wave is initiated by each exploring pulse, and only lasts long enough to allow short-range echoes to light one lamp; the other positive wave is delayed so that the second lamp can only respond to long-range echoes. Between these selected limits, neither of the lamps is lit.

Marconi's Wireless Telegraph Co., Ltd. (assignees of W. D. Hershberger). Convention date (U.S.A.) January 30th, 1943. *No.* 588715.