Wireless World

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Castles in the Air

AFTER protracted Parliamentary debates, the future of the B.B.C., which has so long hung in the balance, was settled on the day before our last issue appeared. Thus we have had plenty of time to think about it, and our thoughts are not predominantly pleasant ones.

The main changes introduced into the B.B.C. charter, licence and agreement are set out on another page. We may say at once that few of them hold much interest for us or our readers. The only change to which much significance can be attached is the superficially trivial addition consisting in the qualification of the word "licence" by the adjective "non-exclusive." This means, as the public has been told by Government spokesmen, that the B.B.C. may lose part of its monopoly; at some rather vague but not too remote date, Parliament may allow the Postmaster General to grant a licence for an independent television service, financed not from licence revenue but from advertisements. Sound broadcasting, including v.h.f., remains a B.B.C. monopoly.

If only from motives of self-interest, every wireless man would welcome an additional television service, however brought about and however financed. But, to us at least, the Government's proposals, in spite of protests to the contrary, lack the air of reality, and it is hard to visualize the setting up of a competitive service in the foreseeable future. And, if this view be wrong, any benefits that might accrue from it are likely to be offset by the fact that broadcasting has been made a party-political issue. That was contrary to the wishes and hopes of most of us. The Radio Industry Council—wisely, we think—conducted an energetic campaign to prevent this very thing from happening. Now we stand to get the worst of both worlds; sponsored television may not arrive, but the threat of it may hamper development.

Let us consider all the things that must happen before the first sponsored television transmission can be radiated. We have few facts to work on, but will base our speculations strictly on official documents or on the pronouncements of Government spokesmen. The sponsored stations are to work on higher frequencies, but, by implication, on the existing standards of definition. The B.B.C. must complete its (interrupted) present scheme for television and also get v.h.f. sound broadcasting at least under way before sponsored television can start. But first the Television Advisory Committee, now charged with responsibility for v.h.f. as well, must advise the P.M.G. on the conditions for the v.h.f. sound service before turning to sponsored television. T.A.C. has not met for a year, and may be a slow starter.

These preliminaries being disposed of, the licensing of sponsored television stations must be debated by Parliament. Presumably the measure will be even more hotly opposed than was the insertion of "non-exclusive licences" into the B.B.C. charter. And what kind of organization can apply for licences? All we have to go on is the White Paper, which mentions "bodies or persons." Is the plural deliberately chosen, indicating that the Government does not intend to create another monopoly? Is the only precedent we have—that of the original British Broadcasting *Company*, financed by leading radio manufacturers—to be followed? *Wireless World* can obtain no confirmation or denial of these ideas. A unified organization, able ultimately to offer national coverage, would, we assume, be most favoured by the big advertisers who would be its main supporters. If the right to conduct sponsored television is in fact so valuable, one can foresee the most intense competition for the privilege, with more delay.

But, after all, will the business world have enough confidence in sponsored television to ignore the declared intention of the Parliamentary Opposition "not to carry on" the policy of the present Government? There can be few less valuable assets than a television station without a licence.

To ask more questions would be to labour the point that the Government scheme can hardly be more than, at best, a project for the dim and distant future. More realistic means must be found to foster the development of television, and if need be, to test the possibilities of advertising programmes. Fortunately, nothing more has been done legislatively than the timid insertion of "non-exclusive" into the B.B.C. charter, and, as the Home Secretary tells us, all earlier charters were non-exclusive anyway, though not so labelled. Therefore the ill-conceived project can be gracefully dropped, or forgotten, without too much embarrassment.

Calculating Transient Response

Simplified Derivation from Frequency and Phase Characteristics

By THOMAS RODDAM

MACBETH, crossing a blasted heath, was not surprised to encounter three witches brewing up : nowadays he would expect to find a rather worn-looking mansion filled with engineers muttering : " When the mu-beta comes to one-nought, beware, beware ! " There they sit, adding more and more feedback round more and more loops, and as the amplifiers get more linear, new troubles appear on the horizon. One of these is a problem which has long been discussed ; when you talk about 0.1 per cent. harmonic distortion, which harmonic ? If you don't think it matters let me just remind you that you can hear a 1,000-c/s tone which is 36db lower than the quietest 100-c/s tone you can hear, so that 0.1 per cent. of 20th harmonic of 50 c/s is as audible as about 6 per cent. of second harmonic. As you know, feedback amplifiers tend to produce these higher harmonics in the overload region—in fact that is the only way you know that they are overloaded. The other problem is that of transient response.

There is an enormous amount of nonsense written about transient response, especially as it affects the loudspeaker. Broadcast programmes are amplified, piped round the country and re-amplified. In the course of this process, every effort is made to keep the frequency response flat, up to 10 kc/s, or whatever the frequency is. Above this, transformer after transformer provides a 12 db/octave cut-off. So what can you do, chum ?

Transient response is important though for three reasons : television, of course, in servo amplifiers and in amplifiers in tandem. The first two applications are fairly obvious, but the third deserves a fuller explanation. Suppose that we are operating two amplifiers, one driving the other : this is quite a common situation, for one may be a microphone amplifier and the other a power amplifier. If the first amplifier produces a large, though very short, overshoot there is no direct audible effect, because the frequencies in the transient peak are above the limit of hearing. This peak may, however, drive some stage of the power amplifier into grid current, and the stage may then be held at an improper bias by the grid CR network for an appreciable time. During this time, perhaps 1/10th of a second, the stage will produce more distortion than usual, and as the gain has been driven down, the feedback will be less effective than normal : muddy transients are the result.

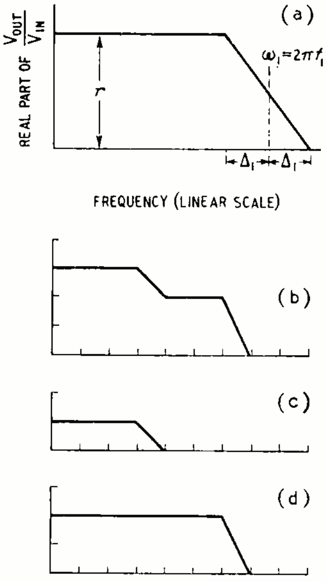

Fig. 1. (a) Basic trapezoidal response which gives the transient response shown in Fig. 2. The more complicated response in (b) may be resolved into the two trapezoidal responses shown in (c) and (d).

It need not be two amplifiers in two boxes for this effect to be apparent. A single multistage amplifier with a transformer in the middle, or perhaps with the feedback arranged in two separate loops can cause trouble of this kind. As our amplifier designs get more and more sophisticated we need to watch out for more and more of these obscure effects.

Circumventing Laplace

The obvious thing for the conscientious designer to do is to calculate the transient response, just as he calculates the frequency response of a feedback amplifier before he starts. Very few designers do this, because they imagine they will be confronted by an immense formula to be fed into the Laplace Transform machine. If this were the only way of studying transient response they would—to use an Antipodean phrase—be too right. Fortunately G. F. Floyd, of the Massachussetts Institute of Technology, has described in a thesis* a simpler way of dealing with the problem. Floyd's method, dehydrated and predigested and generally made fit for engineers' consumption, is the subject to reason about to-day.

First of all we need to know the frequency response and phase characteristic of the amplifier. In all the discussion which follows I propose to treat only the transient due to the high-frequency cut-off, and not the droop due to lack of low-frequency response. I shall, however, comment on the application of the method to " droop" calculation at the end of the article. But back to our frequency response. If you have read any of the papers or books† on the connection between response in time and frequency response you may have noticed that the decibel and the logarithmic frequency scale are not used. We use these logarithmic units for convenience, and because our ears are fairly logarithmic in performance. When considering transient response we start off with a very

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* See also "Principles of Servomechanisms" by G. S. Brown and D. P. Campbell, published by Chapman & Hall.

† For example, "Radio Engineers' Handbook" by F. E. Terman, published by McGraw Hill, p. 968 et seq.

artificial signal and examine how the energy it contains gets redistributed in time, and the energy in one frequency band is as important as that in the neighbouring bands. We must therefore be prepared to draw our frequency response in terms of actual magnification with a linear frequency scale.

There are two separate meanings attached to the term "transient response." To some people it means the response to a square-wave input, while to others it means the response to a very short impulse. Between the two there is, of course, a very close mathematical connection, and it is largely a matter of practical convenience which is used. I prefer to use a short impulse for test purposes, because it is then so easy to recognize the unwanted "ringing" which appears as a train of damped oscillations after the main impulse. In some special circumstances, however, square waves provide much more information: for example, I have arranged amplifiers so that they were unstable on the "swing" of a square wave and stable on the "swong." On the oscilloscope the unstable condition was shown by a growing oscillation on one half of the cycle, followed by a decaying oscillation on the other half. This sort of behaviour corresponds to those bursts of high-frequency oscillation at the low-frequency peaks, which produce such an unpleasant sound and are rather difficult to detect without very full tests.

For the purpose of this article, transient response will be taken as the response to a very short impulse. The method of calculating it depends on a basic theorem, the truth of which we assume in almost all our electrical theory. That theorem is the Superposition Theorem, which states, though not in these words, that two happenings in a linear system go on quite independently of each other. To calculate the transient response we first of all imagine a circuit having a particular frequency response for which the transient response is easily calculated. We then pretend that the actual circuit is made up of a number of these ideal systems in parallel, having different factors in their make-up. Each system passes a transient of the standard type of a particular size and time scale. Then we add all the transient voltages at any instant together. An example will make this clearer.

The standard frequency response, which is called, for reasons which will follow, the "real part" response, is shown in Fig. 1(a). The transient response of an amplifier (or any other network) having this frequency response is shown in Fig.2. Suppose that we find that our amplifier has a response like that shown in Fig. 1(b). We imagine it to be made up from two units, one having the response of Fig. 1(c) and one having the response of Fig. 1(d). We take two curves of the form of Fig. 2 with the appropriate scales, add them, and there is the final transient response of the system.

"Real Part" Response

We must now begin to clothe these bare bones. As I said above, we use a frequency response known as the real part response. This is the graph of $m \cos \theta$, where m is the voltage gain and θ the phase shift between input and output. For calculation purposes this is a great nuisance, because if you are using graphical methods of predicting the frequency response you are working with decibels and a logarithmic frequency scale.

The stages in the determination of the real part response can be followed in Fig. 3. The basic response

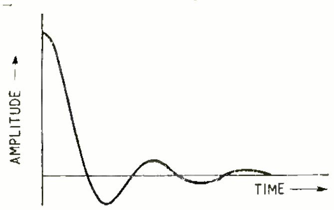


Fig. 2. Response to a single short impulse of a circuit with the frequency response of Fig. 1 (a).

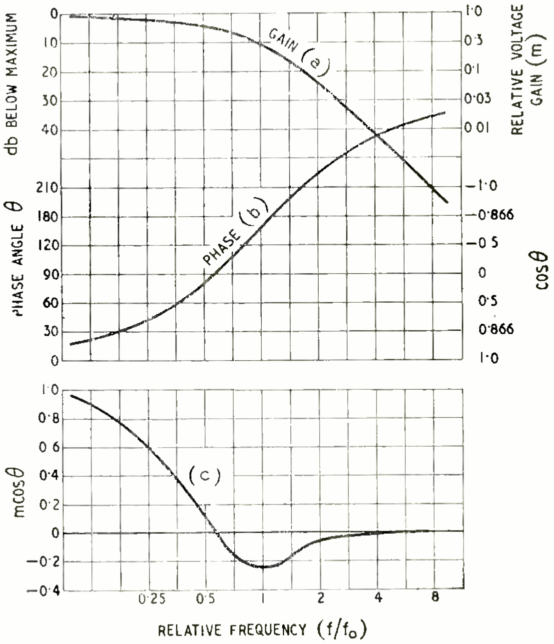


Fig. 3. From the gain and phase to characteristics (a) and (b), the real part response (c) is calculated. Frequencies are plotted on an octave (log) scale.

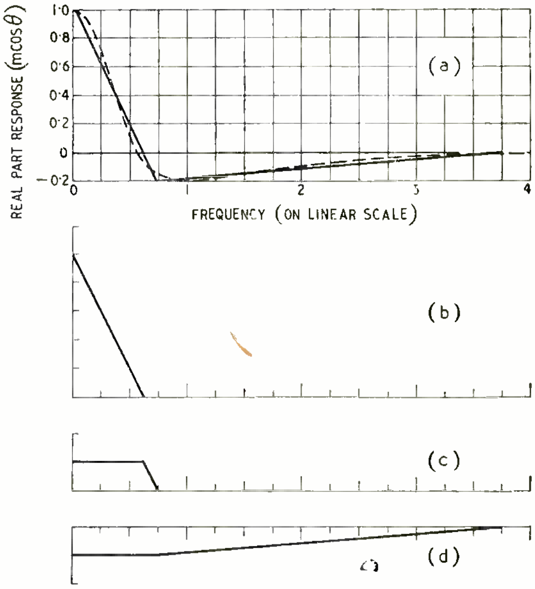


Fig. 4. (a) Real part response of Fig. 3 (c) replotted to a linear frequency scale with superimposed straight-line approximation. (b) (c) and (d) Trapezoidal responses which added together give the straight line approximation of (a).

curves, frequency response in decibels, and the phase characteristic, are shown at (a) and (b). The frequency scale here is an octave scale, which for all theoretical purposes is just as good as a logarithmic scale of the ordinary kind, in fact you can mark a logarithmic scale in on the paper. For practical purposes, however, it is very much better, because it uses ordinary centimetre square paper, which is cheaper and is always available. It is painfully surprising how often in a large organization the 3-decade log paper runs out, and you have to make do with 2-decade or 4-decade. And if you have standard curve shapes, they just don't fit the paper.

In addition to the decibel and angle scales I have marked in the voltage ratio, m, and cos θ scales. At each convenient frequency we take (voltage ratio) × (cos θ) to get the real part (RP) response plotted in Fig. 3(c). This RP response is still plotted on an octave frequency scale, and it must be replotted on a linear frequency scale before we can use it. This has been done in Fig. 4(a), which shows clearly how the logarithmic frequency scale tends to minimize the very important high-frequency behaviour.

The solid line segment response shown in Fig. 4(a) is the approximate form which is used for calculating the transient response. It is not too difficult to see that this can be represented as the sum of the three RP responses shown as Figs. 4(b), (c), (d), which are all of the standard trapezoidal form. All we need to do now is to take the transient response corresponding to each trapezium and add them together (that for (d) of course, must be subtracted).

At this point we introduce the essential formula. With the terms defined in Fig. 1(a), the transient response of a system having a trapezoidal real part characteristic is given by the equation

$$h(t) = \frac{2r}{\pi} \cdot \omega_1 \left(\frac{\sin \omega_1 t}{\omega_1 t}\right) \left(\frac{\sin \Delta_1 t}{\Delta_1 t}\right)$$

whatever you do about it, this formula involves quite a lot of arithmetic. The linear is simplified by making use of a table or graph of the function (sin x/x). I have produced a graph of this function, and it is given at Fig. 5. For each trapezium we then make a table of the form shown:

TABLE

Trapezium 1 :

r =	ω_1 =
$\frac{2r}{\pi}$ =	Δ_1 =

t	$\omega_1 t$	$\Delta_1 t$	$\frac{\sin\omega_1 t}{\omega_1 t}$	$\frac{\sin\Delta_1 t}{\Delta_1 t}$	h(t)
0					
1/10,000			from Fig. 5		
2/10,000					
etc.					

We then transfer the last column to a new table, in which the transient responses for the separate trapezium are collected. Adding the response for each time we have the total transient response : $h(t) = h_1(t) + h_2(t) + \ldots\ldots$

Kronecker, who introduced the delta function, a kind of unit impulse, into analysis, says somewhere : " God made the integer ; the rest is the work of man." He could have hardly been more right about this particular impulse problem, because the average network transient response takes about a page full of closely written figures. But it is only slide rule work and addition, there is no real mathematics to it. I have not carried through the calculation of the transient response for one example : it would make an impressive looking page, but I do not think the Editor really likes to publish a page of dull arithmetic.

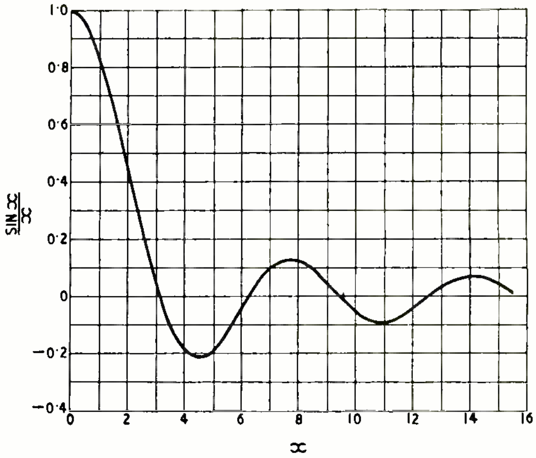


Fig. 5. Graph of the function sin x/x.

Before going on to some related topics let me recapitulate. To find the response to a very short pulse, we find the frequency and phase characteristics, compute the real part response by taking (gain) × cos (phase) at each frequency, plot this on a linear frequency scale. This real part response is then expressed as a set of trapezoidal responses and the transient response corresponding to each trapezium is calculated. Finally, we add (or subtract where necessary) all these transient responses and this is the transient response of the complete system.

When you are considering overload problems, the square-wave response is probably more convenient than the impulse response. The overshoot of the square wave gives a pretty good idea of how much safety margin must be allowed between the steady-state output and the maximum programme output. Fortunately, it is very easy to proceed from impulse response to square-wave response. In Fig. 6(a) I have drawn a fairly typical impulse response. The figures inside the curve show the number of millimetre squares in each 1-cm vertical strip, and the running total from left to right is underneath. This running total is then plotted in Fig. 6(b) and shows the square-wave response corresponding to the given impulse response. The overshoot is very small, so that even the most cautious user of an amplifier with this characteristic could operate it up to its steady tone maximum. There is nothing more to the calculation of the square-wave response : all the work is in the first stage, the determination of the impulse response.

" Ringing "

It is very useful to have some physical appreciation of the causes of the ripples in the transient response. The simplest view is obtained by noticing that our input signal contains a complete frequency spectrum extending up towards infinity. The amplifier cut-off stops all frequencies above a particular limit and therefore acts as though it produced a negative signal containing all these components with phase reversed to add to the original signal. Some of the filter textbooks show what happens to a square wave passed through a high-pass filter, and this damped oscillation is the wave to be subtracted from a square wave which has passed through a low-pass circuit. The reader who checks up on this will no doubt ask why I haven't pointed out that the filter books also show the transient response of a low-pass circuit. The reason is that I wish to emphasize the fact that the transient distortion is due to terms above the maximum transmitted frequency and that they are not in themselves audible.

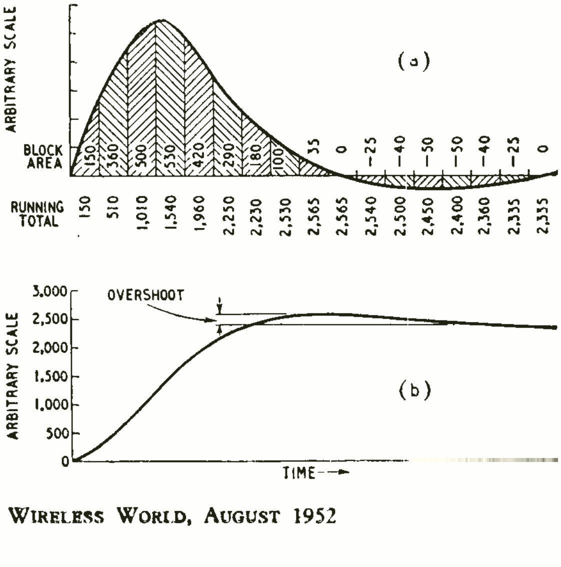
Feedback amplifiers present some special and rather interesting transient characteristics. To the mathematician the reason is very simple : the phase characteristic hugs the zero line up to near the cut-off, and then rises very sharply. That's fine, but what does it mean ?

Delayed Feedback

The easy way to understand what happens in a feedback amplifier is to watch a pulse going through it. A typical amplifier, let us say, has a frequency response without feedback which is 20 db down at 20 kc/s, and we are using 20 db of feedback. The phase shift will probably be 180 degrees at about 25 kc/s. The delay through the amplifier, without feedback, is given by the shape of the phase characteristic, $d\theta/d\omega$, and the average value of this is $\pi/2\pi.25{,}000$ or 1/50,000 sec, or 20 μsec later. Until the pulse reaches the output the feedback cannot begin to have any effect, so that with a square-wave input the first 20 μsec of output is amplified by the full gain of the amplifier. At the end of 20 μsec the feedback starts to operate, but during this short period you may have blocked off a grid somewhere in the circuit. I do not pretend that the description here is complete : it is, however, of very great value if you are designing an amplifier with feedback round an output transformer, when the early stages are usually made with very wide band response in order to achieve stability. These conditions lead to a pulse at the output grid which may be about ten times the size of the steady-state signal. There are quite a lot of complications which can arise in particular circumstances, but I do not propose to discuss them here.

It is not suggested that in all cases you should calculate the transient response before you build an amplifier. One feature of the theoretical method, however, is that it provides a background which helps in interpreting the transient responses you can see on the oscilloscope.

Fig. 6. Square-wave response is obtained by counting squares in the elements of area under the impulse response curve, and then plotting the running total. (a) Typical impulse response. (b) Corresponding square-wave response.



Square-wave responses of amplifiers have often been published in *Wireless World*, but there is a method of studying the transient response which has not been mentioned, so far as I can remember. This is to differentiate the amplifier output and thus obtain the impulse response, at the same time making sure that the amplifier behaves well with both negative and positive swings.

The differentiating circuit is simple, a series capacitance and shunt resistance after the load and before the oscilloscope. The shunt resistance should be fairly large compared with the load, while the capacitance should be chosen to give high impedance compared with the shunt resistance at all frequencies of interest. Typical values would be 100 pF and a few thousand ohms. The advantage of this method is that it shows up the ripples on the response much more clearly : ideally the square wave when differentiated will just give a spike of very short duration ; all else is error.

To conclude, a note on the calculation of " droop " caused by a bad low-frequency response is needed. The procedure here is fairly simple : you plot the real part response in just the usual way, and then take the trapezium, or set of trapezia, which would be needed to make the response go down to zero frequency. The impulse response is then calculated for these trapezia, and the square-wave response obtained by counting squares (integration). This response is subtracted from the ideal square wave, and there is your drooping characteristic.

R.I.C. SPECIFICATIONS

THREE new component specifications and additional sections for some existing ones have just been issued by the Radio Industry Council. These specifications are prepared in conjunction with B.R.E.M.A., R.C.E.E.A. and R.E.C.M.F. and are for the time being intended for use within the industry.

Sections 1 and 2 of the new specifications are available now and these cover performance requirements and production tests. Sections 3 of each, defining types of the components covered, their ratings and sizes, will be issued later.

RIC/151 deals with dolly operated switches of the toggle type for use in d.c. and a.c. circuits not exceeding 500 V and 15 A loading and for frequencies up to 3 kc/s. RIC/154 relates to single- and multi-wafer rotary switches and concerns two types; one for use up to 100 kc/s and the other up to 100 Mc/s.

RIC/251 deals with valveholders of the kind commonly used in radio receivers and other electronic equipment. It covers two types of valveholders; those with low loss insulating material having power factors below 0.002 at 1 Mc/s and those with poorer material with power factors greater than 0.002 at 1 Mc/s. RIC/151 and 154 cost 6s each and RIC/251 5s 6d; this is inclusive of part 3 in each case, which will be supplied later.

The additional sections now available are parts 3 for RIC/111, non-insulated wire-wound resistors, and defines the standard values, tolerances, sizes and finishes; for RIC/122, variable-track composition resistors, again giving values and also switch ratings when fitted; and for RIC/133, defining values, tolerances and ratings of fixed ceramic grade 1 capacitors. These complete the three specifications concerned.

International Television Standards

It has been pointed out that our not-infrequent references to the "C.C.I.R. 625-line" television standard might be read to imply that both the French 819-line system and our own 405 lines do not conform with C.C.I.R. recommendations. It is, of course, quite true that the C.C.I.R. (after a Study Group had inspected and assessed the systems operating in both hemispheres in 1950) advocated the adoption of 625 lines. At the VIth Plenary Meeting of the C.C.I.R. in Geneva last year it was, however, found impossible to arrive at unanimous agreement for the adoption of any one of the existing four systems; 405, 525, 625 or 819 lines. It was, therefore, decided to incorporate in the published report of the meeting* details of each of the systems for the information of administrations wishing to adopt one of them, and these are given in Table A. Each system has, *ipso facto*, the approval of the C.C.I.R., but, as one delegate remarked, to standardize four systems is not standardization.

Ideal vision characteristics, based on details published by the C.C.I.R., for each of the four systems are given in Fig. 1. Details of the frame synchronizing waveforms (incidentally "field" is used throughout the C.C.I.R. documents) and, inset, the line synchronizing pulse for each of the systems are given in Fig. 2.

In certain respects there is a measure of unification. Each of the four systems conforms to the C.C.I.R. recommendation regarding line interlacing (2/1), aspect ratio (4/3), direction of scanning (L to R and top to bottom), vision modulation (amplitude), asymmetrical transmission, independence of black level on picture content, and capability of operation independent of the frequency of the power supply. Incidentally, the C.C.I.R. decided that there was no need to standardize the polarization.

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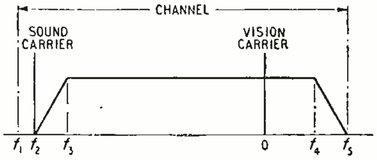
* "Documents of the VIth Plenary Assembly of the C.C.I.R.," International Telecommunication Union, Geneva.

TABLE A. DETAILS OF EXISTING SYSTEMS

	405	525	625	819
Vision bandwidth (Mc/s) ..	3	4	5	10.4
Channel width (Mc/s) ..	5	6	7	14
Sound carrier relative to vision carrier (Mc/s) ..	−3.5	+4.5	+5.5	−11.15
Sound carrier relative to edge of channel (Mc/s)	+0.25	−0.25	−0.25	+0.10
Line frequency (c/s) ..	10,125	15,750	15,625 ± 0.1%	20,475
Frame frequency (c/s) ..	50	60	50	50
Picture frequency (c/s) ..	25	30	25	25
Sense of vision modulation	positive	negative	negative	positive
Level of black as % of peak carrier	30	75	75	25
Minimum level of carrier as % of peak carrier ..	0	≤15	10	≤3
Sound modulation ..	a.m.	f.m. ±25 kc/s 75 μsec pre-emphasis	f.m. ±50 kc/s 50 μsec pre-emphasis	a.m.



