Wireless World

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Long-playing Records

THE release in this country last month of long-playing (microgroove) records, was an event of very considerable importance and one which is likely to have as significent an influence on the trend of sound reproduction as the advent of electrical recording.

Long playing time is naturally the chief attraction to the public, but to the technically minded the introduction of a new moulding material with lower surface noise and better wearing qualities than shellac will be recognized as the basic development. The reduction of surface noise is so considerable that even after reducing maximum amplitudes to the limitations imposed by 240 or more grooves per inch, there is still room to accommodate an increased dynamic range, compared with shellac pressings, before noise level is reached. There is little doubt, too, that with equal care in the choice of pickups and reproducing styli, and in keeping the grooves free from dust, the increase of surface noise with successive playings is much less in the new materials.

To the unaccustomed eye the turntable speed of $33\frac{1}{3}$ r.p.m. seems unconscionably slow and has given rise to predictions of high-note loss at the low linear speeds near the centre of the record. Such misgivings are quite unfounded. Normal tracing distortion is, in fact, less than with standard 78 r.p.m. records, because both lateral velocity and stylus tip radius have been reduced to a greater extent than the linear speed.

The new records have a different recording characteristic and will require separate treatment in the matter of frequency compensation, the weight on the stylus must be reduced to 8 gm or less, and there is also the question of adequate turntable performance at $33\frac{1}{3}$ r.p.m. None of these matters should present any insuperable difficulty.

British long-playing records have been exported to America now for some time and have already established a high reputation for quality. It is unlikely that in this country they will immediately supersede the 78 r.p.m. shellac record, for it will be many years before a comparable library of subjects can be built up in microgroove. Not all subjects call for the long playing time and other qualities of the new system, and can be produced more cheaply on shellac.

Television Isolationism

WE remember a story, current on the continent of Europe many years ago, that was supposed to epitomize the alleged British traits of insularity and self-satisfied complacency. During a season of heavy winter gales, so the story ran, a leading London newspaper came out with the headline "GREAT STORM RAGING IN CHANNEL: CONTINENT CUT OFF."

Unless wiser counsels prevail, there seems some risk that, in the sphere of television, the continent may, as the story put it, be cut off from Great Britain. To avoid charges of being insular ourselves, perhaps we had better hasten to reverse that last sentence, but we admit to being complacent enough to think that the continent as well as Great Britain will lose something unless the easy interchange of programmes is facilitated by the adoption of common standards.

Two or three continental readers have accused *Wireless World* of being "isolationist" in continuing to advocate the general adoption of the British 405-line standard. "Now that the continent has expressed its preference for 625 lines," they say, "why not urge your home authorities to change over at once to that definition."

To give way thus to a majority vote is no doubt in keeping with the principles of international democracy, but, before Britain is asked seriously to do so, we feel a valid explanation of why the 625-line standard is preferred is due to us.

Hearing Aid Design

Some Essential Qualities of a Good Instrument and Their Practical Realization

A. POLIAKOFF (Multitone Electric Company)

MANY technical people regard hearing aids and everything and everyone connected with them with considerable suspicion. They think that a three-valve amplifier with a crystal microphone, no matter how much miniaturized, remains a three-valve amplifier by whatever name you call it, and irrespective of what you charge for it. And what about all the theories and systems of response curve compensation for various types of deafness which have been put forward and then declared untenable by official reports? This I believe to be a very general state of mind among men who are extremely well informed in most other branches of electro-acoustics.

That there is room for more than one point of view may be judged from the fact that when we entered the hearing-aid field in 1933 we firmly believed in drastic tone control (many readers will remember our tone control transformer), and in low prices for all kinds of hearing aids. Now, after seventeen years' work we make an instrument, our latest, with no tone control other than a choice of three earpieces, and charge for it more than any other British manufacturer, 39 gns.

A medium-sized manufacturer cannot, as a rule, engaged in large-scale basic research; he can, however, draw conclusions from his continuous practical work, which, if carefully conducted, becomes almost equivalent to pure research.