	405	525	625	819
f_1	−3.75	4.75	5.75	−11.25
f_2	−3.5	4.5	5.5	−11.15
f_3	−3	4	5	−10.4
f_4	0.75	−0.75	−0.75	2
f_5	1.25	−1.25	−1.25	2.75

Fig. 1. Transmitter characteristics for each of the four systems. Frequencies are relative to the vision carrier which the C.C.I.R. recommends should be 1.25 Mc/s from f_5. The sound carrier (f_2) should be 0.25 Mc/s from f_1.

KEY TO WAVEFORMS IN FIG. 2.

	405-line	525-line	625-line	819-line
A (peak white)	100%	15% $(^{+0}_{-15}\%)$	10% min.	100%
B (black)	30% ± 3%	75% ± 2.5%	75% ± 2.5%	25% ± 2.5%
C (sync.)	0—3%	100%	100%	<3%
D (vert. sync. pulses)	4 lines	3 lines	3 lines	—
E (frame suppression period)	14 lines (1.4 msec.)	13-20 lines (1—1.6 msec.)	19-31 lines (1—1.6 msec.)	41 lines (2 msec.)
F (pre-equalizing pulse)	—	3 lines	3 lines	—
G (post-equalizing pulse)	—	3 lines	3 lines	—
H (line period [μ sec.])	98.7	63.49	64	48.84
J (frame pulse duration [μ sec.])	40 ± 2	27.3	—	—
K (front porch [μ sec.])	1—1.5	1.27	0.64 $(^{+0.32}_{-0})$	0.5
L (line pulse duration [μ sec.])	8—10	5.08 ± 0.634	5.76 ± 0.64	2.5
M (back porch [μ sec])	6—9	3.81 ± 0.634	5.12	5
N (rise time [μ sec.])	0.25	0.254 max.	0.256	—
N_1 [μ sec.]	≯1	—	—	—
P (equ. pulse duration [μ sec.])	—	2.54	2.88	—
Q [μ sec.]	—	31.74	32	—
R [μ sec.]	—	4.44 ± 0.634	5.12 ± 0.64	—

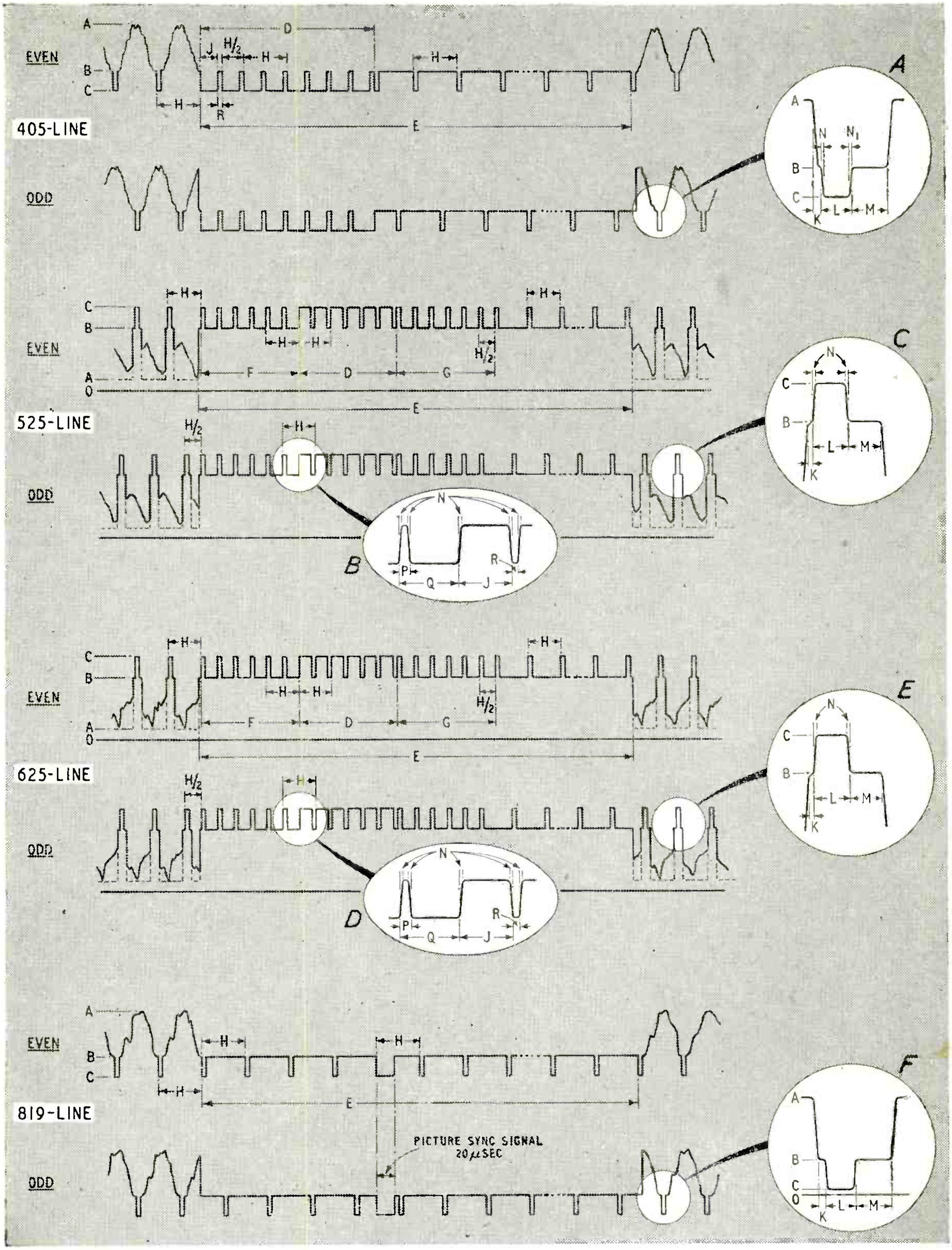


Fig. 2. Waveforms of the line and frame signals for the even and odd frames for each of the existing four television systems. Inset are enlargements showing the details of the line synchronizing pulses. The key to the lettering is given on the opposite page. The C.C.I.R. also gives a modifiation of the 625-line vertical sync signals as proposed by the Swiss delegation. In this D, F and G are 2·5 lines.

Television from Paris

Conversion from French to British Standards

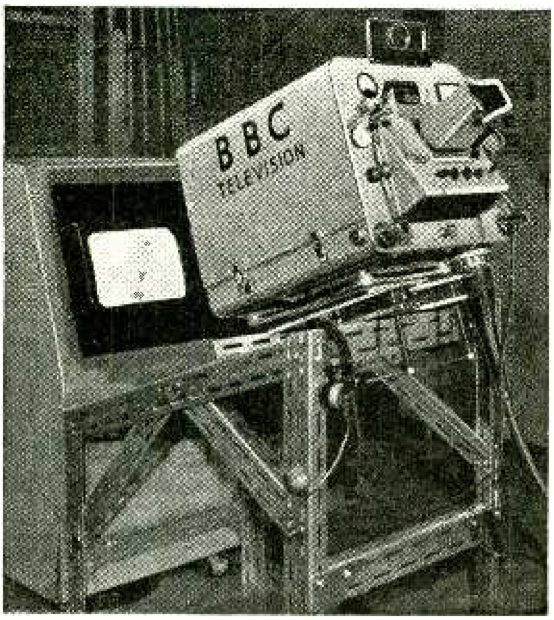
The famous Eiffel Tower, from the top of which the vision signals started their journey by radio relay to London.

THE week of television programmes from Paris which British viewers saw recently was technically a major exercise in outside broadcasting—and outside broadcasting in two senses of the word. First of all, since the aim of the week was to present various aspects of the life of Paris, it was necessary to send out cameras to places all over the city rather than televise from the studios—and, in fact, only one of the seventeen programmes came from a studio. Secondly, from the point of view of the B.B.C. engineers in London it was a matter of a long-distance outside broadcast from Paris, and this with the added complication of having to convert the French high-definition 819-line pictures to our own 405-line standard.

The whole operation was a joint effort of the B.B.C. and its French counterpart, the R.T.F. (Radiodiffusion et Télévision Françaises), and the programmes were seen simultaneously by viewers in both countries.

In Paris the work of televising the sixteen outside programmes was shared between four mobile camera units, each consisting of a group of cameras with an equipment for control and mixing. The first was the normal R.T.F. outside broadcasting van with two super-iconoscope cameras, and the second was a new van with three image-orthicon cameras, both of these vehicles being constructed by the French firm Radio-Industrie. The third was a mobile unit with four image-orthicon cameras, specially lent for the occasion by Pye, of Cambridge, while the fourth was a small "suitcase" equipment with two photicon cameras made by the French Thomson-Houston company. Vision signals from these four mobile units (all 819 lines, of course) were sent to a receiving point on the Eiffel Tower by centimetre-wave radio transmitters made by the Compagnie des Compteurs.

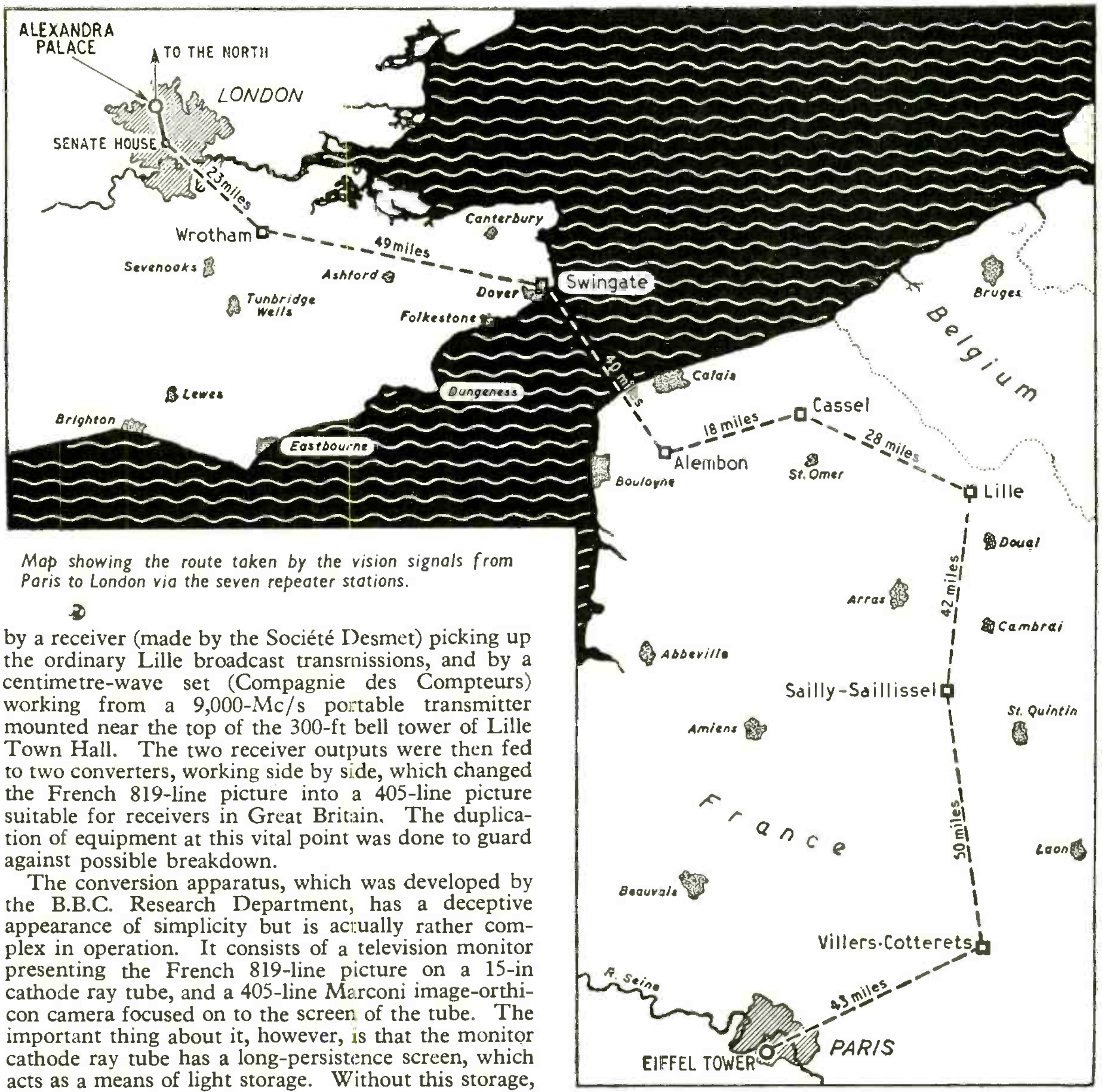
B.B.C. equipment for converting the French 819-line pictures to 405-line pictures.



In the Eiffel Tower are the two R.T.F. television transmitters which serve the Paris area (one for 819 lines at the top and another for 441 lines at the bottom), and these receive their programmes by cable from the studio centre in the rue Cognacq Jay, about half a mile away, and by radio from the outside broadcasting points as explained above. On this occasion the Tower was also the starting point of the chain of radio links, some 300 miles long, which conveyed the vision signals to London.

The first part of the journey, from Paris to Lille, was done by way of the existing French television relay which supplies programmes to the 819-line transmitter at Lille. This is an experimental system installed by the French Thomson-Houston company until a permanent one is built. It has two intermediate repeater stations at Villers-Cotterets and Sailly-Saillissel, which are unattended and controlled by time switches and have duplicate equipment throughout as a precaution against possible breakdown. In each repeater the radio equipment is mounted at the top of a 245-ft tower with two 10-ft paraboloidal aerials, one for transmitting and the other for receiving. About 5 watts of r.f. energy at 850 Mc/s is beamed from one station to the next, and the total gain of each repeater is in the region of 90 db.

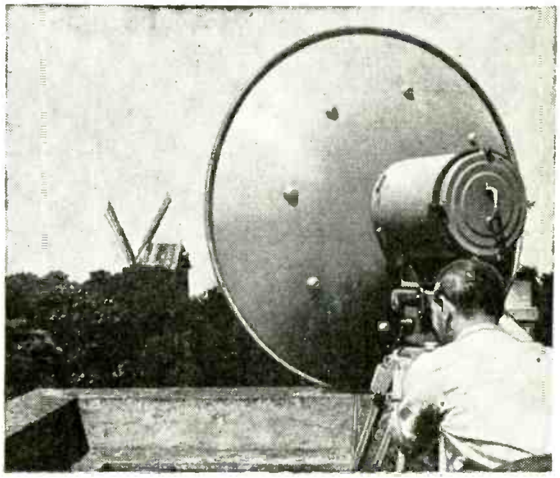
On arrival at Lille, the vision programme was radiated by the transmitter there and passed on to the first of the temporary relay stations set up by the B.B.C. This was at Cassel, a small town which, because of its position on the only hill for miles around, was used as a military headquarters in the 1914-18 war and as a wireless station in both wars. Here, on the roof of an old casino at the very top of the hill, the vision signals were received from Lille in two ways—



Map showing the route taken by the vision signals from Paris to London via the seven repeater stations.

by a receiver (made by the Société Desmet) picking up the ordinary Lille broadcast transmissions, and by a centimetre-wave set (Compagnie des Compteurs) working from a 9,000-Mc/s portable transmitter mounted near the top of the 300-ft bell tower of Lille Town Hall. The two receiver outputs were then fed to two converters, working side by side, which changed the French 819-line picture into a 405-line picture suitable for receivers in Great Britain. The duplication of equipment at this vital point was done to guard against possible breakdown.

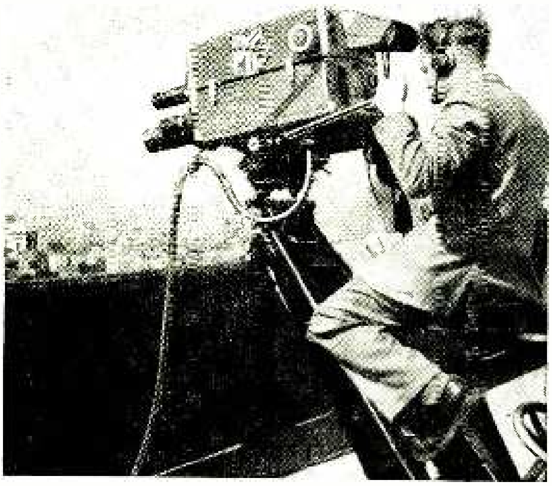
The conversion apparatus, which was developed by the B.B.C. Research Department, has a deceptive appearance of simplicity but is actually rather complex in operation. It consists of a television monitor presenting the French 819-line picture on a 15-in cathode ray tube, and a 405-line Marconi image-orthicon camera focused on to the screen of the tube. The important thing about it, however, is that the monitor cathode ray tube has a long-persistence screen, which acts as a means of light storage. Without this storage, that is, using a short-persistence screen, the camera mosaic would behave like a simple photo-cell, quite independently of the scanning beam, and would give a fluctuating output corresponding to the intensity variations of the cathode ray tube spot. This fluctuating output would be, of course, a replica of the 819-line vision waveform and would beat with any signal obtained from the mosaic in the normal way by scanning to produce a completely meaningless waveform from the camera. By using a long-persistence screen, however, a large component of unmodulated light is introduced, and if the proportion of unmodulated light to modulated light is made sufficiently great the intensity variations of the spot are rendered negligible and have little or no effect on the camera mosaic. One might say that the long-persistence screen serves to "smooth out" the intensity variations *in time* of the

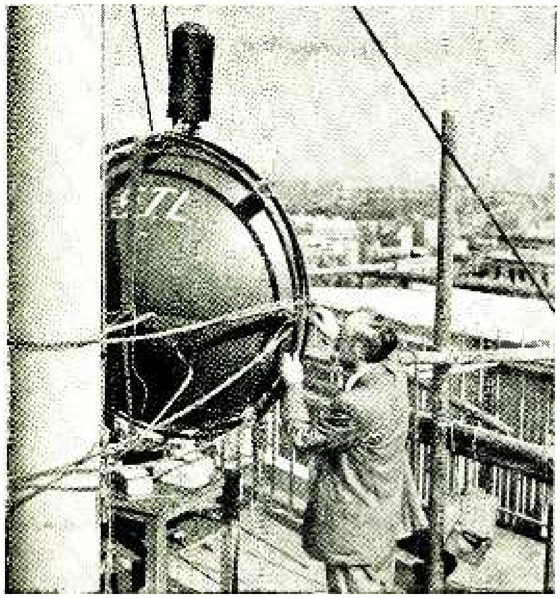


Right : Setting up a Marconi centimetre-wave transmitter on the roof of the casino at Cassel for beaming the vision signals to Alembon.

spot but leaves them recorded at positions *in space* on the screen where they can be detected in the normal way by the camera scanning system. Actually, the persistence of the screen (zinc beryllium silicate) is such that the brightness of any point in the image falls exponentially to 28 per cent of its original value during the period of one frame (20 milliseconds).

In addition to the "photo-cell effect" there is another difficulty which has to be avoided. Although the frame frequencies of the monitor and camera are nominally the same (50 c/s), in actual practice they differ slightly and, of course, the phase relationship of the two scanning systems is continually changing. Sometimes the camera beam is behind the monitor beam, giving a reduced signal output, sometimes ahead, giving an extremely low signal, and sometimes the two beams coincide, giving a maximum signal. The result in the final 405-line "converted" picture would be a fluctuation of intensity corresponding to a beat between the two frame frequencies, and this would occur to some extent even with a long-persistence monitor screen. In the B.B.C. converter, however, the effect is overcome by operating the camera pick-up tube on a part of its characteristic that introduces sufficient storage, or "memory," to smooth out the fluctuations.





Pye 819-line image-orthicon camera televising a panoramic view of Paris from the Eiffel Tower and (below) S.T.C. centimetre-wave receiving paraboloid mounted on the roof of the Senate House, London University.

A certain amount of degradation of the picture is introduced by the optical system of the converter, but this is corrected by equalizer circuits in the camera.

It is customary for the frame scan of B.B.C. cameras to be locked to the 50-c/s mains frequency of the grid system in this country to avoid "hum bars" appearing on viewers' receivers, so on this occasion it was necessary to convey the 50-c/s signal from the mains out to the cameras at Cassel by a special land line.

The vision signals having thus been converted to British standards, they were transmitted over the next link of the chain, from Cassel to Alembon, by a Marconi centimetre-wave radio link working on about 7,000 Mc/s. Similar equipments, made by E.M.I. and working on about 4,500 Mc/s, then conveyed the signals across the Channel to the R.A.F. radar towers at Swingate, near Dover, and on to the B.B.C. experimental v.h.f. station at Wrotham. This last jump was notably long (49 miles) for such high-frequency working, but was made possible by the improved type of klystron valve in the E.M.I. equipment which gives the transmitter an output power as high as 3-5 watts. Finally, the signals were transmitted from the mast at Wrotham to the top of the Senate House of London University by an S.T.C. centimetre-wave equipment, again working on about 4,500 Mc/s. After that they went underground for the first time, being sent by coaxial cable through Broadcasting House to the Alexandra Palace transmitter, from which point they were distributed by our own permanent network of cables and radio links to the transmitters at Sutton Coldfield, Holme Moss and Kirk O'Shotts.

The sound for the programmes was conveyed direct from Paris to London by land line. Over the B.B.C. part of the relay, from Cassel to London, each repeater station was equipped with a Mullard v.h.f. transmitter/receiver so that engineers along the route could communicate with each other.

Incidentally, the conversion of one television standard to another was used at another point in the system, within the French television service itself. In Paris there are, as stated earlier, two television systems, one operating on 819 lines and the other on 441 lines, and hitherto they had been transmitting separate programmes. For the Franco-British week, however, they were arranged to radiate the same programme, and this was achieved by means of a converter, similar to the one at Cassel, which enabled the 441-line viewers to see the pictures produced by the 819-line system. It was installed near the base of the Eiffel Tower and consisted of an 819-line monitor scanned by a 441-line camera, the output of which was fed to the 441-line transmitter in the usual way.

About two-thirds of the 40,000 viewers in the Paris area have 819-line receivers, while the rest are on 441 lines and a few have dual-standard sets. The 46-Mc/s low-definition vision transmitter, however, radiates on the much greater power of 30 kW (as against the 3 kW of the 185-Mc/s high-definition one), so there is a tendency for viewers well outside the city to have 441-line sets, as a matter of necessity, while those in the centre have 819-line sets.

R.F. Characteristics of Capacitors

Outline of Factors Controlling Performance

By R. DAVIDSON,* B.Sc., A.Inst.P.

THE limitations imposed on the effectiveness of a given capacitor in a circuit by the operating frequency, or frequencies, are often overlooked or ignored by users of capacitors. As a result, the circuit either tends to instability or, more usually, the capacitor is not fully effective and its function could be more efficiently performed by a capacitor of different type and, perhaps, of different value.

Two typical applications of capacitors in which these frequency limitations show themselves are in the decoupling circuits of radio frequency amplifiers and in radio and television interference suppression networks. Of these, the former will probably be the more familiar to readers. Fig. 1 shows a single stage of a typical radio frequency amplifier C_1, C_2, C_3, being the anode, screen grid and cathode decoupling capacitors respectively. In such amplifiers the d.c. supply to the anodes and screen grids of the valves represents a low impedance common to each stage of the amplifier. If radio frequency voltages from any stage are developed across this common impedance, regeneration will take place and the amplifier may tend to become unstable. It is essential, therefore, that all radio frequency currents shall be by-passed to earth from all anode and screen grid supplies and all cathodes not themselves returned directly to earth.

Referring to Fig. 1, this means that the radio frequency voltages developed across AE, BE and CE must be negligible. The decoupling capacitors C_1, C_2, C_3, must therefore have as low an impedance as possible at the radio frequency to be by-passed, and it is desirable, again from the point of view of stability, that their reactance be capacitive at this frequency. As will be seen later, owing to the inherent inductance of capacitors and the inductance of their leads, these reactances may be inductive and appreciable. For example, a typical 0.1-μF tubular paper dielectric capacitor with short leads may have an inductive reactance as high as 30 ohms at 45 Mc/s, and would be virtually useless for decoupling or interference suppression at television frequencies. Even a 0.005-μF capacitor with lead lengths as short as 2 cms is inductive at 45 Mc/s and can have an impedance in the region of 10 ohms. Being inductive, it may cause trouble when used as a decoupling capacitor, and its impedance is too high for it to be effective for television interference suppression when used across the low-impedance sources or mains supplies usually met with in this field. However, as will be seen later, a 500-pF capacitor with similar lead lengths can have an impedance as low as 1 ohm at 45 Mc/s, and is substantially non-reactive at frequencies in this region. With shorter lead lengths it will be capacitive and will still have a lower impedance at this frequency than the 0.005-μF capacitor of similar type and lead lengths. Choice of capacitor type and capacitance for by-passing purposes thus depends very much on the operating frequency. The extent of the limitations imposed by the operating frequency on the effectiveness of capacitors and the factors governing these limitations will now be examined in detail.

Every capacitor has a certain value of inherent inductance which, together with lead inductances, will form a series resonant circuit. At frequencies less than the self-resonant frequency the capacitor has a capacitive reactance and, except in the immediate region of resonance, its impedance will be almost the same as its theoretical value. At frequencies greater than the self-resonant frequency the capacitor will have an inductive reactance and its impedance will increase with frequency. This inherent inductance is, therefore, a most important property of every capacitor, since it controls the maximum frequency at which the capacitor will exhibit a capacitive reactance.

The main factors which control this inductance are as follows: (i) The dimensions of the external leads to the capacitor and the internal leads to the capacitor section. This applies to all types of capacitor. (ii) The ratio of the length of the capacitor section to its diameter (for rolled cylindrical paper and tubular ceramic dielectric capacitors). (iii) The proximity of the outer casing of the capacitor, if metal, to the capacitor section. (iv) The method of connection of the leads to the capacitor section.

Of the above (i) has the greatest influence on the total series inductance of the capacitor circuit. With an ordinary two-lead capacitor the minimum lead

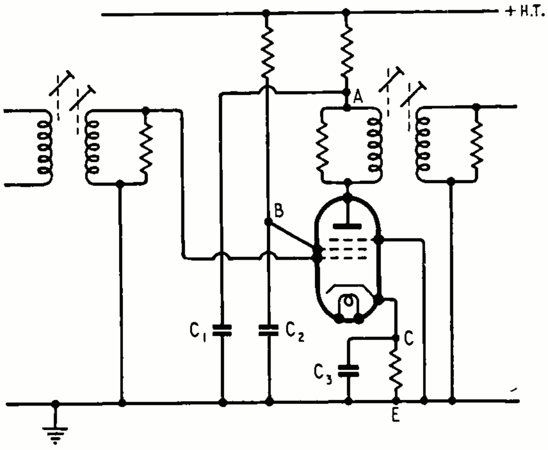


Fig. 1. Single stage of a typical r.f. amplifier showing anode, screen and cathode decoupling capacitors.

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* Dubilier Condenser Co. (1925) Ltd.

lengths necessary, in practice, to make connections to the external circuit will have inductances of the same order of magnitude as that of the capacitor section itself. For example, the inductance of two centimetres of 22 s.w.g. tinned copper wire, often used for the leads of small capacitors, approximates to that of the capacitor section so that an extra two centimetres of lead on either side of the capacitor will reduce its resonant frequency by a third. Thus increasing the lead lengths of a 0.1-μF tubular paper capacitor from 1 cm to 3 cms lowers its resonant frequency from 3.3 Mc/s to 2.2 Mc/s; a similar increase on a 500-pF paper dielectric capacitor reduces its resonant frequency from about 54 Mc/s to 36 Mc/s.

One method of reducing the lead inductances of a capacitor is to take the leads of the external circuit into and out of the respective poles of the capacitor via two terminal connections as shown in Fig. 2. These two terminals make a common connection to the capacitor foils so that the only series inductance remaining in the capacitor circuit is that of the section itself. Apart from the limitation imposed by the inductance of the section, it is practically impossible to eliminate the inductive and capacitive coupling between the incoming lead AB and the outgoing lead BC so that, with the increasing frequency, the capacitor is itself by-passed to an increasing extent. Using the two-terminal method of connection the resonant frequency of a 0.1-μF capacitor with an isolated or non-metal casing can be raised to a maximum of about 6 Mc/s.

The inductance of a capacitor section is controlled by its physical dimensions. For a rolled paper capacitor with extended foil construction the effective inductance at radio frequencies approximates to that of a hollow tube of the outer dimensions of the capacitor section. This inductance L is given by:—

$$L\ (\mu H) = 2l\left\{\log_e \frac{2l}{r} - 1\right\} \times 10^{-3}$$

where l is the length of the section and r is the radius of the section, both in centimetres.

For a given capacitance, therefore, a short section with a large number of turns on the winding will have a lower inductance than a long section with fewer turns and the resonant frequency of the short section will be correspondingly higher than that of the long section. Using the above formula for both the section and the wire connecting leads for a given tubular capacitor the total series inductance, and hence the resonant frequency of the capacitor and its leads, can be predicted very closely. The effect of section dimensions on inductance for various overall sizes of 0.1-μF rolled paper dielectric capacitor plate is shown in the Table together with the self-resonant frequency of the section.

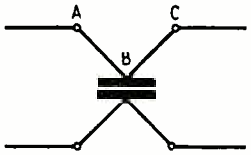
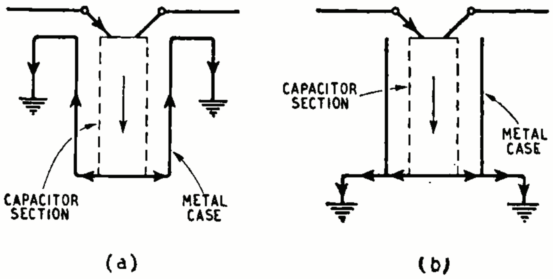


Fig. 2. Capacitor having two terminal connections to each plate in order to reduce lead inductances.

Fig. 3. Capacitor with a metal case forming one plate and showing r.f. current paths with two different methods of earthing.



(a) (b)

TABLE

Dimensions of Section		Inductance of Section	Self-resonant frequency of Section
Cms.		μH	Mc/s
Length	Diam.		
2.9	1.3	6.7×10^{-3}	6.1
3.2	1.3	8.2×10^{-3}	5.3
3.2	1.0	9.4×10^{-3}	5.2
4.8	1.8	12.9×10^{-3}	4.4
4.1	1.0	15.1×10^{-3}	4.1

The inductance of tubular silvered ceramic dielectric capacitors can be similarly derived using in the aforementioned formula the outer dimensions of the ceramic tube.

Silvered ceramic disc capacitors with high permittivity dielectrics are now being used increasingly for by-passing. Such capacitors have inherently low self-inductances due to the shape and small physical dimensions of their silvered areas (the inductance being of the order of half that of the equivalent paper dielectric capacitor). These capacitors are, therefore, suitable for high frequency by-passing in situations where their relatively high power factor and high temperature cœfficient of capacitance are unimportant. Similar discs with low permittivity ceramic dielectric of the type often used as h. f. couplings are in the very low capacitance range and have self-resonant frequencies considerably higher than their normal operating frequencies. They may, therefore, be considered capacitive for all practical purposes providing their external leads are kept short.

In practice, the inductance of the capacitor section may be modified, under certain circumstances, by the type of container in which it is housed. With capacitors housed in metal containers which are isolated from the poles of the capacitor, the metal case has a negligible effect on the inductance of the section. Where the metal case forms one pole of the capacitor (which is usually earthed), the casing forms part of the radio frequency current path through the capacitor. The effective inductance of the section will thus be influenced by the proximity of this casing to the section and will depend on the position at which the external connection is made to the case. Assuming the case is earthed, Fig. 3 shows the two extreme positions for making this external connection. In Fig. 3 (a), the radio frequency current passes through the capacitor section and back via the case in the opposite direction. There is a certain degree of coupling between the case and the section, depending on their mutual proximity, so that the effective inductance of the section is reduced below its free space value. This effect is greatest with a close-fitting case.

When the earth connection is made as in Fig. 3 (b), this reduction of inductance is far less marked and the resonant frequency is correspondingly lower. For example, a 0.1-μF capacitor with close-fitting case and two-terminal type of input resonates at 5.1 Mc/s when earthed as in Fig. 3 (a), and at about 4 Mc/s when earthed as in Fig. 3 (b). Hence, for radio frequency by-passing, it is advantageous to use capacitors with the case forming one pole and with the earth connection made at the same end as the input connection.

The method of connection of the leads to each pole of the capacitor may influence the total inductance of the capacitor. A large number of tubular paper dielectric capacitors nowadays have a so-called non-inductive winding with one set of foils projecting at each end of the capacitor. These projecting foils are all soldered together and the connecting lead usually terminated by a flat spiral soldered to the end of the section. This provides an excellent electrical connection to the section and parallels together the foils of each plate, thus limiting the current flow along the winding to a minimum and reducing the inductance of the section and its connections.

Another method of connection to the capacitor section is via a projecting metal lug inserted during the winding and making intimate contact with the plate. This method is slightly more inductive than the projecting foil method, but, providing the lug is inserted at the correct point of the winding, the inductive effect of current flow along the winding is negligible. The resistance of the foils may, however, be appreciable at very high frequencies, and this will result in the power factor of capacitors made with lug connections being higher at these frequencies than those made with projecting foils.

It is sometimes necessary, because of limited space, to use two or more sections wound on the same mandrel to provide separate capacitors within the same housing. Connections can then with convenience only be made to the sections by means of lugs inserted in the windings and, as the sections are usually wound in series, it is not possible to arrange the points of connections such that all sections are non-inductive. Multi-section capacitors wound in this way will thus have at least one section which will have more inductance than its extended foil equivalent and will hence have a lower resonant frequency.

There is one type of wound capacitor which approaches the ideal capacitor over a range of frequencies up to at least 150 Mc/s and which makes use of the methods described above for reducing series inductance to a minimum. This is the "bushing" or "feed-through" capacitor in which the current carrying conductor passes through the centre of the capacitor. One set of foils is connected by the extended foil technique directly to the central conductor whilst the other set of foils is similarly connected to the outer metal casing. The capacitor is employed as a bushing to carry the central conductor through an earthed plate to which the capacitor is fixed and to which all radio frequency currents carried on the central conductor are to be by-passed. By this method of construction all lead lengths to the capacitor section are eliminated and the incoming lead carrying the radio-frequency currents is completely screened from the outgoing lead by the earthed plate.

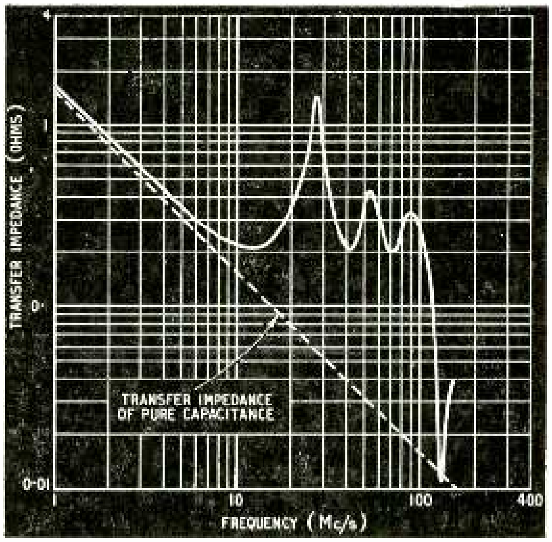
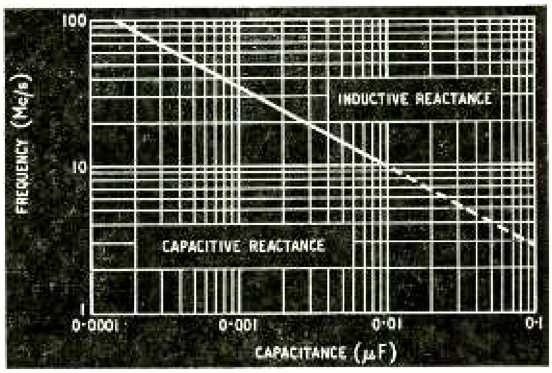


Fig. 4. Transfer-impedance characteristic of a typical 0.1-μF paper dielectric "bushing" capacitor.

Fig. 5. Self-resonant frequency-capacitance curve for metallized paper capacitors with lead lengths of 1 cm.



Detailed examination of the transfer impedance-frequency characteristics of these capacitors is beyond the scope of this article, but the characteristics are so unique as to require a brief description. Feed-through capacitors behave at high frequencies as heavily attenuated open-ended sections of transmission lines of very low characteristic impedance. From details of the construction of these capacitors, it is possible to determine the length, attenuation constant and transfer impedance of the equivalent transmission line, and hence to predict where the resonant peaks and troughs will occur in the transfer impedance-frequency characteristic of the capacitor. The transfer impedance of these capacitors, which is the parameter controlling the effectiveness of the capacitor for radio frequency suppression work, is low for frequencies up to at least 150 Mc/s. A typical transfer impedance-frequency characteristic for a 0.1-μF paper dielectric "bushing" capacitor of 50 A through current rating is given in Fig. 4.

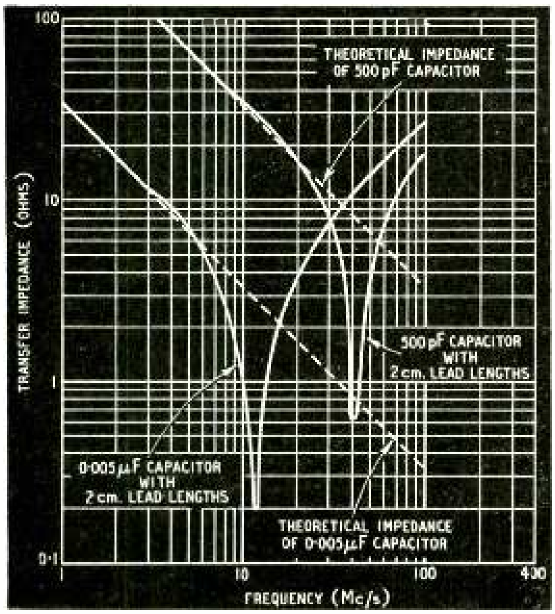
Having examined the factors which control the inductance of a capacitor, the series resonant property can be dealt with in more detail. To illustrate the order of frequency at which series resonance occurs for various values of capacitance Fig. 5 shows the series resonant frequency against capacitance for the miniature metallized paper dielectric type of capacitor having leads one centimetre long at either end. By virtue of the method of construction of this type of capacitor, the overall physical dimensions of the sections vary only slightly over the capacitance range 100 pF to 0.01 μF, so that the graph in Fig. 5 is almost a straight line. The extrapolated portion of the graph will assist in estimating self-resonant frequencies for greater values of capacitance.

Apart from giving an indication of the upper frequency limit of usefulness of a given capacitor, the self-resonant frequency is usually avoided, but recently this property has been put to good use for certain applications. For a 0.1-μF tubular paper capacitor, with extended foil connections, the total series resistance of the capacitor is low and hence the "Q" of the series resonance is high, giving a narrow resonance curve about 500 kc/s wide only at 6 db down. Though capacitors of this size have an extremely low impedance at series resonance the resonance curve is too narrow to be of much practical use. However, with very much smaller capacitors, for example, of the metallized paper dielectric type, the foil losses at high frequencies are not negligible and the self-resonance "dip" is very much wider due to the inherently lower "Q" of the resonant circuit. For such capacitors the impedance may be less than theoretical over a frequency band as wide as 20 Mc/s within the resonance "dip."

Over this frequency band the capacitor will provide better by-passing than any larger capacitance of similar type and equal lead lengths. This is illustrated in Fig. 6 which shows the transfer impedance-frequency characteristic, through resonance, of a 500-pF metallized paper capacitor and a 0.005-μF capacitor of similar type and equal lead length and diameter. It will be seen that, from 30 Mc/s upwards, the smaller capacitor has a lower impedance than the larger capacitor and that from about 25 Mc/s to 50 Mc/s the impedance of the 500-pF capacitor is less than its theoretical value.

Very good use can be made of the series self-resonant frequency property of small capacitors within the television band 40-70 Mc/s where capacitances of the order of 500 pF, using a centimetre or so of connecting lead, provide excellent by-passing over a large portion of the band. By using such low value capacitors at series self-resonance in conjunction with small inductors at parallel self-resonance (also with wide frequency band coverage) most effective filters can be made covering the whole television band. Such filters are unique in that they provide higher attenuation at these frequencies than can be obtained by any combination of larger values of nominal capacitance and inductance. These filters occupy very little space and have recently been successfully used for television interference suppression of electrical appliances. In this connection specially designed television frequency chokes as small as $\frac{1}{2}$in long by $\frac{3}{16}$in diameter are available for use with the well-known types of small metallized paper, paper or mica dielectric capacitors.

Fig. 6. Transfer-impedance-frequency characteristics through self resonance for paper dielectric capacitors of 500 pF and 0.005 μF.



NEW B.B.C. CHARTER

THE plethora of words, both spoken and printed, which preceded the granting of the new Charter[*] to the B.B.C., makes it difficult to dissociate fact from fiction. By and large there are but few major changes in the terms under which it will operate for the next ten years—for that was the period, starting from July 1st, for which the Charter was granted. Of course, the B.B.C. cannot fulfil the function outlined in the Charter without a licence from the Postmaster-General, and it was this Licence and Agreement[†]—and the Government's whole policy on broadcastings[§]—which were so heatedly debated in Parliament.

Technically the main change in the licence is that it stipulates specifically that any additional stations needed to improve the coverage of the Home Services will employ v.h.f.—the actual phrase is "emit waves at more than 30 Mc/s".

The most significant, and certainly the most hotly debated, section of the White Paper was that relating to the introduction of competitive television. In the Charter, too, the phrase "non-exclusive licences" appears.

The proposed introduction of a Committee of Appointment for the selection of Governors was withdrawn by the Government, so that the Board of Governors—now to be nine instead of seven—will continue to be appointed by the Crown. Three of those appointed will in future be "National Governors" for Scotland, Wales and Northern Ireland. In order to give the greatest possible measure of autonomy to these countries, National Councils are to be set up within the framework of the B.B.C.

It may be worth recording that whereas under the old licence the Corporation paid the P.M.G. £10 p.a. for each transmitter, the new licence stipulates an all-embracing annual fee of £500.

Although irrelevant to either the Charter or Licence, it is noteworthy that the Government has stated that it is to grant a fifteen-year licence to the broadcast relay exchanges and "power to the P.M.G. to take over compulsorily then, or thereafter, by two years' notice."

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[*] Cmd 8605. [†] Cmd. 8579. [§] Cmd. 8550.

Simple Line-Scan Circuit

Transformerless System with H.T. Boost

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

THE general principles of efficiency line-scan circuits were discussed in a recent article[1] in some detail. Attention was directed chiefly to the most efficient mode of operation in which the two valves—the driving pentode and the efficiency diode—function alternately during the scan, each for about one-half of the scan period. This is, by no means, the only possible mode of operation, however, and it was pointed out that it is usually necessary to sacrifice efficiency somewhat by permitting the operative periods of the valves to overlap in order to avoid unduly critical circuit adjustments.

Some considerable attention was paid to a circuit embodying a directly-fed deflector coil which has the great practical merit of not requiring a line-scan transformer. In spite of the fact that h.t. boost is not possible with it, it was shown that it is quite practicable to scan a 53° tube operating at 10 kV with an h.t. line of the order of 250 V only.

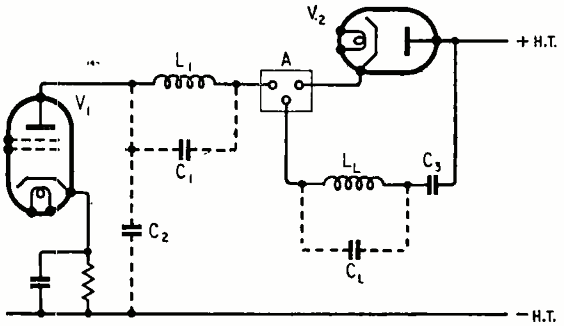

Fig. 1. Basic form of transformerless scanning circuit. The box A is the linearity-controlling device.

The main practical drawback to the circuit is the difficulty of obtaining an e.h.t. supply from it. This difficulty has now been removed by a development referred to by Starks-Field[2]. An extra inductance is included in the circuit which serves two purposes. It increases the peak voltage on fly-back sufficiently to enable e.h.t. to be obtained. If this were all it would not help, for it would necessitate an inconvenient increase in the h.t. line, but it also permits h.t. boost to be obtained. The two factors enable an efficient circuit without a line-scan transformer to be devised.

The new circuit is shown in its basic form in Fig. 1 and without the e.h.t. system ; the box A represents the linearity control and need not be considered at present, there is a conductive path between all three of its terminals. The capacitances C_1 and C_L represent the self-capacitances of L_1 and L_L while C_2 is mainly the output capacitance of V_1, but may, in practice, be augmented by external capacitance. C_3 is the capacitance across which the boost voltage appears and is assumed to be very large ; in practice it is usually over 0.5 μF. The inductance L_L is the deflector coil.

Towards the end of the scan the diode V_2 is cut off and the current of V_1 flows through L_1 and L_L. At the end of the scan it has the peak value i_p and V_1 is then cut off. If L_1 were not present, the current in L_L would undergo one-half cycle of damped oscillation at a frequency determined by L_L and the total stray capacitance. V_2 would then conduct to inhibit further oscillation and to control the decay of current in L_L. At this instant the current would have the value $\epsilon^{-\pi/2Q}$ where Q is the quality factor of the tuned circuit formed by the deflector coil and the stray capacitance.

The factor $\epsilon^{-\pi/2Q}$ has been previously designated by the letter x. It is the fractional current overshoot and usually has a magnitude of around 0.8. Because the overshoot is less than unity the mean diode current is less than the mean pentode current if the deflector-coil current is linear. If h.t. boost is to be obtained the two currents must be equal. Equality is usually achieved with the aid of a transformer, but it can also be obtained if the overshoot can be made 100%.

At the start of fly-back the stored energy in L_L is $\frac{1}{2}L_L i_p^2$. At the end of fly-back, L_1 being absent, it is $\frac{1}{2}L_L i_p^2 x^2$ and the circuit has lost energy $\frac{1}{2}L_L i_p^2(1-x^2)$. If in some way this quantity of energy can be added to the circuit during the fly-back it will just counter-balance its loss and the current at the end of fly-back will be i_p. There will be 100% overshoot.

The inductance L_1, in conjunction with the capacitances, does just this. In spite of the simplicity of the circuit the precise mechanism is complex and exact analysis is very difficult. The circuit is, in fact, a pair of top-end capacitance-coupled resonant circuits ; one circuit is L_LC_L and the other is L_1C_1 and they are coupled by C_2. Each has its own Q factor, L/C ratio and resonance frequency. It is well-known[3] that with such coupled circuits in free oscillation the energy oscillates backwards and forwards between the two so that the current in one grows at the expense of the other and then, after a maximum, the reverse process occurs and the current in the one falls off while that in the other grows. The waveform of the current has a resemblance to that of a modulated wave.

In this case we are only interested in the conditions during the first half-cycle of oscillations in L_L, for

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[1] "Efficiency Line-Scan Circuits," by W. T. Cocking, *Wireless World*, August, September and October 1951, pp. 302, 347 and 425.

[2] "Reactive Time Bases," by A. B. Starks-Field, B.Sc., *J.Brit. Instn Radio Engrs.* : 1951 Convention Paper.

[3] "Principles of Radio Communication," by J. H. Morecroft, 3rd Ed. pp. 308-329. (John Wiley).

after that V_2 comes into play to prevent further oscillation in L_L. Any energy left in L_1C_1 then decays as a normal damped oscillation in that circuit alone. A few things about the circuit are easily seen. Since L_1 must transfer energy $\frac{1}{2}L_Li_p^2(1-x^2)$ to L_L in one-half cycle of oscillation of the latter it must initially have more stored energy than this. The peak current in the two inductances is the same and so the initial energy in L_1 is $\frac{1}{2}L_1i_p^2$. If L_1 had no losses and if all its energy were transferred to L_L, this initial energy would have to be equal to the energy required by L_L and this would give $L_1 = L_L(1 - x^2)$. This is the minimum possible value for L_1 and leads to a value around 0.3 L_L.

However, L_1 has its own losses. If these are of the same order as those of L_L, the initial stored energy, and hence the value of L_1, must be doubled to make up for them. It is obviously unreasonable to expect that L_1 would be left with no stored energy at the end of the fly-back period, or even if it is, that there should also be no energy left in C_1 or C_2. If we assume arbitrarily that the energy left in the circuit is one-half of the initial energy, so that of the initial energy roughly one-quarter is transferred to L_L and one-quarter is lost, then L_1 must be 1.2 L_L. This is not in violent disagreement with practice but in the writer's experience it is better to make L_1 about double L_L.

If the capacitance C_1 is too large, the energy in L_1 cannot be removed from it quickly enough to enable sufficient to be transferred to L_L. In practice, it seems advantageous for C_1 to be as small as possible. The major factor affecting the energy transfer is C_2. If it is too small, the energy transference is also too small and the scan is non-linear (picture compressed on the left). An excess of capacitance is less harmful; in fact, above a certain value C_2 has very little effect on the scanning waveform although it does have an effect on the total amplitude and also on the peak voltage across L_1.

Inductive Back E.M.F.

During the scan of period τ_1 there is a back e.m.f. L_LI_L/τ_1 across L_L, where I_L is the peak-to-peak current in L_L. If the diode V_2 is cut off at the end of the scan and if the overshoot during the fly-back is made 100% by the transference of energy from L_1, then the current I_L is just twice the peak anode current of V_1. It is necessary once every cycle to bring the current in L_1 from zero to i_p; while the current is changing, a back e.m.f. is produced across L_1. In order to minimize the h.t. supply voltage it is necessary to make this back e.m.f. as small as possible. It is a minimum when the change of current is linear and when it occupies as long a time as possible. The current of V_1 should, therefore, rise linearly during the full scan period τ_1 and it can then be expressed as i_pt/τ_1. The back e.m.f. across L_1 is then L_1i_p/τ_1. The mean anode current of V_1 is $\frac{i_p}{2}\cdot\frac{\tau_1}{\tau}$ where τ is the full period of one cycle including the fly-back.

It would, of course, be quite possible to operate with V_1 and V_2 conductive alternately for half the scan period. The back e.m.f. across L_1 would then be $2L_1i_p/\tau_1$ (twice as great) and the mean anode current $\frac{i_p}{4}\cdot\frac{\tau_1}{\tau}$ (one-half). The power involved would be the same. Practical limitations are usually on voltage and peak current rather than on mean current, so that it is usually better to choose the mode of operation in which V_1 is conductive throughout the scan. This in turn requires V_2 to be conductive throughout the scan and to carry a current $i_p(t/\tau_1-1)$. As will appear later, this condition is one which leads more easily to the attainment of linearity than the other.

The three currents,—i_v the anode current of V_1, i_d the current of V_2, and i_L the deflector-coil current—are shown in Fig. 2. This diagram also shows the algebraic expressions for the current during the scan in the convenient form of d.c. components plus time-varying parts having no d.c. component. The latter are indicated by the symbol $A_t(= t/\ {}_1-\frac{1}{2})$.

Linearity Circuit

In the previous article[1] it was stated that the linearity device A of Fig. 1 usually has a form such as that of Fig. 3. This resonant arrangement is necessary when the two valves are not conducting together, for the circuit must be energized by V_1 and yet control V_2 when V_1 is non-conducting. It must, therefore, store energy. While the circuit operates successfully, it is critical in adjustment and there are too many variables for it to be easy to determine the proper values; thus, there are the total inductance, the position of the tapping point, the value of the capacitance and the damping. Practically, only the inductance is variable as a user control, but all have to be initially determined, usually empirically. A major difficulty is to know how much latitude to allow for variations of other components.

When both valves are conductive for the whole scan period a different corrector can be used which is not only much less critical but lends itself to more precise design. The circuit element is the same as in Fig. 3 but with the capacitance replaced by resistance.

In Fig. 4 is shown the equivalent circuit in which L_L and R_L represent the deflector coil and R_d represents the diode V_2 when conducting; this representation is approximate only, since the diode resistance is not a constant. R represents the resistance element of the

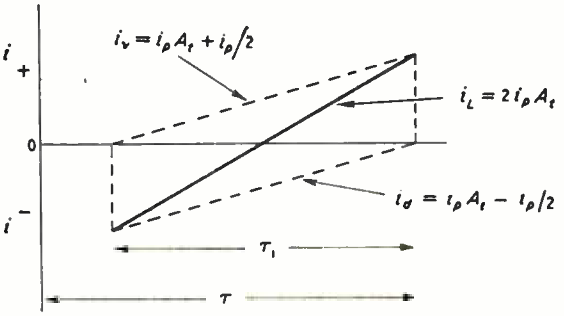


Fig. 2. The currents during the scan of the driving valve i_v and the diode i_d are shown dotted and their combination, which is the current i_L in the deflector coil, by the solid line.