A hearing-aid manufacturer who is also a direct supplier on a large scale has the great advantage of being able to submit thousands of cases that pass through his hands every year to any reasonable test and to experiment with them to his heart's content.

Most hard-of-hearing people are anxious to co-operate and will undergo many tedious tests. The tests themselves may be tedious, but the subject is fascinating and of very great complexity. This may appear puzzling in view of the fact that the Medical Research Council in their report* laid down a response curve which they proved to be the best for most deaf people. Where, then, are the complications? Why the continuous need for experimentation? Surely everything has been settled now? The answer is that the response curve is just one variable among many; an important one, but probably not the most important.

In addition there is a large number of other things to consider. Most people have two ears with sufficient hearing to work on. Receivers in parallel and with the same characteristics can be used on both ears or one at a time. Alternatively, receivers with different characteristics can be used. Binaural listening, that is, by using two distinct amplifiers and microphones, is another alternative. Bone-conduction can be used singly, or mixed with air-conduction. Another variable is that one can work for maximum intelligibility in quiet surroundings, "dead" rooms, noisy surroundings or in resonant rooms, and so on.

Even when all technical requirements are satisfied we are left with the partly psychological problem of size, appearance and weight. No user wants to look like a military radio-set operator, and, whatever is visible he prefers shall have the appearance of a personal article such as a cigarette case, rather than a severely technical-looking object.

I would list the attributes of a good aid in the following order of importance:—

1. Giving the patient his optimum volume in all reasonable conditions of use. In most cases this cannot be achieved without automatic volume control.
2. Avoidance of pronounced peaks.
3. Low case noise.
4. (and last). A nice-looking response curve.

This order of priority must not be taken as a reflection on the conclusions of the Medical Research Council's Report, which states in any case "Startling changes of the overall articulation efficiency do not result from minor departures from the optimum response curve."

I shall now endeavour to demonstrate the importance of the other attributes.

Optimum Volume

Everyone, whether of normal or sub-normal hearing, has a preferred volume of listening which generally, but not always, corresponds to the highest score in a speech intelligibility test. If the level of speech falls far below this optimum, the percentage intelligibility rapidly declines, and it also goes down if the optimum is much exceeded. With many deaf people the effect is very marked. For them a small increase of stimulus produces a large increase in sensation. The phenomenon is known by the term "recruitment," and is not detectable by the normal audiogram taken at threshold. Thus, if the patient has a mean loss of 40 db at threshold and it is desired to make him hear speech of normal strength (60 db), at its right level, it would be wrong to conclude that in the majority of cases the level from the hearing aid should be 60 + 40 = 100 db. On the contrary, one is more likely to find that the patient

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* No. 261, "Hearing Aids and Audiometers," published by H.M. Stationery Office.

prefers to listen at some very low level such as 75 db. To determine the patient's volume requirements there are three quantities to measure: the *optimum* volume, the *maximum* tolerable, and the *minimum* giving sufficient intelligibility.

For some time now we have been using a very simple device which we have called an "Optimeter" for ascertaining these volume levels. This is simply a valve voltmeter with the meter scale calibrated directly in decibels above threshold. The "Optimeter" is connected in parallel with the earpiece of the hearing aid being demonstrated to the patient, and normal conversational voice is used for testing. The results recorded are then the true volume in his ear, subject only to the small correction of variation between earpieces. The minimum, optimum and maximum readings are then noted. The results thus obtained, although less accurate than with an elaborate speech audiometer, have the great advantage of being a measurement under actual working conditions. The speech audiometer, if properly designed, has an entirely flat response, whereas the hearing aid is certainly bound to be more "peaky" and to have a far less low-note response. What is required are the limits *with the hearing aid to be used* and not purely theoretical limits.