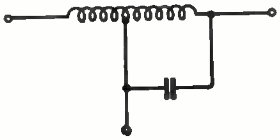


Fig. 3. Form of linearity device (A of Fig. 1) which is commonly used in efficiency scanning circuits.

linearity control. On the left the waveform diagrams show the voltages across each component, as the voltage of its upper terminal with respect to its lower. The top one shows the constant boost voltage V_B across C_B, the next the inductive back e.m.f. across L_L and the bottom the saw-tooth voltage across R_L. The total voltage E is the sum of the three components and is

$$E = V_B - 2L_L i_p/\tau_1 - 2\,i_pR_LA_t.$$

This voltage must also exist across R_d and R on the right-hand side. Here the diode current i_d flows through both resistances, and the transformer of the linearity circuit feeds extra current i to R only. The voltage drop across R_d is shown to its right and the saw-tooth is in the wrong sense to that required. The large saw-tooth required must be produced across R and be the sum of two components, one due to i_d, again in the wrong sense, and the other an over-riding one due to i. We can write for the right-hand side

$$E = i_pR_dA_t - \frac{i_pR_d}{2} + i_pRA_t - iRA_t.$$

It is to be noticed that because of the transformer winding across R there can be no d.c. component in the current i nor in the voltage across R. This equation must equal the previous one and so the terms in them which are time-dependent and those which are not must be independently equal. Therefore the boost voltage is

$$V_B = \frac{2L_Li_p}{\tau_1} - \frac{i_pR_d}{2}$$

and the linearity current is

$$i = i_p\left[1 + \frac{2R_L + R_d}{R}\right].$$

If this current is obtained by connecting the transformer primary as shown so that the valve current flows in the primary, then the ratio of primary/secondary turns, n, must be equal to i/i_v, so

$$n = 1 + \frac{2R_L + R_d}{R}.$$

There must be a voltage developed across the primary and this is n times the voltage across R. This voltage is $i_pRA_t\,n(n-1)$. The total voltage across the whole circuit is thus $E + i_pR\,A_tn(n-1)$

$$= \frac{i_pR_d}{2} + i_pRA_t\,n(n-1) + 2\,i_pR_LA_t.$$

At the end of the scan, when $A_t = \frac{1}{2}$, this is a maximum and the voltage is then

$$E_T = \frac{i_p}{2}(2R_L + R_d)(1 + n).$$

Obviously n should be as small as possible, but it must exceed unity; R should thus be large.

At this stage it is profitable to consider an example. It is found that a certain deflector coil of 30 mH inductance and 55 Ω resistance requires a peak-to-peak current of 0.3 A; a diode resistance R_d of 150 ohms may be assumed. Then $i_p = 0.15$ A and, taking τ_1 as 90 μsec, the inductive back e.m.f. across L_L is 0.3 × 30/90 = 100 V. The mean drop across the diode is 0.15 × 150/2 = 11.25 V and so the boost voltage is $V_B = 100 - 11.25 = 88.75$ V.

The total voltage E_T is 0.075 × 260 $(1 + n)$ = 19.5$(1 + n)$. If $n = 1$, which means $R = \infty$ and is impracticable, $E_T = 39$ V. If $n = 2$, which is an eminently practicable value, $E_T = 58.5$ V. We now must add on the voltage across L_1 of Fig. 1. If $L_1 = 2L_L$ it is 60 mH. The current is 0.15 A and so the inductive back e.m.f. is 100 V and the total voltage becomes 159 V. To this must be added the resistive drop in L_1, the minimum anode-cathode voltage of V_1 and the drop across its cathode-bias resistor. All these will total around 100 V, so that an h.t. supply of around 260 V is called for. The anode current is 75 × 90/99 = 68 mA and the power input 17 W.

It is a fact that practical figures agree very closely with these. Using a metal rectifier for the diode, the boost voltage obtained is nearer 70 V than 89 V; the metal rectifier is, in fact, more accurately represented by a battery and a resistance in series than by a simple resistance. Then the valve used, an EL38, requires 275 V for the screen in order to give 150-mA peak anode current, so an h.t. line of 280 V is suitable in practice, making the input power about 19 W. With a voltage-tripler rectifier system 10 kV at 100 μA can easily be obtained from the anode of V_1. The peak voltage on the deflector coil is slightly under 1.5 kV and that across L_1 rather under 3 kV.

It is desirable that R should not be large, for the inductance required in the transformer is proportional to it. Ideally, this transformer should handle without distortion a saw-tooth current wave when its secondary is loaded by R. If the inductance of that portion of the winding in shunt with R (the secondary) is L, then a saw-tooth wave will droop from its proper value at the end of the scan by τ_1R/L. If we allow 10% droop, $L = 10\tau_1R = 0.0009$ R

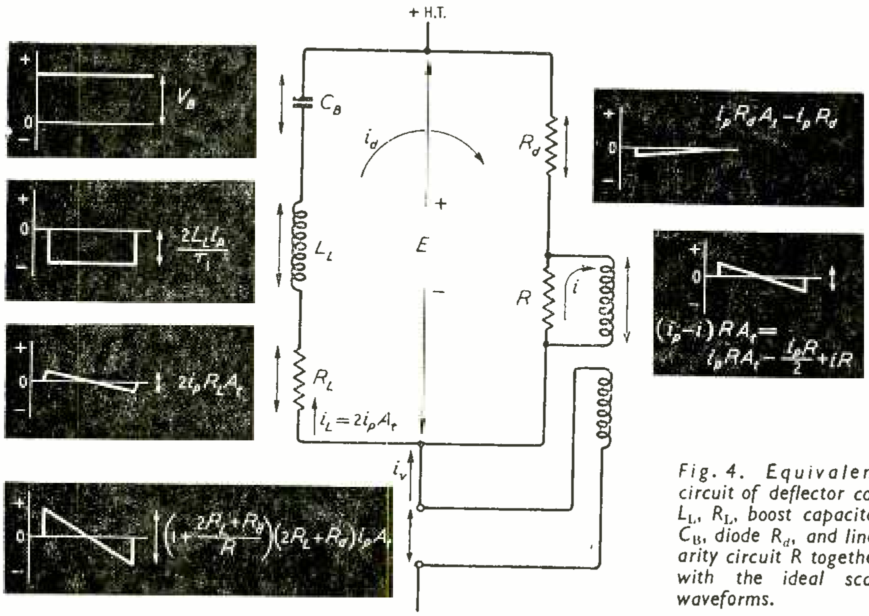


Fig. 4. Equivalent circuit of deflector coil L_L, R_L, boost capacitor C_B, diode R_d, and linearity circuit R together with the ideal scan waveforms.

henrys. The total inductance of the whole winding is $(1+n)^2$ times this. It is easy to show that the total inductance is a minimum when $R = R_L + R_d/2$ and $n = 3$. However, this makes the voltage rather large and it is sometimes better to use a larger value of R. If $n = 1.5$, so that $R = 2(2R_L + R_d)$, the total inductance becomes $0.0056R = 0.0112\,(2R_L + R_d)$. In our example this is $0.0112 \times 260 = 2.9$ H. This must be with the direct current of the stage through the full winding.

However, experiment shows such a large inductance to be quite unnecessary and a value of under 1 H is ample, while 0.25 H only seems sufficient. The reason for this is that the circuit is a correcting one and is correcting a circuit which alone does not depart from linearity by more than 10—15%. Quite a large error in the correcting wave may still lead to a final error which is quite small. Then some correction is possible by adjusting R to a value different from the theoretical one. Then, again, the diode cannot accurately be represented by a resistance.

The theory is approximate only for simplicity, and experiment, always the final arbiter, shows that the inductance can be without harm $\frac{1}{3}$ to $\frac{1}{10}$ of the figure given by the above expression.

The complete circuit diagram of a stage which the writer has used experimentally with very satisfactory results is shown in Fig. 5. The pentode V_1 is driven with a saw-tooth voltage which can be derived from any conventional saw-tooth voltage generator. It is advisable to have a waveform with a negative-going pulse on the fly-back and this is usually easily obtainable by including a resistor of some 2-10 kΩ in series with the charging capacitor. The pulse cuts V_1 off rapidly on fly-back and so increases the e.h.t. voltage.

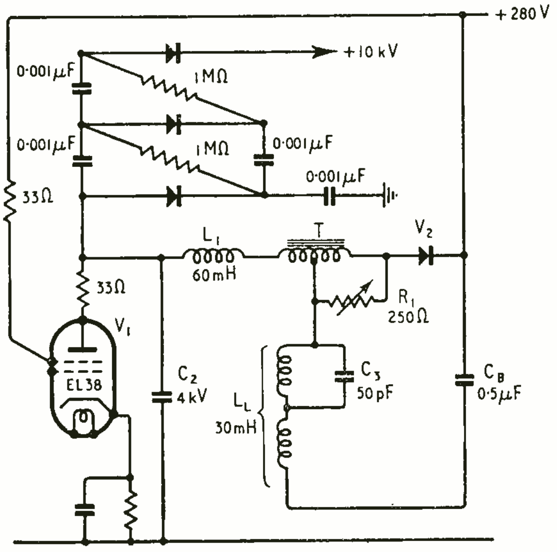


Fig. 5. Complete circuit of experimental line-scan stage.

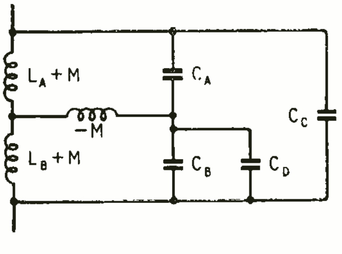


Fig. 6. Equivalent circui of a deflector coil.

L_1 can be any low-capacitance coil wound to withstand some 3 kV across it and up to some 4.5 kV to earth, while T can consist of 1,000 turns of No. 34 enamelled wire tapped at 250 turns from the V_2 end on a ¼-in stack of No. 74 laminations. The smaller part of the winding is in series with V_2. No special insulation is needed in the winding but the winding as a whole must be insulated to withstand at least 1.5 kV between itself and the core. Alternatively the whole transformer, including the core, can be insulated from the chassis. This is, in practice, the most convenient because the transformer needs acoustic insulation also and it is easy to provide both together by placing the transformer inside a block of sponge rubber under pressure. In any case, however, R_1 must as a whole be well insulated from the chassis.

Deflector-Coil Ringing

The capacitance C_3 across one-half of the deflector coil is necessary to prevent ringing in the deflector-coil assembly itself. The equivalent circuit of the assembly is shown in Fig. 6. The two inductances L_A and L_B together form the deflector coil and are equal, or nearly so, and have mutual inductance M between them. The capacitances C_A and C_B represent the self-capacitances of L_A and L_B and are roughly equal. C_C and C_D are the capacitances to earth of L_A and L_B.

In this circuit there are several possible modes of resonance and the troublesome one is when L_A and C_A together are inductive and come into series resonance with a capacitive L_B and $C_B + C_D$. The circuit rings in this mode to produce a series of vertical light and dark stripes on the picture towards the left-hand side.

The effect is not peculiar to this circuit but occurs with any lightly-damped deflector coil. A simple remedy is to increase the capacitance across the non-earthy coil of the pair so that the parallel resonance frequencies of the two circuits, considered independently, are the same. The series mode then disappears. The capacitance for complete avoidance of visible ringing is quite critical; however, a fixed capacitance will usually remove it sufficiently for it not to be detectable save on a blank raster. This is usually sufficient and in view of the voltage (750 V) it is not always convenient to use an adjustable capacitor.

The capacitance C_2 in Fig. 5 can be used as a width control if it is made variable. Its mechanical form is a little troublesome since it must withstand at least 4.5 kV. An air-dielectric capacitor becomes very large physically and for practical convenience a solid dielectric is desirable. However, it is difficult to make a solid-dielectric variable capacitor which does not have, in some degree, an air gap between the plates and the solid dielectric. If there is such a gap a discharge occurs across it. In the writer's experience, therefore, it is better to make C_2 fixed and to control picture width in some other way, such as, by varying the saw-tooth drive to V_1.

This capacitance C_2 can then be mainly the valve capacitance, but it does need some 5-10 pF extra. It is best obtained with an air dielectric using about $\frac{3}{16}$-in spacing of the plates. Provided that it is not too small, it can be fixed and the amount of overshoot can be controlled by varying the rate of cut off of V_1. This can be done by including a 10-kΩ variable resistor in series with the charging capacitor of the saw-tooth voltage generator (not shown in Fig. 5).

This circuit has proved very satisfactory in use and gives ample output to scan a 53° tube operating at

10 kV with a deflector-coil assembly having an LI^2 figure of 1.4 mH-A^2 (this is for an MW 22-7 tube at 5 kV, see "Deflector-Coil Characteristics," *Wireless World*, March, April and May 1950). It has also proved to be non-critical in adjustment and consistent in performance.

Under typical conditions with an EL38 valve and a 280-V h.t. line the mean anode current was 73 mA and the boost voltage was 60 V while the e.h.t. supply was 9.8 kV at 100 μA.

The deflector coil must be designed to withstand up to 1.5 kV on fly-back. So far, the writer has had no difficulty from this and no coil has yet broken down from this cause.

LETTERS TO THE EDITOR

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

"*Restrictive Practices*"

IN the leading article of the June *Wireless World* you suggest that the General Post Office, by licensing the television-to-schools transmissions, has shown signs of a more liberal attitude towards non-broadcast applications of television. Would that I could agree with your argument in support of that view!

As I see it, you underestimate the monopolistic powers granted under the Wireless Telegraphy Act to the Postmaster-General. His only real obligation is to keep within the framework of the International Convention to which this country is a party. According to my reading of the Radio Regulations annexed to the 1947 Convention, the P.M.G. did not need to "take his courage in both hands" before licensing the schools transmitter, which could come into the category of either a "Special Service" or "Experimental" station. Licences for cinema television transmitters, or, for that matter, for any likely non-broadcast uses of television, would readily fall into the same categories.

London, S.W.1. C. R. HUGHES.

V.H.F. Broadcasting

HAVING also recently returned from a visit to the U.S.A., I can in general confirm the comments of J. R. Brinkley in your July issue. To the average American "f.m." and "v.h.f." broadcasting are, of course, synonymous. So far as we in England are concerned, however, there are two aspects: the pros and cons of (1) v.h.f. broadcasting and (2) of the system of modulation, and we should not tend to confuse the issues. I propose to air my views on (1) only.

In a country where there is established a generally satisfactory medium-wave broadcast service, v.h.f. broadcasting only offers to the man-in-the-street the advantage of high fidelity (but only at considerably increased cost). We all know how few can be persuaded to take an interest in high fidelity—give them a simple tone control on an ordinary broadcast receiver, and nine out of ten will wipe off what high frequency response the receiver has! They prefer the "woomf."

So far as minority areas are concerned; that is, those not adequately covered by the existing medium-wave service, v.h.f. can be looked upon as a valuable supplement in providing interference-free channels. In my opinion, only in these areas would limited B.B.C. expenditure on new stations be warranted.

There is no doubt that in a few years television will be of prime interest and will hold a greater public than sound broadcasting, which will gradually take a back seat.

This fact should also not be overlooked—it is happening in U.S.A. already—and therefore, large-scale B.B.C. expenditure should be on television development.

If it came to a choice, those areas poorly served by the present sound broadcasting service would, I think, rather have a good television service than merely v.h.f. broadcasting.

The case would be different if we were just setting up a sound broadcast service; I would then be all for v.h.f., but it would now seem rather late in the day to be thinking about it.

Liverpool. D. W. HEIGHTMAN.

Thorn Needles

S. KELLY'S article in your June issue provides welcome data on the performance of thorn needles. May I suggest, however, that insufficient damping of the pickup itself may have been responsible for the excessively pronounced peaks in the high-frequency response?

I have made similar tests using a well-known commercial lightweight pickup specifically designed for use with thorns; normally this pickup has no tendency to excessive resonances within the limits of Decca test record K1804, regardless of needle length. When in a particularly undamped state, however, due to the magnet having been momentarily removed from the polepieces, resonances of up to 10 db in amplitude have been plotted between 6 and 9 kc/s, depending upon stylus length and thickness.

While agreeing with Mr. Kelly about the disadvantages of thorns, I hope that he does not seriously challenge their one great advantage, namely their kindness to valuable discs. It is this alone that induces me, and, I believe, a great many others, to adhere to them in spite of the extra trouble involved. It is conceded, however, that there is much room for improvement in the durability of the material used in their manufacture.

Stevenage, Herts. BERNARD DRIVER.

Too Many "Recording Characteristics"?

IT is generally assumed that three different characteristics are currently used for 78-r.p.m. domestic gramophone recordings: (a) the E.M.I. (English Columbia, H.M.V. and Parlophone records) which has a level treble frequency response; (b) the English Decca *ffrr*, which pre-emphasizes the treble in the order of 3 db per octave as from 3,000 c/s; and (c) the American N.B.A. characteristic, which pre-emphasizes the treble at approximately 5 db per octave as from about 1,000 c/s.

Three different characteristics for 78-r.p.m. records—especially as there is now yet a fourth for 33⅓-r.p.m. long-playing records—is bad enough. It means that even to approach the ideal in reproduction, manufacturers need to provide their amplifiers with, in addition to a level response, two different compensations for 78-r.p.m. records alone.

But unfortunately that is not the end of the story. From bitter experience I am led to believe that certain American concerns (e.g., Capitol and many of the smaller companies whose records are also available here) are employing various characteristics which differ from any of those I have mentioned.

In fact, the whole position as regards recording characteristics is becoming chaotic; leaving amplifier makers at a complete loss to know how best to cope with the situation.

The solution to the problem would seem to be for all the recording companies to get together and agree on one single characteristic, or, if they cannot so agree, to use at the most two characteristics—the level treble and one pre-emphasized treble—and state the characteristic employed on the record labels.

The only way to get such a policy adopted would appear to be by calling public attention to the present miserable state of affairs.

Incidentally, pre-emphasis seems to be a mixed blessing anyway. Admitted that in the case of the familiar shellac disc it helps to attain a better signal/noise ratio. But at the same time it tends to magnify the effects of harmonic distortion, and surely a better way of reducing surface noise would be to use a level treble response and press on a more suitable stock (e.g., Vinylite), slightly more costly though this would be.

London, N.16. RUTH JACKSON.

Greenland Expedition

YOUR readers may be interested to know that the British North Greenland Expedition has been allocated the amateur radio call-sign of G3AAT/OX.

The station which will use c.w. and telephony in the 3.5, 7, 14, 21, 28 and 144 Mc/s bands, will be operated from either one of two fixed stations, one in the centre of the ice cap and the other adjacent to Britannia Lake. In addition it is possible that one of the weasel teams may use an Army 19 set.

The Signals Officer is Capt. J. S. Agar, Royal Signals, aided by C.R.E. H. Dean, R.N., and P.O. Tel. K. Taylor, R.N. The licencee of the call-sign is Instructor Lieutenant-Commander R. Brett-Knowles, R.N., who is also the assistant seismologist and navigator of the seismic weasel team.

We very much regret that it is entirely impossible at the present time to give any details of operating times, as these will depend on local conditions, such as power and operator availability. The Expedition is to be away for two years, however, and it should be possible for interested amateurs to contact us at some time during this period. Owing to absence of any mail facilities it is impossible to send QSL cards while the Expedition is in Greenland, but it is hoped that cards will be sent after the Expedition returns in 1954. Any cards for the Expedition should be addressed to BNGE, Queen Anne Mansions, London, S.W.1.

It may be recalled that G3AAT, when holding the only British Virgin Islands call-sign of KV4AAT, organized amateur communication during the riots in Grenada, B.W.I., in 1951 and also handled the communications from one of H.M.S. *Devonshire's* (Cadet Training Cruiser) long-distance cutter sailing cruises —Operation Bligh—from Barbados to St. Lucia.

M.V. *Tottan*, R. A. HAMILTON,
At Sea. Chief Scientist, BNGE.

"Valve Voltmeter Without Calibration Drift"

SINCE the publication of my letter under this heading in your April issue (p. 146) my attention has been drawn to another commercially produced instrument whose circuit diagram closely resembles my Fig. 4 in your January issue: the Model 23 pH Meter by Electronic Instruments, Ltd. Although the principle of operation and the results obtained differ considerably, the main framework of both circuits is a pair of balanced two-stage, negative feedback, direct-coupled amplifiers. I understand that a circuit of this type has been used by Electronic Instruments, Ltd., since as long ago as 1945, but as it had not been published my search did not find it. Although I developed my circuit quite independently, I made no claims for originality, being only too well aware of the risks of so doing! But it would be interesting to know whether anybody can, in fact, claim a prior arrangement combining the following properties:

(1) Input conductance less than 10^{-10} mho.

(2) Output resistance less than 5 ohms.

(3) Output voltage equal to input voltage within a fraction of 1 per cent, for any meter resistance from 300 ohms to infinity and up to 3 mA meter current.

(4) No significant change in calibration or zero setting on varying mains voltage 10 per cent or output valve characteristics 100 per cent, as described in the article.

Bromley, Kent. M. G. SCROGGIE.

"Re-designed Government Hearing Aid"

THIS article in your May issue has been read with interest.

As co-author of the article in *The Post Office Electrical Engineers' Journal*, January, 1952, may I draw your attention to Table 2 of that article and the figures of 0.57 mA and 2.5 mA for anode current consumption quoted in your article? The figures quoted are those for the *insert* aid with a 45-V h.t. battery and the *external* aid and conflict with actual improvements made, which in fact, for the insert aid, are 0.35 as against 0.40 mA.

You will see from the table that while it has been possible to effect improvements in the filament consumption for both external and insert type aids, in the case of anode current, improvement is effected only as regards the insert aid.

You may be interested to know that we ultimately hope to reduce the filament current to 25 mA and possibly 20 mA and in the case of the insert aid to reduce the present h.t. consumption of 0.35 mA with a 30-V battery to something like 0.22 mA with 18 V.

Appreciable improvement in the anode current of the external aid is also expected to be made.

London, N.W.2. C. J. CAMERON.

WORLD OF WIRELESS

National Training Scheme for Technicians ◆ Earls Court Show ◆ Large-screen Television ◆ B.B.C. Appointments

Technicians' Training

WITH a view to increasing the number of technicians in the industry, the R.I. Council has introduced a national scheme of training which, in addition to being beneficial to the industry in general, may also qualify trainees for deferment of military service. It has, therefore, been necessary to define a radio technician and it has been given in these terms: "a person who carries out in a responsible manner approved techniques which are either common knowledge amongst those who are technically expert in his branch of industry or specially prescribed by professional radio engineers. These techniques are not those of the craftsman, though they may involve manual skill; in many cases they include the skilled use of delicate and complicated instruments and may also require the intelligent and accurate use of approved methods of calculation. They involve practical experience of some limited branch of radio engineering combined with the ability to complete the details of a project using well-established practice." He must have received a technical education up to a standard at least, and preferably beyond, that of the ordinary National Certificate in Electrical Engineering.

Trainees must register with the R.I.C. at 16 and will be given progressive training (until 21) through workshops (not on repetition work) followed by a period in test departments and/or laboratories. They must also be released for a day a week for training in a recognized course at an educational centre.

Television Interference

INTERFERENCE on the sound (41.5 Mc/s) and vision (45.0 Mc/s) channels of the London television station, which was widely experienced in the southern and central parts of the country during the last few days of June, was mainly caused by a station thought to be Italian on 45.6 Mc/s, Stockholm on 41.615 Mc/s and by the Paris 441-line television service on 42 and 46 Mc/s.

The ionospheric measurements made at the D.S.I.R. station at Slough on 24th June show that Sporadic E, capable of reflecting frequencies of the order of 9 Mc/s at vertical incidence, was prevalent for several consecutive hours.

This would appear to account for the interference from Stockholm and Italy, for Sporadic E with highest reflected frequency of the order of 9 or 10 Mc/s at vertical incidence would be capable of propagating the Swedish and Italian signals over the distances between the transmitting stations and this country. The interference from Paris—which was mainly experienced along the south coast, but was also heard as far north as Newcastle—cannot, however, be accounted for in this way. Since, however, it has previously occurred along the south coast during periods of settled summer weather it is evidently due to meteorological conditions, propagation being by reflection or refraction from "layers" of air in the troposphere.

The Radio Show

SINCE the ballot was held for the allocation of stands at the National Radio Exhibition (Earls Court, 26th August-6th September) a number of additional applications for space have been made so that exhibitors now total 94.

26th August (11 a.m. to 6 p.m) is to be a private view day when admission will be by special invitation from the R.I.C., by Press ticket, dealers' season ticket or by paying 5s at the door, instead of the 2s 6d admission on subsequent days.

In our next issue we shall again include an illustrated, tabulated guide to the main exhibits at the show.

Amateur Licence Changes

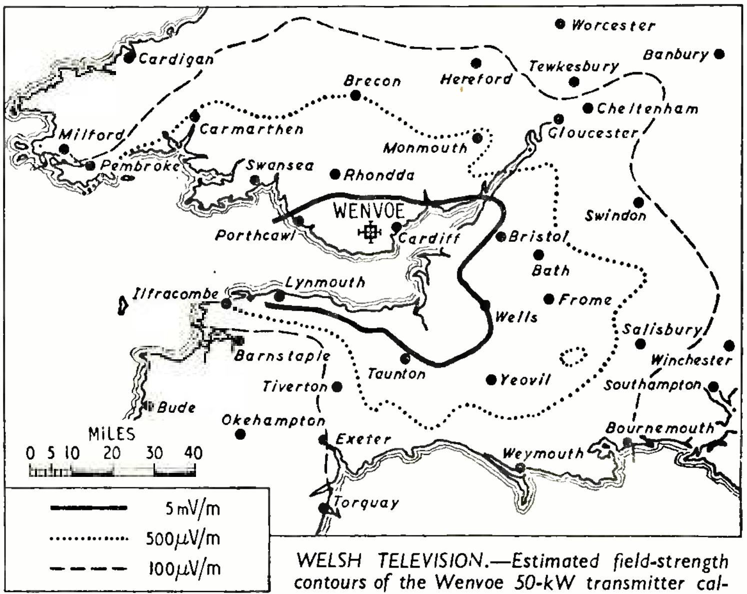
THE Post Office has decided to amend the licences under which amateurs are permitted to operate their stations at alternative addresses or under portable conditions.

"/A" and "/P" licences will continue to be available at a charge of 10s per annum, but the holder is now permitted to operate his station occasionally at an alternative address, or his portable station within 5 miles of any notified geographical location, for a period of 48 hours, provided that in both cases the Post Office Engineering Department has been notified in advance by registered letter or telegram of the location at which he intends to work. The use of a portable station on certain inland waters and lakes is also now permitted.

In addition, a new licence is now available at a charge of 10s which will permit an amateur to operate for a period of up to one month at a temporary address. This is designed to cater for amateurs who desire to operate their stations during annual holidays.

Cinema Television

LARGE-SCREEN television, using a screen 21ft by 16ft, was recently shown as part of each even-



WELSH TELEVISION.—Estimated field-strength contours of the Wenvoe 50-kW transmitter calculated from site tests. A 5-kW transmitter will, however, be used initially when the service opens on 15th August. Test transmissions are now being conducted each weekday from 11-12 and 3-4.

ing's programme during the first week's screening of "The Importance of Being Earnest" at the Odeon, Leicester Square, London. Using a closed circuit, members of the cast and mannequins wearing the costumes used in the film were interviewed and televised from an improvised studio beneath the auditorium.

Although the television picture was not as brilliant as the best film reproduction, the definition was excellent during close-ups and the general effect very pleasing.

A 625-line system is employed and the projection unit, which is remotely controlled from the normal film projection room, is located on the balcony where it is now permanently installed.

The screen, which is concave in the horizontal direction, was erected 8ft in front of the normal cinema screen in order to reduce the throw to within the limits of the optical system—52ft.

B.B.C. Engineering Appointments

WITH the retirement of Sir Noel Ashbridge from the position of B.B.C. Director of Technical Services, which he has held since 1947, Harold Bishop, who has been with the B.B.C. since 1923, is appointed to the post. He succeeded Sir Noel as chief engineer in 1943. Prior to joining the Corporation, Mr. Bishop was with Marconi's and worked on the original 2LO transmitter at Marconi House, London.

The new chief engineer is R. T. B. Wynn who, too, joined the Corporation from the Marconi Co. in 1926 as head of the technical correspondence department. He became assistant chief engineer in 1943 and deputy chief engineer in 1950.

F. C. McLean, who for the past year has been acting assistant chief engineer because of the illness of H. L. Kirke (asst. c.e.), is appointed deputy chief engineer. He joined the B.B.C. in 1936 from Standard Telephones & Cables.

(Left)
H. BISHOP, C.B.E., B.Sc.

(Right)
R. T. B. WYNN, C.B.E., M.A.

I.E.E. Premiums

IN addition to the ten Radio Section Premiums awarded by the I.E.E. for papers read or accepted for reading during the 1951/52 session, four of the awards not confined to specific sections of the Institution have been given for papers on radio and allied subjects. The recipients and the title of the paper for which they received the award are :—

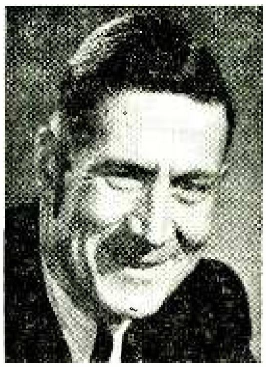
Duddell Premium (£20) to Drs. R. N. Bracewell, K. G. Budden, T. W. Straker, K. Weekes and J. A. Ratcliffe ("The Ionospheric Propagation of Low- and Very-Low-Frequency Radio Waves over Distances less than 1,000 km"); Ambrose Fleming (£10) to T. Kilvington, F. J. M. Laver and H. Stanesby ("The London-Birmingham Television Cable System"); Fahie (£10) to J. Bell, J. A. B. Davidson and E. T. A. Phillips ("Some Recent Developments in Phototelegraphy and Facsimile Transmission"); Heaviside (£10) to P. M. Woodward and I. L. Davies ("Information Theory and Inverse Probability in Telecommunication"); Webber (£10) to R. H. J. Cary ("A Survey of External and Suppressed Aircraft Aerials for Use in the High-Frequency Band" and "The Slot Aerial and its Application to Aircraft"); Oversea (£10) to G. Fuchs ("Reflections in a Co-axial Cable due to Impedance Irregularities"); Extra Premiums (£10) to Dr. A. T. Starr and T. H. Walker ("Micro-Wave Radio Links"); H. Grayson, T. S. McLeod, R. A. G. Dunkley and G. Dawson ("Circuit Technique in Frequency-Modulated Microwave Links"); G. King, L. Lewin, J. Lipinski and J. B. Setchfield ("Microwave Technique for Communication Links"); Dr. G. H. Metson, Dr. S. Wagener, M. F. Holmes and M. R. Child ("The Life of Oxide Cathodes in Modern Receiving Valves"); A. R. Boothroyd ("Design of Electric Wave Filters with the Aid of the Electrolytic Tank"); and Extra Premiums (£5) to Dr. E. C. Cherry ("A History of the Theory of Information"); W. J. Bray ("The Travelling-Wave Valve as a Microwave Phase Modulator and Frequency-Shifter"); and G. Millington ("The Effect of the Earth's Magnetic Field on Short-Wave Communication by the Ionosphere").

PERSONALITIES

Dr. C. J. Milner, M.A., F.Inst.P., who has been head of the physics section of the research laboratory of British Thomson-Houston Co., Rugby, since 1945, has been appointed to the Chair of Applied Physics at the New South Wales University of Technology, Sydney, Australia. Dr. Milner, who joined B.T.H. in 1936, was closely associated with the development of the klystron and magnetron. He is a Ph.D.

Dr. R. Jessel, B.Sc., F.Inst.P., A.M.I.E.E., the new chief of the Engineering Division of Electronic Tubes, Ltd. (the E.M.I. subsidiary), joined the Gramophone Co. in 1933 and in 1940 transferred to the company's c.r.t. department. For the past seven years he has not been in the radio or electronic industries.

E. C. Cherry, M.Sc.(Eng.), A.M.I.E.E., who was on the G.E.C. Research Staff from 1936-45, and after lecturing for two years at the Manchester College of Technology joined the staff of Imperial College of Science, London, has had the degree of D.Sc.(Eng.) conferred on him by the University of London. Dr. Cherry was appointed in 1949 to the City & Guilds Readership in Telecommunications endowed by Standard Telephones & Cables to provide post-graduate teaching and research in this field.



F. C. McLEAN, M.B.E., B.Sc.
(See "B.B.C. Appointments").

J. P. Broadbent has been appointed engineer-in-charge of the Wenvoe television station which is to be brought into service on 15th August. Joining the B.B.C. in 1931, he was at the Moorside Edge transmitter until 1935, when he went to Droitwich. During the past year or so he has been at the Midland and Northern television stations. At Holme Moss he was assistant e.-in-c.

Richards W. Cotton, who during the war was Controller of Signals (Communications) at the Ministry of Aircraft Production, has been appointed director of the Electronics Division and chairman of the Electronics Production Board of the American Defence Production Administration. He will be on leave of absence from the Philco Corp. where he is assistant to the president. A native of Massachusetts, he lived in this country from 1934-46 and was at one time chairman of British Rola. He is a director of Philco (Overseas), Ltd., London.

R. Davidson, author of "R.F. Characteristics of Capacitors" in this issue, graduated from University College, Southampton, with B.Sc. in physics in 1941. Served for five years in the Technical Signals Branch of the Royal Air Force, four of which were spent on the radar and signals planning staff of H.Q. Air Command S.E. Asia. In 1946 he joined Dubilier Condenser Co. as a senior development engineer, and for the past two years has been engaged mainly on research into radio and television interference suppression and on the development of components for use in this field.

H. F. Humphreys, who was at one time engineer-in-chief of the Droitwich transmitter and is at present on loan from the B.B.C. to the Hellenic Broadcasting Institute as technical adviser, has been appointed head of the Development Co-ordination Service of the Institute. The immediate development plans for broadcasting in Greece include a 150-kW m.w. transmitter at Athens, a 50-kW station at Corfu and four 5-kW stations.

G. A. Jackson has been appointed manager of the Spare Parts Division of E.M.I. Sales & Service. He joined the Marconiphone service section in 1923. During the war he was concerned with the servicing of electronic gear for the Services.

K. A. Russell, B.Sc., A.M.I.E.E., chief engineer of British Relay Wireless, Ltd., and its associated companies, has been elected president of the Society of Relay Engineers.

OBITUARY

Louis Pacent, president of the Pacent Engineering Corp. of New York, which he formed in 1933, died on 6th April at the age of 58. An amateur of the early 1900s, he was a prime mover in the original transatlantic amateur radio tests of 1921 organized by *Wireless World* and the American Radio Relay League. As we recorded last year, he was awarded the Marconi Memorial Medal of Achievement by the U.S. Veteran Wireless Operators' Association for his pioneer work in radio communication.

IN BRIEF

Royal Patronage.—Her Majesty the Queen has graciously granted her Patronage to the British Institution of Radio Engineers (of which King George VI became Patron in 1946) and the Electrical Industries Benevolent Association.

Birthday Honours.—In addition to those mentioned in the last issue as having been honoured by Her Majesty, Col. A. H. Read, director of Overseas Telecommunications, G.P.O., who was formerly G.P.O. Inspector of Wireless Telegraphy, became a C.B., and among the new Officers of the Order of the British Empire (O.B.E.) were T. H. Gill, senior radio engineer, No. 90 Group, R.A.F., Farnborough, and E. Grundy, manager of the Ferranti works at Moston, Lancs.

Receiving Licences.—There were over a million and a half television licences in force in the U.K. at the end of May when the total number of receiving licences (both sound and vision) was 12,691,000. The month's increase in television licences was about 36,000, bringing the total to 1,523,000.

Standardization of communications among member nations of the North Atlantic Treaty Organization was the main subject for discussion when representatives from seven other countries recently met the British Joint Communication Board in London. During the four-day visit the group of communication officers, including representatives from the U.S.A., France, Holland, Belgium, Norway, Greece and Italy, inspected a number of radio and cable installations. Rees Mace Marine, Ltd., took the visitors on a tour of the Port of London in their launch, *Radio Dolphin.*

Professional Recording.—A new topographical list of members of the Association of Professional Recording Studios, of which the Earl of Harewood is president, has been received from the general secretary, M. K. Howells, whose address is 14, Wynchgate, Harrow Weald, Middlesex.

The Telekinema on the South Bank was re-equipped with 625-line projection television gear by Cinema-Television for the recent International Dental Congress. By its use dentists were able to demonstrate to large gatherings of delegates their latest techniques.

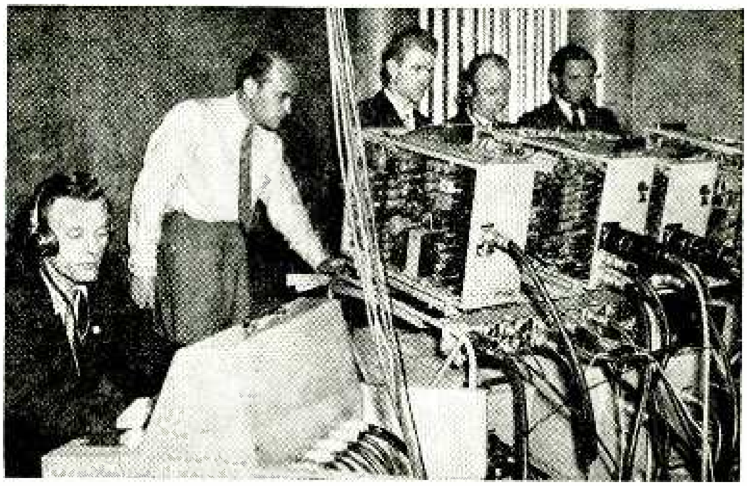
U.R.S.I.—The tenth general assembly of the International Scientific Radio Union, of which Sir Edward Appleton is president, will be held in Sydney, Australia, from 11th to 23rd August. This will be followed by a three-day meeting in Canberra of the Joint Commission on the Ionosphere.

Electronics Symposium.—The Scientific Instrument Manufacturers' Association is holding its fourth exhibition and symposium of papers at the Examination Hall, Queen Square, London, W.C.1, from 2nd to 5th September. Details of the programme, which includes papers on the use and development of electronic equipment for measuring, control and research, are obtainable from S.I.M.A., 20, Queen Anne Street, London, W.1, from whom tickets of admission may also be secured.

Marconi's have presented a "Seamew" radiotelephone transmitter-receiver to the *Centurion*, which is touring British ports to publicize the work of the Society for the Propagation of the Gospel in celebration of the 250th anniversary of the voyage of the original *Centurion* carrying the first missionary to go overseas for the society.

FROM ABROAD

German Exhibition.—The radio and television exhibition planned to be held in Dusseldorf from 22nd to 31st August, has been postponed until next year—27th February to 8th March.



CINEMA-TELEVISION.—Some of the equipment installed by Cinema-Television in the Odeon Cinema, Leicester Square, London, W.C.2, for the large-screen projection of television. E.M.I. 6-lens-turret cameras and associated equipment is employed in the studio.

American Radio Engineers.—A graph in the American I.R.E's annual report, giving the trend of membership since 1912, shows how steeply the curve has risen since the entry of the U.S.A. into the war. In 1941 the membership was a little over 6,000; at the end of last year it was 29,408.

French Television.—It is announced by Télévision Françaises that it will be adopting the C.B.S. frame-sequential system when colour is introduced for French viewers. Requiring a bandwidth of 8-10 Mc/s, it will readily be accommodated in the 14-Mc/s band used for the 819-line system. It is also planned to build six new transmitters at Strasbourg, Lyons, Marseilles, Bordeaux, Toulouse and probably Rennes.

India's Radio and Electronics Exhibition, originally planned by the Radio & Electronics Society to be held in Bombay in February, and subsequently postponed until November, has now been postponed indefinitely.

Canadian Television.—Test transmissions of fixed patterns started from Canada's first television station atop Mount Royal, Montreal, early in June on American Channel 2 (54-60 Mc/s). Initially a temporary 70ft mast was used but will be replaced by a 290ft structure.

Venezuelan Television Service will be provided by British equipment operating on 625 lines. Marconi's are supplying a 5-kW vision transmitter, 3-kW sound transmitter, aerial system and studio installation, together with a mobile outside broadcasting unit with radio relay links.

Hawaii's first television station, which will operate on Channel 4 (66-72 Mc/s), is to be erected in Honolulu by the Radio Corporation of America for a publishing company. The 10-kW transmitter is expected to be brought into service next February.

"Radio Communication," our Massachusetts contemporary, which was formerly published under the titles of *FM, FM Radio-Electronics* and *FM-TV* (which is still incorporated in its full title *FM-TV the Journal of Radio Communication*) now incorporates the Journal *TeleVision Engineering.*

British Gear for Yemen.—Equipment which will form the nucleus of the first permanent internal and external communication system in the Kingdom of Yemen—74,000 sq mile territory on the eastern shore of the Red Sea—has been ordered from Marconi's. The installation includes two 100-watt h.f. transmitters for internal services, 100-watt "Oceanspan" transmitter for communication with shipping in the Red Sea, and a 200-watt station for external working. Associated receivers are also being provided by Marconi's.

Export Enquiry.—Quotations in dollars (c.i.f.) for amplifiers, loudspeakers and record changers are wanted by Sight and Sound of 1320, Sixth Avenue, Seattle, Washington, who would be prepared to act as distributors for the eleven Western States. Offers should be sent direct to the company, but if copies are sent to the British Consulate-General, 1814, Exchange Building, Seattle, 4, Washington, it will enable the enquiry to be pursued.

TRAINING

Engineering Research Fellowships are to be awarded annually by B.T.H. to selected Honours graduates who are in their last year of apprenticeship with the company. The holder of a Fellowship will engage in engineering research for from one to three years at a university and/or at B.T.H. One of this year's recipients is P. C. McNeill who served during the war with R.E.M.E. and, when demobilized with the rank of captain, studied at Queen's University, Belfast. His research will be on secondary emission coefficients in magnetrons. The other recipient is P. H. G. Allen whose research will be concerned with heat flow in large transformers.

New Prospectus.—Full-time and part-time day courses in radio, radar and electronics are outlined in the Northern Polytechnic prospectus 1952/53, which also includes five evening courses embracing telecommunications engineering, radio and television servicing and electronics in industry. The prospectus is obtainable from the Northern Polytechnic, Holloway, London, N.7.

Amateur Radio Classes will again be held this autumn at the Wembley Hill Evening Institute (Middx) to prepare candidates for the C. & G. Radio Amateurs' Examination. They will be held on Mondays 7-10, the first hour being devoted to morse and the last two hours to theory. Enrolment will take place at Park Lane School, Park Lane, Wembley, Middx, each evening during the week 15th-19th September.

Radio Course for Teachers.—Another vacation course for teachers of radio and television has been arranged jointly by the Ministry of Education and the R.I. Council for the week beginning 8th September at the Borough Polytechnic, London, S.E.1. The programme includes, in addition to lectures on such diverse subjects as "The Servicing Examinations" and "Projection Television," visits to valve, receiver and component factories and B.B.C. studios.

BUSINESS NOTES

Baird.—It is proposed to change the name of Scophony-Baird, Ltd., to Baird Television, Ltd., at the extraordinary general meeting on 30th July.

R.G.D.—When the Automatic Telephone and Electric Co. took over the Radio Gramophone Development Co. twelve months ago it was stated that the subsidiary would be employed principally in meeting defence requirements for radio and associated equipment. It has now been decided to continue these operations at the Bridgnorth factory under the new name of A.T. & E. (Bridgnorth), Ltd. That part of R.G.D. concerned with the manufacture and sale of domestic radio and television gear has been taken over by William Harries, and the new Radio Gramophone Development Co. will operate from 3 and 4, Hampton Court Parade, East Molesey, Surrey (Tel.: Molesey 4357). Mr. Harries, the new chairman and managing director of R.G.D., holds similar positions at Regentone Products. A service depot is being maintained at 27, St. Mary's Street, Bridgnorth, Salop.

RADIO on the new cable ship "Stanley Angwin" which Cable & Wireless Ltd. put into service last month. She is to be stationed at Singapore. The Marconi equipment shown is (L to R) "Worldspan" and "Oceanspan" transmitters, "Reliance" standby transmitter, shortwave and m-l-wave receivers between which is the remote control for the aerial splitter installation. Radar and echo-sounding gear was supplied by Kelvin & Hughes. D. A. Sydenham is the Radio Officer.

Bush Radio, Ltd., announce that C. C. Moore has been appointed assistant managing director and H. C. Baker, W. T. Deuchrass, W. H. Harrison and G. P. Wickham Legg have become directors of the Company.

Marconi Marine.—A. E. H. Boaz, who entered the Marconi Co.'s service as a sea-going radio operator in 1917, and since 1930 has been at the Grimsby depot, latterly as deputy manager, has been appointed manager of the Falmouth depot.

Metals Division of the Telegraph Construction and Maintenance Co. is to move from the Telcon Works, Greenwich, to the satellite town of Crawley, Sussex, where a new factory for the production of the company's special alloys used in the electrical, radio and communications industries is to be built.

Ferguson transmitters and receivers to the value of $2,500,000 have been ordered by the United States Government for N.A.T.O. aircraft.

Foreign Vessels being equipped by the Marconi Marine Co. with radio communication equipment and navigational aids include the 16,500-ton Chilian tanker *Sonap*, built at Antwerp, and a 7,850-ton bauxite and oil-carrying vessel for a Canadian shipping company.

Reductions in the prices of H.M.V. and Marconiphone television and radio receivers, varying from £2 17s 6d to 65 gns. (including purchase tax) are announced by E.M.I.

E. K. Cole are to provide new v.h.f. ground-to-air communication equipment for the airport at Guernsey, Channel Islands.

Philips have recently installed sound-reproducing equipment at the Betteshanger and Chislet Collieries in Kent.

NEW ADDRESSES

R.C.E.E.A. Moves.—The Radio Communication and Electronic Engineering Association, one of the four constituent bodies of the R.I.C., has moved from 59, Russell Square, London, W.C.1, to 11, Green Street, London, W.1 (Tel.: Mayfair 7874/5).

G.R.S.E.—The new secretary of the Scottish Area of the Guild of Radio Service Engineers is J. F. Barrie, 2, Willowbrae Road, Edinburgh.

Furzehill Laboratories, of Boreham Wood, Herts, which was founded by J. H. Reyner, the well-known author and consultant in 1927, have opened a new laboratory and production unit at Cheltenham.

Addison Electric Co., makers of test and measuring instruments, have moved their offices and works to new premises at Bosworth Road, London, W.10 (Tel.: Ladbroke 4280). A showroom will be retained at the old premises at 163, Holland Park Avenue, London, W.11. (Tel.: Park 6760).

L. Glaser & Co., the instrument repairers, are now operating from 96-100, Aldersgate Street, London, E.C.1 (Tel.: Monarch 6822).

Stanley Sound and Vision Products are now at Lower Street, Haslemere, Surrey (Tel.: Haslemere 1426).

Whiteley Electrical Radio Co. advise us that their London showrooms at 109, Kingsway, W.C.2 (Tel.: Holborn 3074), are now open on Saturdays from 9 to 12.

Faulty Interlacing

(Concluded from p. 254 of the previous issue)

A New Sync Separator Circuit

By G. N. PATCHETT,* Ph.D., B.Sc., A.M.I.E.E., M.I.R.E., A.M.Brit.I.R.E.

CONTINUING the investigation, a thyratron time base as shown in Fig. 12 was next tried. When the time base was fed with ideal positive sync pulses from the pattern generator, interlace was found to be perfect and it was impossible to get the time base to run with partial or even complete lack of interlace. The time base was now fed from the same differentiating circuit and limiter as used for the blocking oscillator time base, but a phase reverser (with unity gain) was placed between the limiter and the time base in order to obtain the correct polarity (positive) pulse. It was found that failure to interlace was due to:

(1) Differences in the triggering instant as shown in Fig 13(a), where the time base is triggered by the trailing edge of two different half line frame pulses.

(2) Differences in the end of the frame pulse. This is shown in Fig 13(b) and (c), where the flyback is shown interlaced but owing to different pulses on odd and even frames, two scans are produced similar to those of the blocking oscillator. It is fairly easy to see how some of the sync pulse may be fed to the output in the case of the blocking oscillator, since there is a direct connection (through the transformer) from the anode to the output terminals. With the thyratron it is not so easy to see how the pulse is transferred from the grid to the anode circuit, since when the time base was not synchronized, the flyback was completed long before the end of the frame sync pulse period. No pulses could be detected in the output with either the h.t. or heater disconnected, so that the effect was not due to capacitance. The answer was found by applying the ideal pulse from the pattern generator and varying the amplitude. Fig. 13(d) shows the output at the end of the flyback with a small sync pulse, when the flyback is completed rapidly; Fig 13(e) shows the effect when a large sync pulse is applied, the pulse ending at X in both cases. It is now seen that the thyratron is maintained in a conducting state due to grid current, the pulse on the grid being sufficiently large to maintain an arc between grid and cathode and so prevent the current in the anode circuit from ceasing. In this way the pulses are transferred to the anode and the output circuit. The effect can be reduced by reducing the magnitude of the sync pulses to the valve to about the magnitude of the standing bias, but then the time base is more critical to correct frequency setting.

Although the differentiating circuit gives a pulse with a sharp leading edge this does not mean that it will produce a correctly interlaced picture and, as has been shown, careful adjustment of the time base frequency control and limiter is necessary. In practice these settings are unlikely to remain fixed over a period of time.

The next type of sync separator tried was the integrator circuit. As has already been mentioned the start of the pulse obtained from this circuit is different on odd and even frames. With a simple integrator feeding the blocking oscillator time base (on the grid) it was found that partial interlace

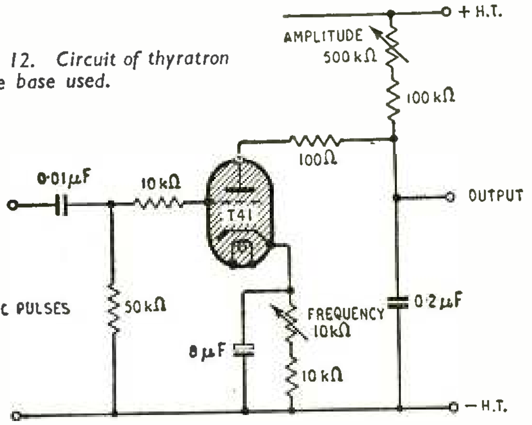


Fig. 12. Circuit of thyratron time base used.

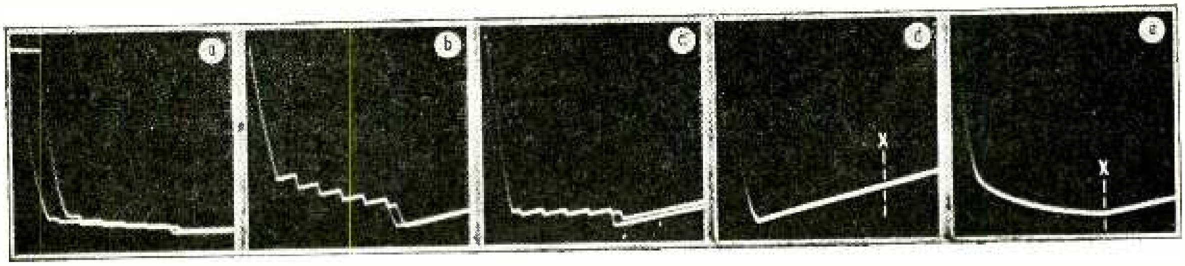


Fig. 13. Oscillograms during the flyback of the thyratron time base. (a), (b) and (c) synchronized from differentiating circuit, (d) and (e) synchronized from ideal pulse.

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* Bradford Technical College.

normally occurred and correct interlace could only be obtained with critical setting of the frequency control. The partial interlace occurred because of incorrect triggering of the time base, due to differences at the start of the pulse. As the frequency control is varied the voltage to cause triggering varies and the triggering point moves up and down the leading edge of the pulse. As can be seen from Fig. 8 the difference in the leading edges varies up the pulse, being worst on line AB and small on line CD, and hence the degree of interlace varies. This difference in the leading edge can be reduced to negligible proportions by obtaining a large pulse and using a small time constant so that a large rate of rise occurs. In order to remove the line pulses, which are also increased by a small time constant, a limiter is usually necessary.

The integrator was now followed by an amplifier limiter so as to remove the line pulses and obtain a pulse with identical leading edges on odd and even frames. The output from this circuit was negative and therefore fed to the anode of the blocking oscillator. It was still found that partial interlace was easily obtained and the reason is shown in the end-of-flyback oscillograms Fig. 14(a) and (b). It is seen that in (a) the interlace fails because of the differences in the end of the sync pulse on odd and even frames. In (b) the interlace presumably fails because of slight differences in the peaks of the pulse, causing the valve to cease conducting at different instants, on the two frames. The latter effect may be overcome by clipping the top of the pulse before applying it to the time base. It was found that much better interlacing could be obtained by following the integrator (with a large pulse output) by a double clipper (as developed by a well-known firm and used in many commercial sets) so that a small "slice" of the integrated pulse is used. The start of the pulse is shown on a large time scale in Fig. 15(a) and the end of the pulse in (b). Increasing the time constant of the integrator circuit by a factor of three gave the results shown in Fig. 15(c) and (d). The effect of increasing the time constant is to reduce the rate of rise at the start of the pulse and, in this case, to produce two distinct traces. The effect on the end of the pulse is, in this particular case, the opposite, owing to the selection of a different "slice" of the integrated pulse.

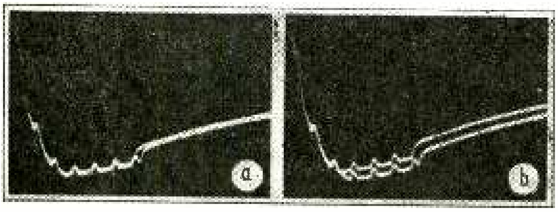
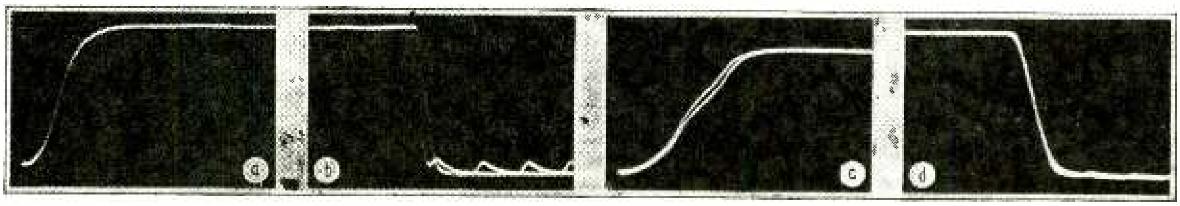


Fig. 14. Oscillograms of flyback of blocking oscillator when synchronized from integrator circuit.

Fig. 15. Pulse from integrator and double limiter. (a) and (c) start of pulse, (b) and (d) end of pulse, (c) and (d) with the time constant increased by a factor of three.



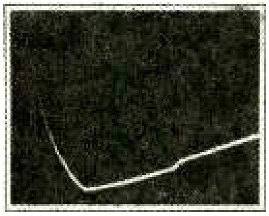
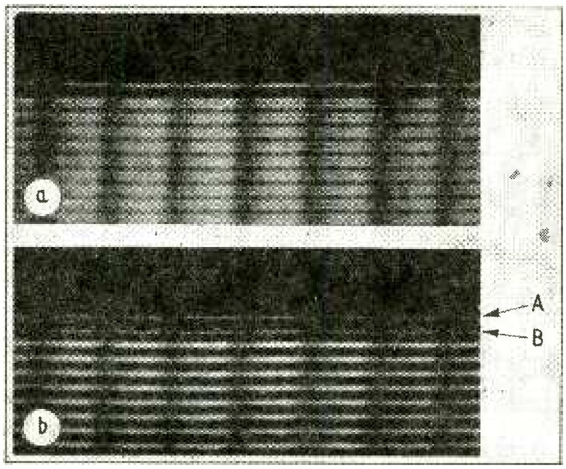


Fig. 16. Output waveform of blocking oscillator when synchronized on the anode from the pulse shown in Fig. 15.

Fig. 17. Photographs showing the displacement of one frame relative to the other.



From this it is obvious that the value of the time constant is rather important in relation to the remainder of the circuit. When the circuit was used to feed the grid of the blocking oscillator time base (with a positive pulse) interlacing was good, but when the pulse was reversed and fed to the anode (with the same amplitude) the result was not as good, but better than the other cricuits. Although no trace of the pulse could be seen on the output when the pulse was fed to the grid, a small "dent" on the scan waveform could be seen (Fig. 16) when the pulse was fed to the anode. This was not sufficient to be able to distinguish two scans (as shown, a difference of only 0.05 per cent is sufficient to upset the interlace) but was probably the cause of the interlace not being as good when the sync pulses were fed to the anode. Similar results were obtained using the thyratron time base, and with the double limiter good interlace was obtained. From this it is seen that the simple integrator circuit is not good, but when followed by amplification and double limiting satisfactory results can be obtained, provided care is taken in the design of the circuit.

It will be noted that in Figs. 11(e), 13(c) and 14(b) the differences in the scans are large, much larger than the half line necessary to cause normal lack of interlace. It was found that it was possible to obtain nearly perfect interlace, but with a line-and-a-half difference on odd and even frames, instead of half a line. This is shown in Fig. 17(a), which is the start of the horizontal white bar of a test pattern. It will be seen that one line of one of the frames is displaced by approximately one line from its correct position. Fig. 17(b) is another example, although not interlaced, showing a displacement of approximately two lines, the white lines of the odd and even frames being superimposed on all but the lines A and B. Although this is perhaps not very normal, it does occur with certain settings of the limiter and time base frequency control and is reasonably stable. The result is, of course, a lack of vertical definition.

Owing to the possible number of variations it is impossible to try all the combinations, since, as has been shown, whether a circuit interlaces correctly or not depends very much on the amplitudes and component values, as well as on the circuit itself. It is therefore difficult to say whether one circuit is better than another without exhaustive tests. The author has not tried these two sync separators on other time bases but it is felt that, in general, similar results would be obtained. The author has tried synchronizing various blocking-oscillator time bases, a multivibrator time base and a Miller integrator transitron time base with ideal pulses from the pattern generator and perfect interlace was obtained in all cases. It appears, therefore, that failure to interlace is due to the differences in the frame pulses from the sync separator and not in the time base itself. Cocking has stated* that he found difficulty in obtaining correct interlace from a Miller integrator and a blocking oscillator using a pentode with the discharge circuit in the anode. One circuit of the first type and two variations of the latter were tried and correct interlace was obtained when fed with ideal pulses.

In order to obtain correct interlace it would appear to be essential that the sync pulse obtained from the sync separator should:

(a) Have a sharp leading edge with a fixed time delay to the first frame pulse, this time delay being identical on both odd and even frames.

(b) Be identical in all respects on odd and even frames. The ideal pulse would be one of very short duration, say 10-20 microseconds, so that it would not affect the flyback of the time base. It is possible to obtain such a pulse by using a flip-flop circuit, but this is complicated and not really necessary so long as the above conditions are satisfied.

A circuit producing pulses which are identical on odd and even frames is shown in Fig. 18. This circuit is fed with negative going pulses so that V_1 is cut off during the pulse and C_1 discharges through R_1. Between pulses C_1 is charged to the full h.t. voltage. On line pulses C_1 only discharges a small amount and the cathode of V_2 does not fall below its anode potential and hence there is no output. During the longer frame pulses C_1 discharges further until V_2 becomes conducting, and the output then follows the potential of C_1 up to the end of the pulse. Fig. 19(a) shows the voltage across C_1 and (b) the output voltage obtained from this circuit when viewed on a 50-c/s time base. It will be seen that the output waveform is identical on odd and even frames but that the leading edges of the pulses are not sharp.

In view of the fact that the simple sync separator circuits leave much to be desired, the author set about to develop a circuit which would fulfil the above requirements and yet be simple and inexpensive. The circuit of the resulting sync separator is shown in Fig. 20, which operates on the Miller integrator principle. A negative going video signal (positive sync pulses) is fed to the suppressor grid through the capacitor C_1. The signal is d.c. restored by half of the double diode valve V_2 so that the whole waveform is negative, as shown. During the period between pulses

Fig. 18. Frame sync separator circuit.

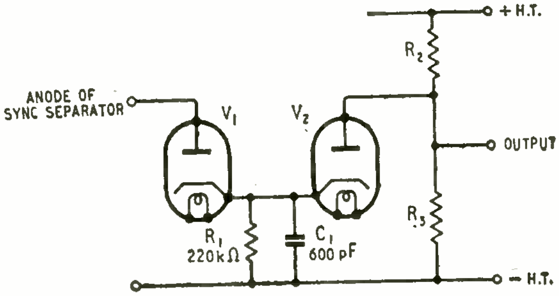


Fig. 19. (a) voltage across C_1 in Fig 18, (b) output voltage.

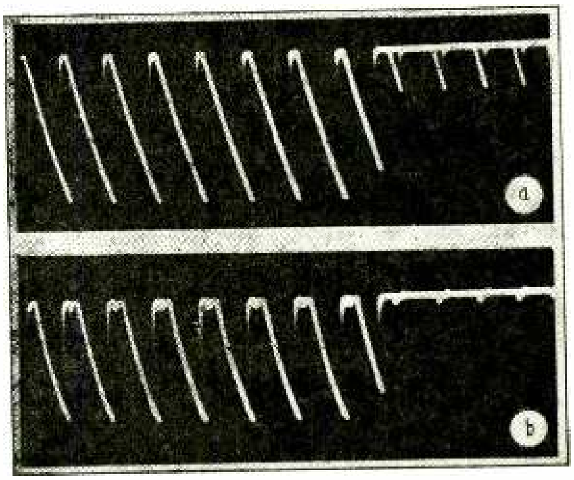
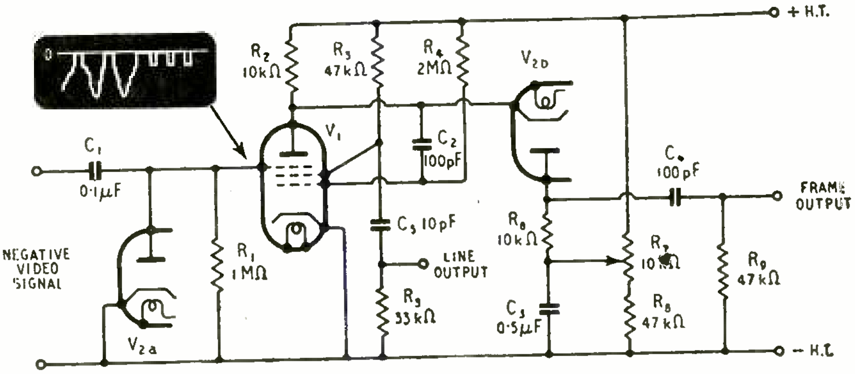


Fig. 20. Circuit of new sync separator. V_1 = 6F32 or 6F33, V_2 = D63 or similar.



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* *Wireless World*, April 1947, p. 124.

the suppressor grid is driven sufficiently negative to cut off the anode current, and the anode, therefore, rises to full h.t. potential and C$_2$ becomes charged to the full h.t. voltage by the flow of grid current. During a pulse the suppressor grid is at approximately zero potential and the anode conducts. As the anode current increases and its potential drops, it drives the control grid negative through the capacitor C$_2$, thus tending to reduce the anode current. An equilibrium condition is soon reached after an initial drop in anode potential. The capacitor C$_2$ then gradually discharges during the pulse through resistors R$_2$ and R$_1$, and the anode potential falls linearly owing to the Miller feedback action. At the end of the pulse the suppressor grid in driven beyond cut-off and C$_2$ recharges to full h.t. voltage. During the short line pulses the fall in anode potential is small, but during the longer frame pulses the fall is four times as great (neglecting the initial drop in anode potential).

Fig. 21(a) shows the waveform (on a 50-c/s time base) at the anode during the frame synchronizing period. The half of the double diode V$_{2(b)}$ is biased by R$_7$ and R$_8$ so that it only conducts on frame pulses. The resulting voltage across R$_6$ is shown in Fig. 21(b). This waveform is identical on odd and even frames but has no sharp leading edges. The waveform is now differentiated by C$_1$ and R$_9$, the result being shown in Fig. 21(c). During the slow fall in potential of the pulse across R$_6$, an approximately constant negative voltage is obtained on differentiating, but, on the sudden charge of C$_2$ at the end of the pulse, a sharp positive pulse is produced on differentiation. Fig. 21(d) shows the start of the frame synchronizing period on a larger time scale, where it will be noted that an exceedingly sharp leading edge results—so sharp that it fails to record on the oscillogram. It will also be seen that there is only one trace for odd and even frames. The leading edge of the first sharp pulse corresponds to the end of the first frame pulse and is, therefore, rigidly fixed in time relative to the start of the first frame pulse. Fig. 21(e) is the output at the end of the frame pulse period, again showing identical pulses for odd and even frames, the exposure for this oscillogram being 1 second on a 50-c/s time base. The output from this sync separator therefore fulfils the conditions set out earlier.

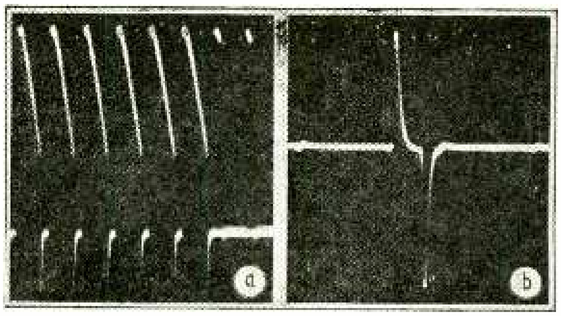


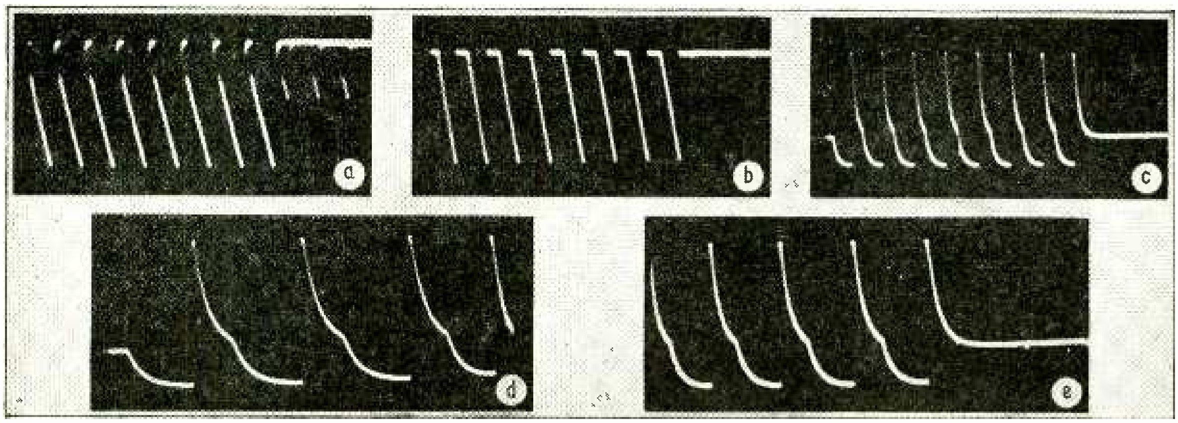
Fig. 22. Waveforms on new sync separator. (a) voltage on screen grid during frame pulse period (50-c/s time base). (b) voltage across R$_5$ (10-kc/s time base).

Since the control grid is driven negative during the pulse periods, an output is also available from the screen grid across the resistor R$_3$. This consists of positive pulses, and the screen grid voltage during the frame synchronizing period is shown in Fig. 22(a), where it is seen that pulses are produced with a sharp leading edge. Fig. 22(b) shows the output from the screen grid after differentiation by C$_5$ and R$_5$, the oscillogram being taken on a 10-kc/s time base. Again there is an excellent positive sync pulse.

Tests using this sync separator with a thyratron time base gave perfect interlace, and it was found impossible to get the time base to come out of perfect interlace. The same result was obtained when using a blocking oscillator time base. Fig. 23(a) shows a portion of Test Card C using this sync separator, where perfect interlace is seen. Fig. 23(b) shows a photograph of a portion of the screen during the morning transmission of the test film (not the Test Card C portion but the portion with moving pictures). This is a 3-*minute* exposure, so that no picture is obtained, but it shows the excellent interlace and rigidity of the line structure. Both photographs were taken on a commercial set (with the frame time base replaced with this sync separator and the thyratron time base) operating near the centre of a large city. Fig. 4(b) was taken with the same set, using the normal sync separator and line time base (consisting of an integrator—with double limiter—and blocking oscillator-time base) and 4(a) with the above sync separator and thyratron time base. These two photographs show the great reduction in line structure obtained by correct interlace.

Since the suppressor grid must be cut off between

Fig. 21. Waveforms of new sync separator. (a) anode voltage, (b) voltage across R$_6$, (c) output voltage, (d) output voltage at start of frame pulse period, (e) output voltage at end of frame pulse period. All on 50-c/s time base.



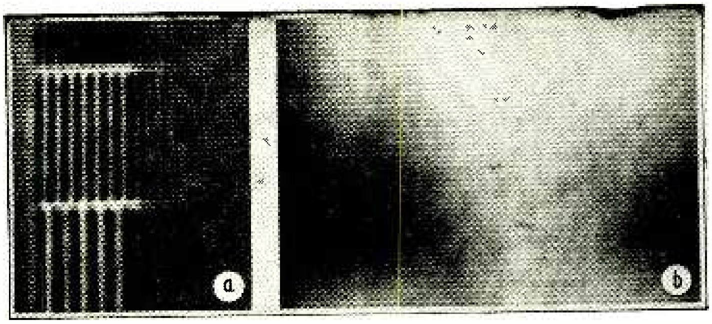


Fig. 23. *Photographs of portion of raster using new sync separator. (a) portion of Test Card C, (b) 3-minute exposure of moving picture.*

pulses the valve V_1 must be of the short-base suppressor grid type, such as a 6F32 or 6F33 (the 6F33 has an internal diode connected to the suppressor grid and the half diode $V_{2(a)}$ is not required). The author's tests were taken with a 6F32 (VR116), which is more readily available. With a 250-V h.t. supply the minimum value of the sync pulses for correct operation is about 6 volts peak-to-peak, and with 150-V h.t. about 3.5 volts peak-to-peak. The sync pulse amplitude available varies from set to set and, of course, with contrast, but the normal minimum value appears to be about 6 volts peak-to-peak. If the sync pulses are smaller the sync separator must be operated on the lower value of h.t. The magnitude of the sync pulses available is about 10 volts peak-to-peak for the frame and at least 15 volts peak-to-peak for the line (this depends on the capacitance loading the differentiating circuit and is difficult to measure accurately). These figures are for a 150-V h.t. supply and are increased for 250-V h.t.

Apart from the sync separator producing excellent interlace, it is very simple and uses few components. It must be remembered that it also separates the picture from the sync pulses (being fed with a video signal), whereas with the other circuits described the picture must be removed in a separate picture sync separator. Figs. 22 and 23 were all taken with the sync separator fed with a composite video signal. The circuit only requires two valves (one a double diode), five small capacitors and nine resistors of small wattage. Actually C_3 and R_6 may be omitted and the output taken from the tap on R_7 through C_1 and R_9 with only slight alteration in performance. R_9 and R_5 are also commonly part of the time base and should not really be included. A well-known integrator circuit with double limiting uses two valves (one pentode and half of a double triode), seven capacitors, ten resistors and one choke. The new sync separator therefore compares favourably and has no critical adjustment, the only adjustment being R_7, which, once set, should need no further attention. None of the component values is at all critical.

A sync separator of this type has now been in use over a period of several months, giving excellent results. It is impossible to see the lines on a 12-in tube when more than about two feet from the screen (much nearer than the tube would be viewed in practice), except occasionally on a moving picture when the two sets of lines *appear* to split up, as the eye follows a moving object. This difficulty is inherent in any interlaced picture and is nothing to do with failure of interlacing.

Although the sync separator does produce perfect interlace it must be remembered that the interlace can also be upset by line pulses injected directly into the frame time base circuit which have nothing to do with the sync separator. Reasonable care is therefore necessary in the layout and screening to prevent this. The effect did occur in one of the sets constructed using this sync separator, where the interlace was found to be good but not quite perfect. The trouble was cured by fitting a screen between the line output stage and the frame time base.

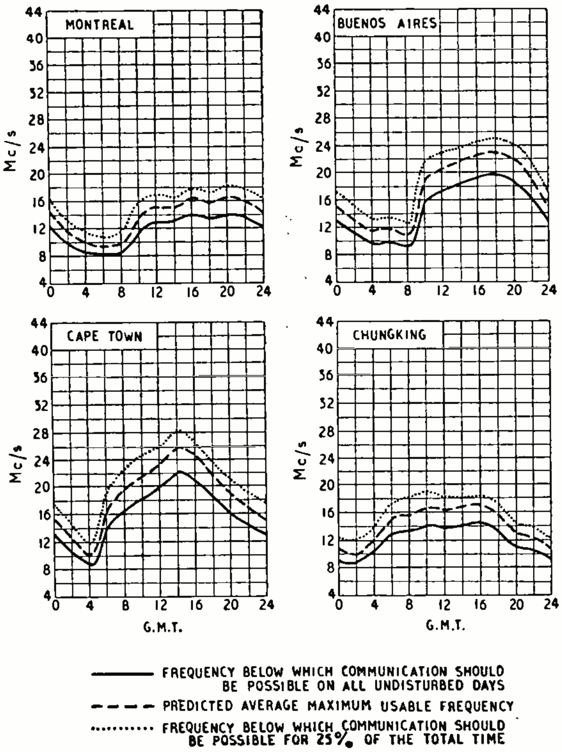
In view of the number of ways in which interlace may fail it is not surprising that few sets produce a perfectly interlaced picture. It is the opinion of the author that if really correct interlace were present on a greater number of sets, less would be said about the need for a greater number of lines with the attendant difficulties and increased costs. With a correctly interlaced picture it is quite impossible to see the lines of a 12-in tube from any normal viewing distance, but this is far from true when incorrect or no interlace occurs.

Short-wave Conditions

Predictions for August

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

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



DUPLICATING TAPE RECORDINGS

New U.S. System for Quantity Reproduction

By DONALD W. ALDOUS

MAGNETIC tape is used today for the original recording of nearly all new commercial discs, which are then produced by re-recording from the edited master tape. An obvious extension of this technique is the production of tape copies by means of a similar re-recording process.

For broadcasting, educational institutions, Services' applications, as well as supplying recorded tapes for domestic entertainment, has recently grown an important demand for mass tape duplication.

Attempts have been made to gang together one playback and many recording machines, but the results have been unsatisfactory. Additionally, loading and unloading times are excessive and, as normal tape speeds are often used, the output in finished tapes is too low for the method to operate as an economic proposition. Another system is a "printing" process in which a virgin tape and the master tape are rolled together in close contact at high speed through a special magnetic head, thus producing a facsimile of reasonable quality.

A radically different approach to this problem has been adopted in the last few months by Dr. Francis Rawdon Smith, formerly of Cambridge, England, now an engineer and designer of electronic devices in Washington, D.C., in collaboration with L. S. Toogood, of the Toogood Recording Company, Chicago.

A common mandrel, powered by a large, synchronous motor, is used to drive all the tapes involved, both master and slaves. This enables copies to be produced which are equal in length to the master, with an accuracy of better than one inch in 1,200 feet. Thus, with standard tape speeds, the accurate timing essential for broadcasting is solved.

"Multitape" duplicating machine being loaded by Dr. Rawdon Smith, one of the designers.

With this "Multitape" machine, shown in the accompanying illustration, forty half-hour tapes can be produced from one master in an hour, and these copies are virtually indistinguishable from the original.

Practical Requirements

The mechanical arrangements of this machine are due to L. S. Toogood, but many difficult electronic problems had to be solved by Dr. Rawdon Smith before the final "Multitape" machine could meet the stringent requirements of its co-designers. Examples of these problems are (a) the provision of bias for as many as twelve channels, necessitating an unusually high-powered bias source; (b) as it is desirable to run the tapes very fast, to increase production, special equalization is necessary; (c) the high tape speed necessitates a very high bias frequency, otherwise the recorded bias might fall in the audio range when the tape is played back at low speed; (d) this very high bias frequency also makes it necessary to use heads with extra thin laminations which, in turn, increases head wear unless special materials are used, and tape tension is low.

Still another problem in multiple tape duplication arises from the fact that not all playback heads on the diverse reproducing equipment used are always in perfect alignment. A novel design of head has been developed to reduce the sensitivity of the tape copies to playback head azimuth misalignment.

This highly specialized equipment has been exhaustively tested for fidelity of the duplicates to the original, for freedom from introduced harmonic distortion, and particularly for any increase in wow or flutter content in the copies. It is claimed that, with each channel in proper adjustment, copies are produced of such a standard that when *any* copy is spliced at the appropriate point to the master tape, it is impossible to detect the changeover, even on the highest fidelity channel.

"DECALS"

THE above expression seems to be the modern name for the once-popular "transfer," well known some two decades ago. In the form now produced by Alexander Equipment, Ltd., Child's Place, Earl's Court, London, S.W.5, the transfers provide a bold white lettering, ⅛in high, for marking control panels and the like.

The transfers are supplied as a book containing six pages totalling some 500 different markings and each page applies to a particular branch of radio or electronics. Page 1 covers communication, amateur radio and audio equipment; page 2 television and oscilloscopes; page 3 radar and pages 4, 5 and 6 industrial electronics and general purposes. Books cost 4s 9d each.

Series or Parallel?

Thoughts on the "Clapp" and Other Oscillator Circuits

By "CATHODE RAY"

SOME considerable while ago* I remarked on the possibility of dispute as to whether circuit elements are in series or in parallel. An example of this actually occurred recently. One eminent authority stated that in a valve oscillator the maintaining system (i.e., the valve and its appurtenances) always took the form of a shunt (parallel) circuit across the tuned system; and another eminent authority objected, holding that there were oscillators in which the maintaining system was in series with the tuned circuit.†

When originally discussing the general series-or-parallel question I said that what settled the matter was the position of the generator. Two circuit elements connected as in Fig. 1 could, if nothing more were known about them, be considered as either in series or in parallel with one another. But if a generator is connected as in Fig. 2(a) there is no doubt about L being in series with C; while in Fig. 2(b) they are equally clearly in parallel with one another. Now in a valve oscillator L and C are the tuned circuit or frequency-determining system, and the valve, etc., is the generator. So it comes to deciding whether the valve generator is connected as at (a) or at (b) in Fig. 2.

This looks as if it ought to be quite easy. In most oscillator circuits there is little or no doubt that Fig. 2(b) applies. But what about the so-called Clapp circuit, Fig. 3?** In this it looks as if L and C are in series with one another and with the maintaining system. But it all depends on where you draw the line between the maintaining system and the tuned circuit. Where do C_1 and C_2 come in? If they are parts of the valve system, there is no doubt about it being a series circuit.

But, if a series circuit, how does it work? Most valve oscillators are essentially amplifiers with positive feedback. The feedback circuit is so arranged that only at one frequency is sufficient signal fed back to keep oscillation going. That is the object of the tuned circuit—it is the part of the feedback system that is responsible for weeding out all but the desired frequency. Now there are two conditions that decide whether oscillations can be maintained. One is that the total amplification round the system must be at least 1. That is, if you start at any point, say the valve grid, and reckon right round, through the amplifier and the feedback connection, back to the same point, the voltage received there must be at least equal to what is being put in to cause it. If the valve has a voltage magnification (at the desired frequency) of 20, then at least one-twentieth of it has to be fed back to the input. The other requirement is that the fed-back voltage must be exactly in phase with the input. This double condition is really pretty obvious: if you break the feedback connection and drive the valve from some independent source which gives, say, 0.5V at a certain

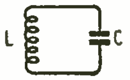
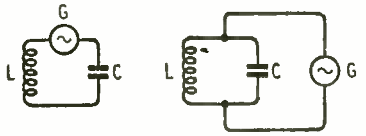


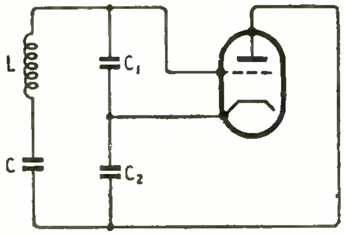
Fig.1



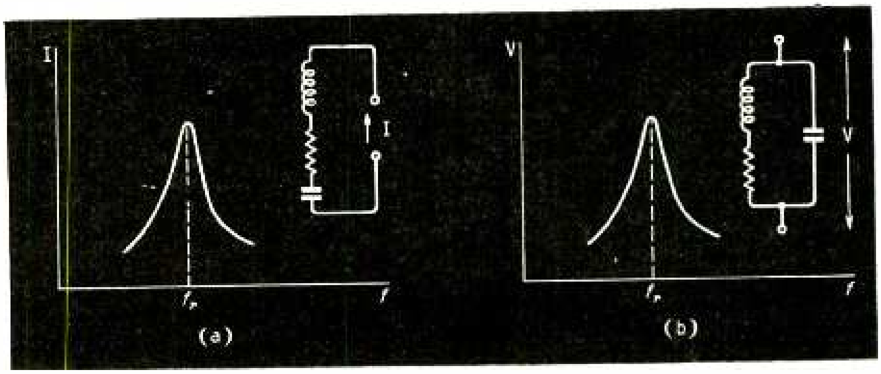
(a) Fig.2 (b)

Fig. 1. Are L and C in series or parallel ?

Fig. 2. The question in Fig. 1 is settled by the position of the voltage generator, G. In an oscillator, G is a valve circuit. Usually it is in parallel (b) ; can it ever be in series (a) ?



Right : Fig. 3. Essentials of the "Clapp" circuit. Details like d.c. supplies, which might distract attention, have been omitted.



Below : Fig 4. Comparison between (a) series and (b) parallel resonance. The frequency at which resonance takes place is denoted by fr.

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* "Conventions and Viewpoints," Sept., 1946.

† *Wireless Engineer*, Dec., 1951, p. 374.

** I say "so-called" because G. G. Gouriet, of the B.B.C., seems to have a much earlier claim to it. Hereinafter, "'Clapp' circuit" is to be taken as meaning "so-called Clapp circuit."

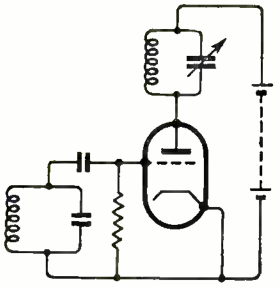


Fig. 5

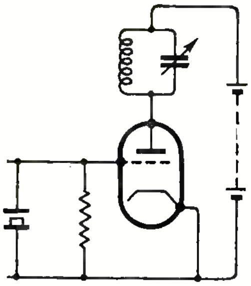


Fig. 6

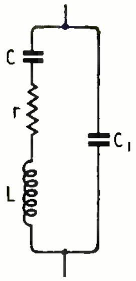


Fig. 7

Fig. 5. Tuned-anode tuned-grid oscillator circuit, where the tuning circuits are obviously parallel.

Fig. 6. Typical crystal-controlled oscillator circuit, which should be compared with Fig. 5.

Fig. 7. Electrical equivalent of the crystal in Fig. 6. L is very large, C is very small, and both are extremely constant. C_1 is much larger than C, but of the same order as valve and stray capacitances, so is much affected by them.

frequency, and the resulting signal at the end of the feedback circuit happens to be 0.5V, in phase with the input, then it would make no difference from the valve's point of view if the fed-back signal were substituted for the independent signal, but it would mean that the valve would be acting as its own generator.

Tuned-anode Tuned-grid Circuit

Since a valve is a voltage-operated device—the grid responds to voltage, not current—the feedback or tuning circuit must be devised to have a *voltage* maximum at the desired frequency. So a series tuned circuit, which has a *current* maximum (Fig. 4(a)) seems to be quite the wrong medicine. Surely it would tend to cause oscillation at any *but* the desired frequency! What is needed is a parallel tuned circuit (b), with its voltage maximum. The great majority of oscillator circuits clearly support this general theory. I need hardly show examples, but Fig. 5 (the well-known tuned-anode tuned-grid circuit) is one. The feedback circuit is perhaps not too obvious, since its essential link is mainly the anode-to-grid capacitance of the valve itself, but there is no doubt about its parallel tuned circuits.

I chose the t-a.t-g. circuit on purpose, because it emphasizes the great and baffling crystal mystery. It baffled me for a long time, thanks to the unhelpfulness of so many books purporting to deal with the subject. Fig. 6 is a typical crystal-controlled oscillator circuit, which looks the same as Fig. 5 except that the quartz crystal takes the place of the grid parallel tuned circuit. The mystery arises when one is informed that the electrical circuit equivalent to the crystal is as in Fig. 7—an extremely high-Q high-L/C *series* resonant circuit, in parallel with C_1, which is the parallel capacitance of the plates—a few pF—to which, of course, must be added the grid capacitance of the valve, and sundry strays. The mystery is really two-fold. First, how can a t-a.t-g. circuit work with a series tuned circuit in the grid? Especially a very high-Q circuit, such as the crystal is alleged to be; surely it would short-circuit the grid to earth at the resonant frequency? Secondly, having concluded that it cannot be a series circuit, but must be a parallel circuit tuned by C_1, how can one account for the phenomenal frequency stability of this oscillator, seeing that C_1 is very far from stable, and is affected by every change in the valve and wiring?

One must, I suppose, give the specialist books on quartz crystals the benefit of the doubt by assuming that somewhere among their hundreds of pages of mathematics could be found the answer, if one were good at finding needles in haystacks. Most of the books on radio in general, however, provide all the ingredients of the mystery by publishing Fig. 7, and then display a masterly but tantalizing restraint by withholding the explanation. No doubt one ought to be able to work it out for oneself (and that is what I had to do in the end), but what are authors paid for if not to save one the trouble ?

And again, what about "Clapp," whose tuned circuit bears an obvious similarity to Fig. 7, for its L and C preferably form a high-Q high-L/C circuit, with C_1 (and C_2) very much larger than C?

Well, first, the general-principle argument that because a valve is a voltage-operated device the tuned circuit must inevitably be one that gives a voltage resonance, that is to say a parallel circuit, doesn't hold water. A current peak can be converted into a voltage peak by passing the current (from the series tuned circuit) through an impedance. Reactance would affect the tuning, so let us call the impedance a resistance. Consider Fig. 8, for instance. The anode current of the valve flows through R_2, which is the output coupling resistance. Any alternating part of this anode current causes an alternating voltage across R_2, which, being in series with LC, produces a maximum current through LC when its frequency is f_r, the frequency of resonance. This a.c. causes a maximum voltage across R_1, and that voltage is applied to the grid. And does it cause oscillation at that frequency? No! At resonance, the impedance of LC is (theoretically) zero, so the alternating voltage at the grid must be the same as at the anode. But there is the usual phase reversal through the valve, between

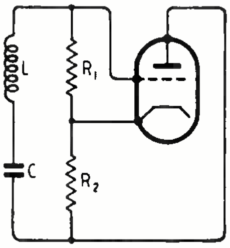


Fig. 8

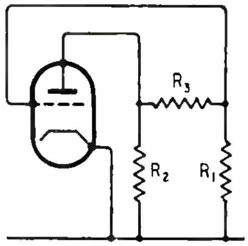


Fig. 9

Fig. 8. This attempt at a series-LC oscillator circuit breaks down for lack of phase reversal between anode and grid.

Fig. 9. Another way of drawing Fig. 8, showing the feedback circuit as a filter. At resonance L and C cancel out, leaving only a resistance (usually small), R_3.

grid and anode, so the fed-back voltage is opposite in phase to what is necessary for oscillation. Fig. 8 could be drawn in another way, showing the feedback circuit in conventional filter form (Fig. 9). In practice the impedance of LC at resonance is not entirely zero, but consists of the resistance of the coil, etc., shown here as R_3. So the feedback circuit (at f_r only, remember) is nothing more than a simple attenuator, giving no change of phase.

The necessary phase reversal to cause oscillation could be obtained by inserting a perfect transformer between R_1 and the grid (or between the anode and R_2). This is all right theoretically, but in practice a transformer, for r.f. at least, would be far from perfect, introducing so much reactance that it would have to be reckoned in with the tuning circuit.

Instead of a transformer one could use a second valve to get the phase reversal, as in Fig. 10. Maximum positive feedback would occur when the impedance between A and B was least, and purely resistive (i.e., no phase shift). This is exactly what happens at the series resonance of LC. The maintaining system, which is everything except LC, could be shut up in a box, with only the terminals AB for external connection. Connected in series with any reasonable series tuned circuit, it would generate oscillations at a frequency controlled by the L and C values of that circuit.

But again there is a practical snag, especially at high frequencies. The resistance coupling between the two valves is inevitably shunted by stray capacitive reactance (valve electrodes and so forth), which shifts the phase angle from zero. Since oscillation cannot take place unless the total phase shift right round the loop is zero, and there is an overall phase shift in the two-valve amplifier, what happens? Clearly, the zero-phase condition can only be fulfilled if the feedback-circuit (LC) has an equal and opposite phase shift. As we know, it is only exactly at resonance that it has zero phase shift. A rise in frequency (as we saw last month with our reactance sketches) makes LC equivalent to an inductance, which shifts the phase in one direction, and a fall in frequency makes LC equivalent to a capacitance, which shifts the phase the opposite direction. The lower the resistance of LC (i.e., the higher the Q), the smaller the frequency shift needed to bring about sufficient phase shift to cancel out the phase angle in the amplifier. So here we have an important conclusion—to minimize undesired frequency variation, use a high-Q tuned circuit. But however high the Q of LC, we cannot say that the frequency of the oscillator is controlled exclusively by the tuned circuit: it depends to some extent, even if only slightly, on stray capacitances and any other phase-shifting influences in the maintaining system.

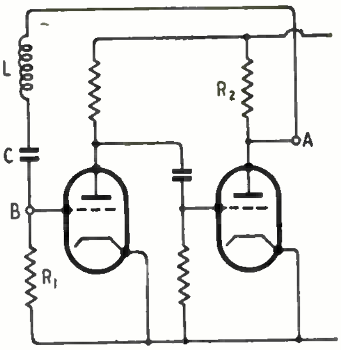
Seeing that even in practical apparatus one probably could, at least over a limited range of frequency, arrange for the influence of the amplifier to be very small, it may seem like hair-splitting to bring this into the discussion, presumably in order to deny this system the right to be called a series-tuned oscillator. Even if the amplifier phase shift wasn't quite zero, and LC had to work a shade off resonance, what of it?

Well, where precise maintainance of frequency is concerned, splitting hairs is none too delicate an operation—in fact it is comparatively clumsy. Unintended frequency variations of even one cycle in a million cause concern, and the specialists at the job are beginning to think about one in a thousand millions. It is no use taking immense care to keep L and C constant if the frequency depends also on a whole lot of rather indefinite and variable quantities in the amplifier. Any ordinary oscillator varies noticeably in frequency if the h.t. voltage drops, due, say, to a heavy load on the power station. It wouldn't do at all if the oscillators controlling the frequencies of broadcasting stations behaved like that. So, adjusting our mood to one of high scientific precision, we must face the fact that in general, owing to phase shifts in the maintaining amplifier, a feedback circuit such as LC in Fig. 10 is not worked exactly at resonance, and therefore it is equivalent to *either* a coil *or* a capacitor. Assuming the former, for example, we have, as shown in Fig. 11, the amplifier in a box, with the coil equivalent to LC connected to the terminals AB. The other part of the frequency-determining system must be inside the box and presumably equivalent to a capacitor. So our series-tuned oscillator is beginning to look like a parallel-tuned oscillator!

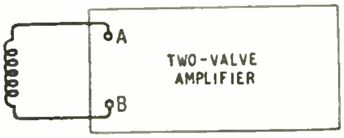
Off-tune Oscillation

This line of thought can be developed more instructively by going back from Fig. 10, which is not a very familiar type of oscillator circuit, to the "Clapp," Fig. 3. Its resemblance to Fig. 8 is obvious. And that may at first be rather puzzling, for you will remember that we found Fig. 8 couldn't possibly oscillate, because there was no phase reversal to cancel that of the single-valve amplifier. How can substituting C_1 C_2 for R_1 R_2 make so much difference?

And that, as Hamlet remarked, is the question. If the frequency of oscillation were the frequency to which LC was tuned, it couldn't. LC would be a low resistance, as in Fig. 9, and substituting C_1 C_2 for R_1 R_2 wouldn't shift the phase by anything like the required 180°. In short, if LC were in tune the "Clapp" oscillator couldn't possibly work. Since, however, it does work it follows that the frequency of oscillation must be different from the frequency to which LC is tuned, and that LC alone is not sufficient to determine the frequency. Clearly an oscillation frequency below LC resonance wouldn't do, as reference to the appropriate reactance sketch shows that LC would be capacitive, and a three-capacitance network wouldn't have a hope of shifting the phase 180°. But if you are *au fait* with filter theory, or can turn up my treatise thereon in the February, 1950, issue,



Left: Fig. 10. Here the necessary phase reversal is obtained by a second valve.



Right: Fig. 11. At frequencies above resonance LC in Fig 10 is equivalent to an inductance, so Fig 10 is equivalent to this.

Figs. 3 and 4, you will see that a simple low-pass section, as in Fig. 12 here, at its cut-off or resonant frequency shifts the phase 180°. And this is just what a "Clapp" circuit is, at frequencies above the resonance of its LC. If we redraw it back into its original (Fig. 3) form, we get Fig. 13, which we recognize at once as our old friend the Colpitts parallel-tuned oscillator circuit. L′ is the equivalent, at the frequency of oscillation, of LC in Fig. 3. When I say equivalent, I mean that you could calculate the impedance of the path LC in the "Clapp" circuit at the frequency of oscillation, find that it was an inductive reactance of a certain number of ohms, calculate the inductance needed to give that number of ohms at that frequency, wind a coil of that inductance, disconnect LC and substitute the new coil, and find that the oscillator would go on working at the same frequency as before.

Why, then, prefer Fig. 3 to Fig. 13? It needs an extra component, to say nothing of causing all this argument.

The answer is that L′ is equivalent to LC *only at the one particular frequency*. So although Fig. 13 is equivalent to Fig. 3 so long as the frequency remains exactly the same, the slightest change in frequency is enough to reveal the difference. LC doesn't behave as a constant inductance but as one whose value varies with frequency. It does so in such a way as to make any change in frequency less than it would be in the Fig. 13 circuit. This point calls for a little further explanation.

Advantage of the "Clapp"

The object of the "Clapp" circuit is to keep the frequency of oscillation as free as possible from the influence of the maintaining system. The idea is to determine it as much as possible by L and C, which are provided by components designed and constructed to be as constant and stable as possible; if necessary, kept at constant temperature in a thermostatically controlled box. In particular, the valve capacitances, which vary appreciably with the working voltages and currents, should be kept out of it. One way of minimizing the influence of a varying capacitance is to shunt it by a very much larger capacitance. If a 5-pF valve inter-electrode capacitance is liable to vary to the extent of 0.1pF, the variation is 2 per cent, which is serious. But if the 5pF is shunted by 5,000pF, the 0.1-pF variation is only 0.002 per cent of the whole. So the designer, in either Fig. 3 or Fig. 13, would tend to make C_1 and C_2 as large as possible. He would have another reason for doing so. If they were small, then the tuned circuit as a whole would have a high impedance, and, as it forms a coupling impedance, the valve's amplification would be much greater than was needed to maintain oscillation, and the oscillation would grow until the valve was very much over-driven, which would distort the waveform and increase variations in valve capacitances and consequently frequency. Still another adverse effect would be a considerable change in the equivalent shunt *resistance* of the valve, and (as is explained in treatises on resonance and equivalent series and parallel circuits) the frequency of a resonant circuit is affected by shunt resistance. So for all these reasons, C_1 and C_2 are made as large as they can be, subject to their reactance being sufficient to keep oscillation going at all. L′, for a given frequency, is, therefore, quite small. The L/C ratio, in other words, is as small as possible.

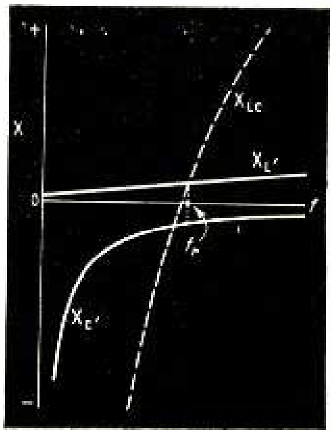


Fig. 14. Reactance sketches for L′ and C′ (equal to C_1 and C_2 in series) in Fig. 13, where C_1 and C_2 are preferably large, and L′ small, on the assumption that L′ is the inductance of a real coil and therefore constant. But if it is LC in Fig. 3, its reactance sketch is as X_{LC}, which has a much steeper slope.

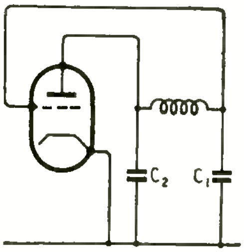


Fig 12

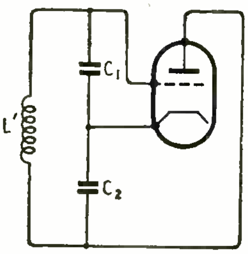


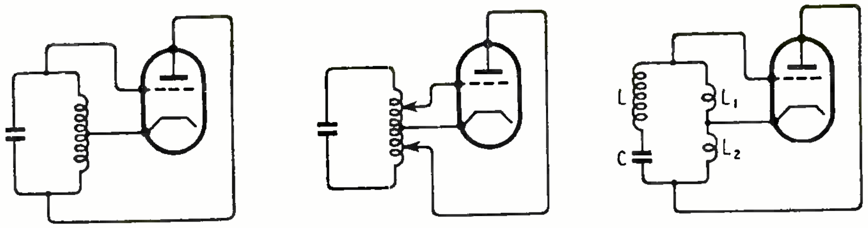
Fig. 13

Fig. 12. At the frequency of oscillation, necessarily above that of LC resonance, the "Clapp" circuit is equivalent to this, in which LC (inductive) and C_2 C_1 form a filter section giving the needed 180° phase shift.

Fig. 13. At the working frequency of Fig. 3, which is necessarily higher than the frequency at which LC resonates, the circuit is equivalent to this. L′ is normally very much smaller than L.

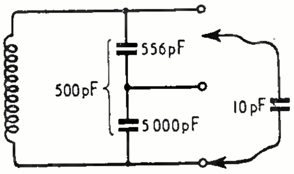
How the use of LC in place of L′ is beneficial is a nice little example of the reactance sketching I advocated last month. First, since the reactances of L′ and its opposite number (mainly C_1 and C_2 in series), which one could appropriately call C′, are relatively small, we must sketch their curves close to the frequency axis as in Fig 14. Their resonant frequency, at which they are equal and opposite, is marked f_r, and (if the value of C′ takes account of the valve impedance) is the frequency of oscillation. Now if C′ varies slightly due to changes in the maintaining system, this would be represented in Fig 14 by the $X_{C'}$ curve moving nearer or farther from 0. Suppose C′ increases; then $X_{C'}$ must be moved nearer 0, and in order to maintain equality of $X_{C'}$ and $X_{L'}$ the point f_r must slide along a little way to the left. This represents the slight drop in frequency caused by the increase in C′, and pictures the action of Fig 13.

Now let us compare the action of Fig 3. The reactance curve of a path consisting of L and C in series is obtained by adding together those for L and C separately. If X_L and X_C are made very much larger than $X_{L'}$ and $X_{C'}$, their separate curves, and consequently the X_{LC} curve, will be very steep, as shown dotted in Fig 14. Since LC is equivalent to L′ at f_r, its curve must coincide with the $X_{L'}$ line at that frequency. And now we see the difference between the Colpitts and "Clapp" circuits very clearly.



(a) (b) (c)

Fig. 15 (a) is the Hartley circuit in its simplest form ; (b) is a tapped-down variety, which can be redrawn as (c), for comparison with Figs. 3 and 8.



Right : Fig. 16. Showing how tapping 10pF across one tenth of the capacitive tuning reactance affects the resonance frequency one hundredth as much as when it is connected across the whole.

Even on the absurd supposition that C′ strayed right up to infinity, the most that the frequency of oscillation could change is represented by the little fragment of f axis between f_r and the point at which it is crossed by the X_{LC} curve. Below that, LC becomes capacitive. Since in any well-designed practical oscillator the biggest change in C′ would be a very small fraction of 1%, the change in frequency needed to bring X_{LC} again to equality would be ultra-microscopic. Hence the merit of the scheme. If at f_r the X_{LC} curve is 100 times steeper than the $X_{L'}$ and $X_{C'}$ curves (as can easily be), the frequency is 100 times as stable as the already quite good low-L/C Colpitts circuit from which it has been adapted.

In a crystal-controlled oscillator, L, the equivalent series inductance of the crystal, may be many *henries*, and C is only hundredths of a pF, so the L/C ratio is enormous, and the line is almost vertical. So it doesn't affect the frequency much even if C_1 (which, although small by ordinary standards, is vastly greater than C) varies widely. We have the curious paradox that although C_1 is the capacitive half of the parallel tuned circuit, the frequency depends very little on it and almost wholly on LC, simply because LC is equivalent to a wide range of inductance (to balance C_1) within an extremely small range of frequency. To a less extent this is true also of "Clapp" tuning.

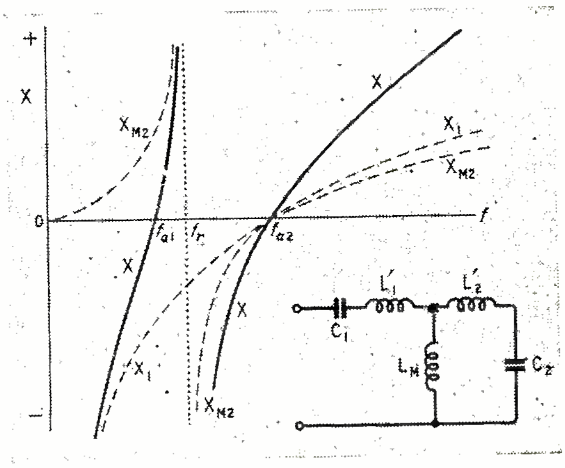
Summing up, one can say that the answer to the series-or-parallel question depends on how the tuned circuit is defined. If it is reckoned as the circuit that is in resonance at the frequency of oscillation, then the first eminent authority is right. If it is reckoned as the circuit that *mainly* decides the frequency of oscillation, regardless of whether it is in resonance or not, then the second is right. Note that the second view is necessarily an approximate one, for the series circuit doesn't exclusively determine the frequency—the parallel element has some say in the matter. But for any except very precise work the effect of the parallel element can, by good design, be made negligibly small. So for practical purposes the tuning is effected by a series circuit or its crystal equivalent. You can incline either one way or the other, according to whether you are theoretically or practically minded.

Personally I incline to look on the "Clapp" type of circuit as a tapped-down or loose-coupled Colpitts, and therefore a variety of conventional parallel tuning. It is well known that the simple Hartley circuit, Fig. 15(a). is improved if a high-Q tuning circuit has the maintaining valve tapped across only a part of it, as at (b). To emphasize the similarity to Figs. 3 and 8 we can redraw this as at (c). Fig. 13 is the simple Colpitts circuit, which differs from the Hartley only in having the cathode connected on the capacitance side instead of on the inductance side of the tuned circuit. "Clapp" is the tapped-down variety of Colpitts, corresponding to the Fig. 15(b) or (c) variety of Hartley. If a relatively small capacitance is tapped across one nth of a tuned circuit, either on the inductance or capacitance side, its effect is practically one (n^2)th of what it would be if tapped across the whole. Hence the benefit of tapping the maintaining valve across as small a fraction of the tuned circuit as will just do to maintain oscillation. In Fig. 16, for example, tapping 10pF across the whole tuned circuit adds 2% to the tuning capacitance and so alters the frequency by about 1%. Tapping it across one-tenth of the tuning reactance (5,000pF) alters the tuning capacitance by one hundredth of 2% and the frequency by only one hundredth of 1%, as you can check by calculation.

"REACTANCE SKETCHES"

Answer to "Cathode Ray's" Problem

This is the answer to last month's problem—to sketch the reactance curve of the circuit shown. Since C_1L_1' was made equal to $L_2'C_2$, both resonate as acceptors at the same frequency, f_{a2}. L_m resonates as a rejector with $L_2'C_2$ at f_r and as an acceptor with $L_1'C_1$ at f_{a1}. X_{m2} is the reactance of the $L_mL_2'C_2$ group, "translated" from the B curves in last month's Fig. 9 ; and X_1 is the reactance of C_1L_1' (or C_2L_2') alone, which added to X_{m2} gives the reactance of the whole circuit, X.



30 Years of Broadcast Engineering

Retirement of Sir Noel Ashbridge

WHICHEVER way one looks at it, control of the technical side of the B.B.C. is a big job—the biggest of its kind in the world, as the Corporation undoubtedly radiates more kilowatt-hours per day than any other broadcasting system. The job of Sir Noel Ashbridge, who has just retired from his post as Director of Technical Services of the B.B.C., has been truly a notable one. He has been concerned with broadcasting from the start, and for over a quarter of a century has held positions of high responsibility.

Sir Noel's entry into wireless was unspectacular; indeed, casual and haphazard. After taking his B.Sc. in engineering in 1911 he entered the "heavy" side of the industry, and showed little more interest in wireless communication than most other young engineers of the period. But, when he joined the infantry early in the 1914-1918 war, there was a call for volunteers who "knew something about wireless." Among those who took the traditional one pace forward was Private Ashbridge — a highly significant step, as it turned out.

At the end of the war Ashbridge returned to the heavy side of electrical engineering for a year before transferring in 1920 to Marconi's Wireless Telegraph Company, where he turned his wartime experience to account in designing field-station equipment. Shortly after joining Marconi's he moved to the experimental station at Writtle, then in charge of P. P. Eckersley, where, early in 1921, he made his first acquaintance with broadcasting during the weekly experimental transmissions from that station. Later jobs included receiver designing, including the earliest broadcast sets. When Eckersley left to become chief engineer of the British Broadcasting Company, Ashbridge was promoted to engineer-in-charge of the Writtle establishment, remaining there until he left to become Assistant Chief Engineer of the B.B.C. in 1926.

These were the great days of broadcast engineering, marked by the change from scattered 1kW transmitters to the Regional scheme that foreshadowed the present chain of high-power medium-wave stations. This was real engineering, and Ashbridge came into his own, first as assistant to Eckersley, who conceived the Regional idea, and then, three years later, as Chief Engineer of the Corporation. Decisions were made during this period that still affect the whole pattern of the B.B.C. Home and Overseas services. The honour of knighthood, conferred in 1935, came as a fitting tribute to the consolidation of the B.B.C.'s basic structure. But Sir Noel, though described by a senior member of his staff as "a pessimist, like all good engineers," never suffered from excessive conservatism, and was soon to make the difficult decisions leading to the establishment of the world's first public television service.

The rest of Sir Noel's career is fresh in the memory of most of us. Landmarks are his appointment as Deputy Director-General of the B.B.C. (1943-1947) and Director of Technical Services from 1948. He was elected President of the I.E.E. in 1941-2.

Just before Sir Noel left Broadcasting House, *Wireless World* tried to extract from him his views on the future of British broadcasting. We should have known better; he is, first and last, an engineer, and prophecy is none of his business. But he did commit himself to saying that for the B.B.C. even to maintain its present standards of coverage in the face of increasing interference the use of v.h.f. transmission is essential as a supplement to the present system. He believes the Wrotham a.m./f.m. experiment proves conclusively that frequency modulation is the right method for such a purpose.

Television is considered by Sir Noel as one of the greatest achievements of radio, and one guesses that this branch of broadcasting is very near to his heart. He believes this country has lost nothing by choosing the 405-line standards, and, on the next stage of development, thinks we shall have a colour system "compatible" with the present one, but that a *de luxe* colour service in parallel is not out of the question.

"Should a radio engineer be a physicist with a leaning towards engineering, or an engineer with a leaning towards physics?" Sir Noel refused to be drawn on this controversial point, and rightly points out that one of the things we have learned of recent years is team work. There is plenty to do for both engineers and physicists. On the training of engineers, he stresses the importance of early factory experience, and regards the present tendency towards specialization as more or less inevitable, but undesirable if allowed to go to extreme lengths.

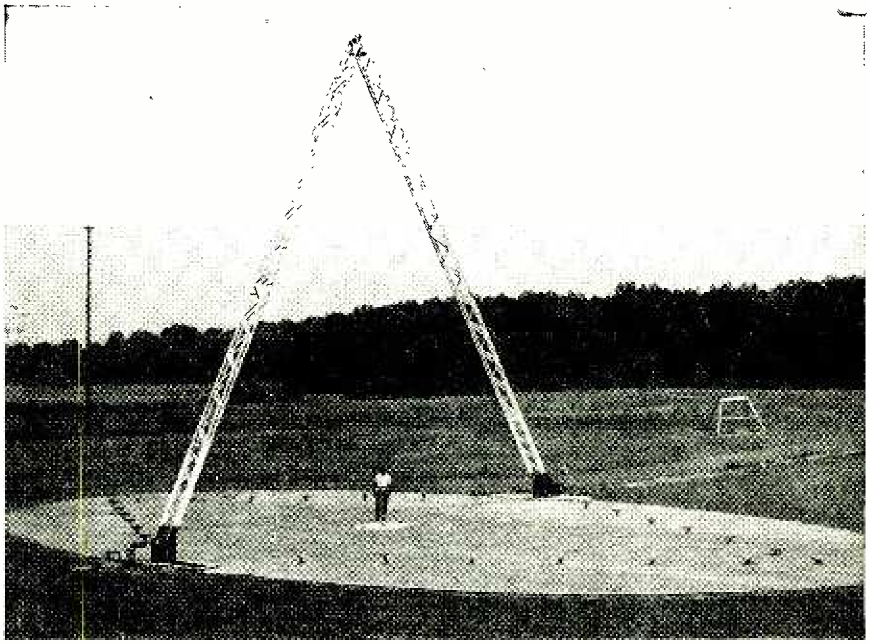
One feels, with a touch of sadness, that Sir Noel's departure from Broadcasting House marks the end of an epoch. But ability to keep his feet on the ground is his outstanding characteristic, and he would certainly not subscribe to the idea that the present time marks any particular stage in broadcast development. Doubtless he would say the engineering side is still passing through a steady process of growth, and would never mention his own contributions. Our readers will join with us in wishing him all good fortune.

Testing Aerials

Actual Conditions Simulated by Scaled-Down Aerials and Centimetre Waves

By

MICHAEL LORANT



Full view of model aerial range with target transmitter raised to the 90-deg position.

THE U.S. National Bureau of Standards has recently completed a new model aerial range to facilitate the measurement of radiation patterns in the vertical plane. The range is believed to be the largest ever designed for this purpose and is composed of an inverted "V" type structure which supports a test or target transmitter more than 50 feet above a ground plane, in the centre of which is placed the scaled-down aerial to be tested. The model techniques employed in this type of installation are being applied to investigation of the behaviour of high-frequency aerial systems used in ionosphere-sounding equipment.

The investigations are particularly concerned with the long range band from 3 to 30 Mc/s. At these frequencies the wavelength varies between roughly 300 and 30 ft; consequently measurements of full sized aerials would require a site several thousand feet long. This presents a problem when merely ground plane radiation patterns are desired; but, when the pattern in a vertical plane is required, the problem becomes even more complex. Some investigators have utilized free-flight balloons and aircraft to carry the test or target transmitter aloft, but the results have been only partially satisfactory. The new model range was set up to provide a more reliable means for such studies.

Principles of Operation

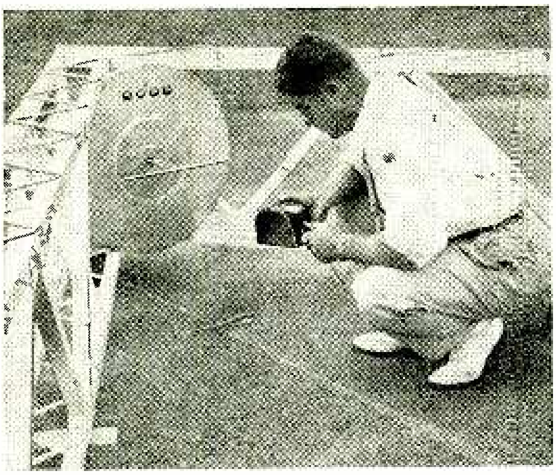
The model techniques employed are similar in many ways to those used in the investigation of mechanical, hydraulic, and aero-dynamic structures. The principle is known as electrodynamic similitude. As applied to an aerial, an equivalent performance is obtained from a model $\frac{1}{n}$th as large as the original if its operating frequency is made n times the prototype frequency. As the model frequency is increased, the free-space wavelength is decreased proportionately, and the distance between the transmitting and the receiving aerials can then be reduced by the same scaling factor n. Thus it becomes possible, by using a sufficiently large scaling factor, to mount a target transmitter on a rigid structure, to move it over and about the model aerial under test, and to obtain radiation patterns substantially the same as the true long-distance radiation patterns of a full-scale aerial. The term "radiation pattern" is used here synonymously with the receiving pattern of the aerial.

The measurement of aerial radiation patterns are very complex, especially when the system is intended for long-distance operation. Several restrictive problems must be overcome before actual transmitting conditions can be simulated. For example, the wavefront intercepted by the aerial to be tested must be essentially plane, and the phase relationship of the voltages induced in it must appear as though the wave had originated at a distance large compared to the size of the aerial. Also, a separation of at least several wavelengths must exist between the target transmitter and the test aerial in order to minimize the surface wave component of the radiated fields.

Scaling Factor

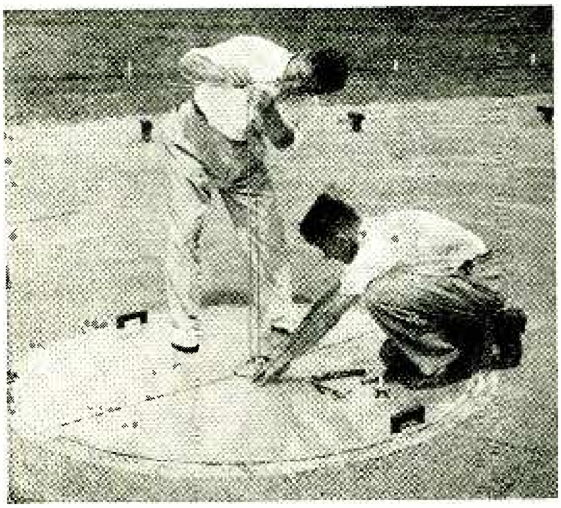
In recognition of these restrictions, a scaling factor of 60 ($n=60$) is employed in many of the applications. Thus, a prototype frequency between 1 and 25 Mc/s is represented by model transmitter frequencies between 60 and 1,500 Mc/s. At these frequencies it is comparatively easy to arrange a model transmitting-receiving system so that it satisfies both of the previously mentioned limitations.

In addition to dividing the physical dimensions of the model by the scaling factor n, and multiplying the frequency by the same factor, it is necessary to multiply the conductivity of the aerial and the earth by n. Fortunately, in most practical h.f. aerials the copper losses are small, and the conductivity effects may be ignored without introducing any serious error. On the other hand, in considering earth conductivity certain factors must be recognized; in a given location the conductivity as well as the dielectric con-



Checking the operating frequency of a target transmitter. The working frequency is between 60 and 1,500 Mc/s.

Adjusting a model aerial on the testing range. The wire netting "earth" shows up well in this view.



stant of the earth varies with weather conditions, and the earth constant varies from one geographical location to another. Consequently, it becomes necessary to specify a "standard earth" for certain operating conditions. Ideally, if different values of scaling factor are to be used, the material forming the earth plane of the model range should be changed so that its conductivity would be that of the "standard earth" corresponding to the new scaling factor. One type of earth which does not require a scaling factor is a perfectly reflecting surface. Communication sites located on salt marshes and over sea water have practically this type of earth. For the purpose of the model range the problem was resolved by using an earth covering consisting of a small mesh wire netting, thus simulating a perfect earth.

The target transmitter is supported by two open-truss beams, each 60 ft in length, fastened together at one end to form a 60-deg angle. The other two ends of the beams are mounted to two horizontal colinear axes located just high enough above the ground to permit a 180-deg movement of the structure. In the vertical position, the structure resembles a giant inverted V. The structure is counterweighted so that it requires very little power to move it through its path. The target transmitter is fitted into the vertex of the inverted V, and the model aerial is located at the centre of the earth plane.

The radio energy intercepted by the model aerial is rectified and the signal voltage is transmitted along underground cables to a recording pen attached to an automatic pattern plotter. Synchro-generators, connected to the axes of the V frame, transmit its position to the turntable of the pattern plotter. Thus an automatic record of the radiation pattern is plotted as a function of the angular displacement of the transmitter moving above the aerial. All the recording equipment is located in a shelter 200 ft from the aerial site.

A series of target transmitters which derive their operating power from small storage batteries within the unit are employed. This obviates the necessity of using connecting cables and wires which could reflect or otherwise disturb the radiated field. To prevent reflections that would be set up by a conducting material, the truss beams forming the V frame are made of non-conducting hard plywood. The frame, with the exception of the counter-weights, is comparatively light, and its maximum deflection due to its own weight is approximately 0.5 deg about the centre of the range.

NEWS FROM THE CLUBS

Birmingham.—Meetings of the Slade Radio Society are now held in the Church House, High Street, Erdington, on alternate Fridays at 7.45. On August 15th a d.f. test is planned with instruction for beginners. Sec.: C. N. Smart, 110, Woolmore Road, Erdington, Birmingham, 23.

Brighton.—The weekly meetings of the Brighton and District Radio Club during August will be informal and visitors to the town will be welcome. They are held on Tuesdays at 7.30 at the Eagle Inn, 125, Gloucester Road, Brighton. Sec.: R. T. Parsons, 14, Carlyle Avenue, Brighton, 7.

Coventry.—The first of a series of talks on 144 Mc/s will be given by Ray Bastin at the meeting of the Coventry Amateur Radio Society on August 18th. It will deal with receivers. Meetings are held on alternate Mondays at 7.30 at the Y.W.C.A., Queen's Road. In order to foster members' interest in v.h.f. the chairman of the Club (F. Miles, G5ML) has presented a cup for competition. Sec.: K. G. Lines, 142, Shorncliffe Road, Coventry.

Manchester.—Meetings of the Manchester and District Radio Society are now held at the Brunswick Hotel, Piccadilly, at 7.30 on the first Monday of each month. Sec.: P. Dean, G3FNT, Fairfield, 31, Park Lane, Whitefield, Lancs.

Reading.—The programme arranged for the coming session by the Reading Radio Society includes lectures, demonstrations and contests covering v.h.f., tape recording, aerials and high-fidelity reproduction. Meetings are held regularly at the Abbey Gateway, Reading. Sec.: L. A. Hensford, G2BHS, 30, Boston Avenue, Reading, Berks.

Walsall.—As part of a recent carnival, organized on behalf of the British Limbless Ex-Service Men's Association, the Walsall and District Amateur Radio Society set up a transmitting station (G2FPR/A) and provided a display of radio gear. The station was on the air for 8½ hours on 160 metres. Sec.: F. J. Merriman, G2FPR, 123, Wolverhampton Road, Walsall.

Remote Control of Large Travelling Cranes

THERE are two quite distinct applications of radio to the control of large overhead travelling cranes; one is when the crane operator should be close to the load being handled in order to exercise precise control and the other when he should be, in the interest of personal safety, as far away as possible. The latter is obviously a rather necessary condition, for instance, when handling radio-active materials and certain poisonous substances.

Both these applications were demonstrated by the Vaughan Crane Company at the Mechanical Handling Exhibition and Convention organized by *Mechanical Handling*, and held in London in June. Radio equipment for remote control of the crane is made by Heenan and Froude and goes under the name "Vestrad."

Transmission and reception is effected on closed loops in order to limit the range, three carrier frequencies on 52, 56 and 61 Mc/s respectively being employed. One controls the travel of the crane along the gantry, another the transverse motion and the third the lifting mechanism. Audio modulation tones are used for movement in one direction or the other in each case, and the three carriers can be used simultaneously or separately.

Radio equipment fitted to the crane comprises a three-channel receiver, tuned relays and selectors to distribute the controlling tones to the electric motors of the crane.

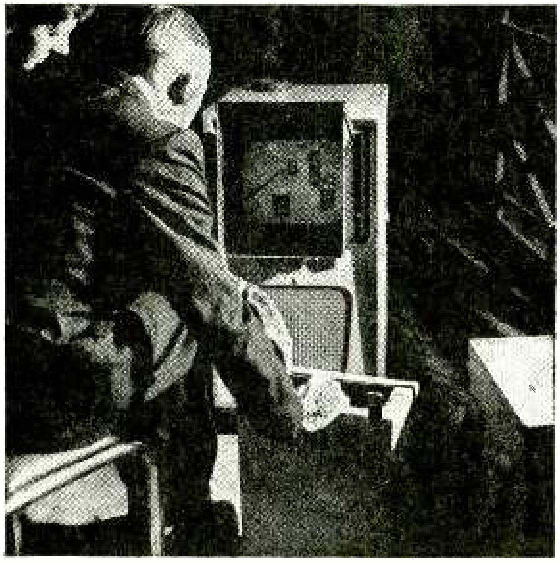
There are safeguards against all contingencies and a radio failure in any channel brings the motion concerned to a halt, while limit switches prevent overrunning.

Rather less than 5 watts transmitting power is used for the control of loads up to 100 tons or more. The equipment is constructed for portability and easily carried by one man, the transmitters and control panel in a case slung on his chest and the loop aerials in another carried on his back.

For control at a distance, such as when handling the "dangerous" class of materials, a television camera and remote viewing screen are used. These enable the crane operator to "see" from a safe distance, or a secure place, the movements of the hoisting "grab" on the crane and the actual load it is required to move.

The camera is a standard Marconi Image Orthicon as used by the B.B.C. and also for underwater television. It is connected to the viewing screen by a multi-wire cable, instead of a radio link.

With the additional facility of television it will usually be more convenient to employ a fixed rather than a portable radio transmitter and this can be mains operated. Some modification in the aerial systems may be needed as the effective range of the small portable loops is limited to about 20 to 30ft outside the actual area of the gantry.



Television viewing screen and radio equipment used for remote control of the Vaughan crane.

RANDOM RADIATIONS

By "DIALLIST"

A Useful Tool

When I come across something original and good in the tool line I make a point of passing on the results of my tests for the benefit of those readers who may be interested. It may be mentioned, in passing, that I try out a fairish number of new tools and workshop gadgets in the course of a year and that very few of them qualify for so much as a line of description. Here's one that definitely does. For some weeks now I have been using a Burgess Vibro-spray painting tool and I can't think of anything quicker, handier or more effective for painting and varnishing cabinets—or any of the jobs involving the application of a thin and even coating of material in a liquid state which come the way of the wireless man. The principle is most ingenious. A.C. from the mains is fed to the windings of an electromagnet, provided with a laminated armature, free to move inwards and outwards, and working against a coiled spring. As current rises towards a peak, the armature overcomes the thrust of the spring and moves towards the magnet poles. When current is approaching zero value the spring asserts itself and pushes the armature away from them. Connect the armature to the piston of a small pump provided with ball-valves, and there you are. During the outward movement of the piston, paint is drawn up from a container through a feed tube. The inward movement of the piston forces the paint through a tiny nozzle arranged on the lines of the old fishtail gas-burner. The result is a narrow, flat "beam" of finely divided paint.

Colour-Coding Problem

A Manor Park, London, reader very kindly sends me a resistor which seems to prove my point that colour-coding is not always quick to read, or foolproof. This is a half-watt resistor with a greyish-white body. At one end are the following bands, reading inwards: brown, green, gold. "A number of service-men and others," says my correspondent, "were asked to read the colour coding. In most cases the answer was a not very confident '15 ohms.'" He adds "I wonder if your answer would be the correct one." I'm ready to admit that it would not have been. When doing a good deal of constructional work one gets the code more or less into one's head. But it soon goes. To confirm my correspondent's figures I had to use a "crib" in the shape of the invaluable *W.W.* Diary. The brown band means 1 right enough and the green one 5; so far, then, we have 15. But what of the gold band? It indicates a decimal multiplier of 0.1; so 1.5 ohms is the correct answer. The resistor is one of ±20 per cent tolerance, as shown by the "no-colour" body. Would it not, though, be a quite understandable slip to read its markings as indicating a value of 15 ohms with a ±5 per cent tolerance? For gold also indicates a tolerance.

Spot-Wobble Again

I have found several eminent designers with whom I have discussed spot-wobble still inclined to fight shy of it: "Too risky in the hands of the man in the street. Might cause troubles worse than those it's meant to cure." For the life of me I cannot see why. There must, of course, be an on-off switch for the wobble and both serviceman and user must have it impressed on them that focusing must be done with the spot unwobbled. And, supposing that the user is odd enough to find that he prefers the presence of the lines to their absence, all that he has to do is to move the wobble switch to the off position—and keep it there. About spot elongation and other methods of deliberately introducing a certain amount of astigmatism, I'm not quite so sure. Certainly an on-off switch is equally necessary here, so that the user may see for himself just what the system does and may be able to put it out of use if he doesn't like the results.

Traps for the Unwary

Invaluable as it is to the radio man and the television man, if properly used, the oscilloscope can furnish images full of pitfalls for those who do not look before they leap; or, in other words, those who base their readings on a hasty appreciation of the "obvious" indications. Here is a case in point that I came across recently. The output of a diode detector was being tested by means of the Lissajous-Figure method. The hook-up was this: an r.f. oscillator was used to modulate an h.f. oscillator, the modulated output being fed *via* a pentode amplifier to the diode. The output of the diode was fed to the Y_1 plate of the tube. The a.f. signal was passed to X_1 by way of an amplifier. Y_2 and X_2 were earthed. The difference in the X and Y sensitivities was balanced out approximately by suitably adjusting the X amplifier. Thus, with no phase difference between the X and Y voltages, the image would have been a straight line, lying (with these connections) at about 135 deg.

The detector was, actually, a rather poor one and the image proved to be a deformed ellipse with its major axis at roughly 135 deg. The upper and lower ends were distinctly pointed and the trace was not "clean"; the envelope for some distance above and below the middle of the major axis was "muzzy." The bright youngster who was operating the oscilloscope gave his reading without hesitation: Linearity poor; considerable phase-difference; h.f. leakage through the detector. An old hand spent rather more time in examining the screen. "Take another look," he said, "and see if you are sure about that h.f. leakage." "Why, yes," said the young fellow after another glance. "Surely, it's obvious. Look at those muzzy bits." If you are an oscilloscopist, draw the hook-up I've described and, also, the pseudo-ellipse showing the vague, broadened trace in the parts I've mentioned. Done that? Good! Well, who was right? The output of the detector was connected to Y_1; hence, had there been h.f. leakage, the broadening of the trace would have been in a vertical direction: it would have affected, that is, the parts of the envelope that are most nearly horizontal—small sections near the pointed ends. Actually, the muzziness is seen to be in the most nearly *vertical* parts of the envelope and it can be due only to horizontal deflections of the spot, produced by the X-plate voltage. Hence it indicates h.f. in the X-plate supply and must be due either to pick-up by the wiring or to oscillation in the X-amplifier.

Vive La Télévision!

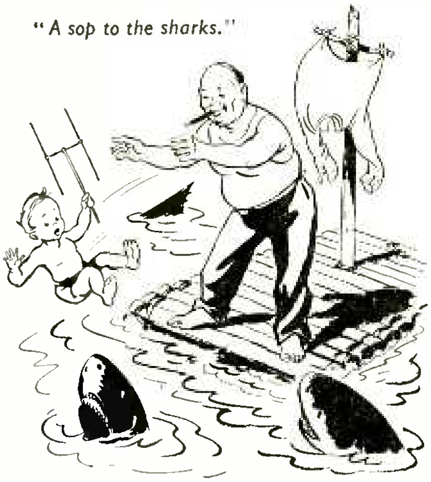
Monsieur Sallebert, the London representative of Radiodiffusion et Télévision Françaises gave a most successful cocktail party a few days before the opening of the Franco-British television relays. One excellent point that he made in his speech of welcome was that throughout the development work done by B.B.C. and R.T.F. engineers prior to the broadcast, there was not the smallest hint or thought of rivalry. The keyword was co-operation. Neither side made any effort to plug the superiority of its own system. What both wanted was a practical means of converting French 819-line television to British 405-line standards and vice-versa. That had been developed and there was now no practical obstacle to programme exchanges between countries using widely different definition standards, provided that the necessary co-axial cables or radio links were available.

UNBIASED

By FREE GRID

A Television Munich

IT has been said that a potted history of these islands could be written merely quoting the popular catchwords and phrases that have been in vogue from time to time. Thus in 1752 it was "Give us back our eleven days," in 1911 it was "9d for 4d" and in 1938 it was "appeasement." At the present moment it is undoubtedly "sponsoring" or, more fully, "sponsored television." Some people, notably Lord Reith, profess to see a strange similarity between the catchwords of 1938 and 1952.



"A sop to the sharks."

However, it is no business of mine, writing in a technical journal like *Wireless World*, to debate, like the architect of the B.B.C.'s great prestige, whether or not some sinister hidden hand is compelling Mr. Churchill to throw television overboard as a sop to the sharks as some say Mr. Chamberlain had to do with Czechoslovakia at Munich.

But, if political considerations are no concern of mine, it certainly is my business to deal with the technical tangles involved in this matter and to point out the perilous paths on which television might be forced to take in order to unravel them.

I feel, however, that before dealing with these technical pitfalls, I ought to confess that, having had some experience of the nightmare conditions prevailing in the world of U.S. "telecasting," to say nothing of the babbling Bedlam of American sound broadcasting, I am prejudiced against sponsored programmes in any shape or form and should be so even were there no grave technical objections. Dante's Inferno "pictorialized specially for television by the Fyrene Co." would just leave me cold. I would far rather watch an indifferent broadcast of "The Tempest" by the B.B.C. than a first-rate one paid for by an umbrella manufacturer.

At the present moment we have a very good television service which gives us the highest definition we can at present afford, both in terms of money and of etheric elbow room, but there are certainly no channels to spare. Now, there is one way of getting more etheric elbow room and that is by using much higher frequencies than we do at present, and it might seem, on superficial examination, that here lies the solution for the B.B.C. and S.T.V. (Sponsored Television) to exist side by side. But in a few years' time, with the coming of colour and other technical improvements, the B.B.C. television service will want all the extra elbow room it can obtain by the use of higher frequencies and there will still be none to spare for S.T.V.

The only way to get sufficient etheric room for both B.B.C. and S.T.V. when both are using colour, and other developments which can already be foreseen, would be to use extra-high frequencies indeed. Now apart from the fact that, owing to the restricted range of e.h.f. television, a very large number of stations would be required to give nation-wide coverage, receiver design would become very involved and maintenance very costly for, in addition to the complications of design which extra-high-frequency television would bring *per se*, there would have to be switching or tuning arrangements so that viewers could change from one service to another.

The sets would, in fact, be too complicated to be placed in the hands of the ordinary public, and a state of affairs would arise where everybody depends for their television and, eventually, their sound broadcasting too, on a wired relay service. It has been pointed out time and again in this journal what a bad thing it would be if wired wireless became universal and I am not going to dwell on it again here as it is a political matter and not a technical question.

The Scopetron

CAN anybody suggest a more suitable name for the heart and soul of our television sets and oscilloscopes than cathode-ray tube? The abbreviation c.r.t. is altogether lacking in dignity and makes it unable to hold its head up among its fellow thermionic tubes.

The name must describe the tube's function and it must end in "tron," but please don't suggest the obvious, but meaningless, "cathotron" to me. Since the tube enables us to examine a lot of things, ranging from a football match to our heartbeats, I would suggest "scopetron" (three syllables, please) which means a device whereby we can make an examination. Can you do better?

Electronicitis

WORDS which are *over*-used, as so many of them are nowadays, tend to become *mis*-used. Women in particular seem to take a delight in using a favourite word whenever they can squeeze it into a sentence. They mangle its meaning with as much zest as they endeavour to mutate their faces into something rich and rare. Concerning these facial mutations—or should it be mutilations?—Gilbert tells us that:

"Little dabs of powder
Little dabs of paint,
Make a woman's features
Look like what they ain't."

But no bard has yet sung of the far more serious mutations of meaning which women inflict on words. Some of the B.B.C.'s female announcers, with their eternal and infernal misuse of the word "nostalgic" are among the chief offenders.

I am sorry to say, however, that this wretched habit of treating a new word like a new toy has spread to the radio and electrical industries where "electronic" has become a fetish word which must be worked in at all costs no matter whether it be redundant or not. At a recent industrial exhibition I was invited to inspect a piece of apparatus which was, in fact, a simple three-valve a.f. amplifier and nothing more, but was it so described? Not on your life! It had become an *electronic* amplifier and it employed nothing so old-fashioned as thermionic valves but *electronic* ones. It is true that both were indeed electronic devices but not more so than were the ones we used a generation ago.

I rather wonder why nobody has yet thought of founding an Institution of Electronic Engineers; on second thoughts I think I will do it myself, as I should rather fancy writing M.I.Etron.E. after my name.

"Rich and rare."