We have been measuring, systematically, a very large number of cases that have passed through our various offices in the last twelve months. The curve (Fig. 1) represents the result of these measurements on a sample of 500 cases. Considering the optimum volume only, the following percentages may be given to save unnecessary integration:—

Percentage of cases tested	Optimum volume
13.0	75 db or under
49.5	85 db ,, ,,
84.5	95 db ,, ,,
92.0	98 db ,, ,,

This appears to us to be a very interesting result. Nearly half of all the cases tested have an optimum volume not exceeding 85 db, that is to say, needing an amplification for normal speech of only 25 db.

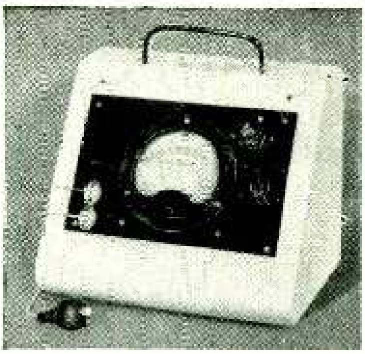
These measurements also disclose a large number of cases with exceedingly narrow ranges between the minimum and the maximum (Fig. 2). There are other cases, the easy ones, which have an enormous range between minimum and maximum or whose maximum is outside the range of normal instruments.

It has been clear to us for some time, long before we made systematic measurements of the volume requirements of all cases, that automatic volume control was an absolute essential for some cases and was very useful for most. Our first instrument incorporating automatic volume control was of the box type, called the "Reactor," and was made in 1936. Further development of automatic volume control suffered a setback by the need to make subsequent models of hearing aids wearable, with the consequent restriction of space available for additional components. It was not until 1948 that we incorporated it in our "Monostat" instrument (described in the *Wireless World*, October, 1948).

Our work with the "Optimeter" showed us the need for extremely wide control over volume compression to fulfil all the conditions. By varying separately the degree of compression, the amplification of the instrument for weak signals and the efficiency of the earpiece, we believe that we are now able to meet any requirements, even extremely freak ones. Since automatic volume control no longer properly described what we were doing, and, anyway, is apt to give the idea of complete levelling up, we have now introduced the expression "Contrast Control" In our new instrument, the "Selector," we are able to obtain as much compression as a range of from 20 db input to 6 db output and to decrease this compression by successive stages to completely linear amplification.

For the majority of cases of deafness, absence of pronounced peaks is quite important. In manufacturing on a large scale this is one of the most difficult things to achieve, especially as response curves of

Multitone "Optimeter" for measuring volume levels in association with the patient's own hearing aid.



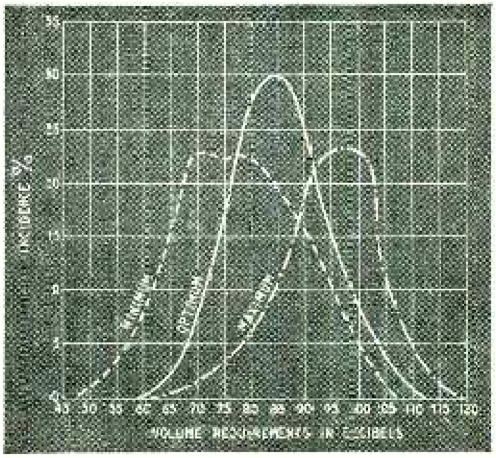
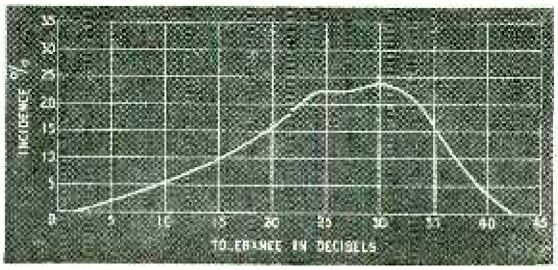


Fig. 1. Curves showing volume requirements, plotted from observations of 500 cases.

Fig. 2. Tolerance range (difference between minimum and maximum) in 500 cases.



both microphones and earpieces vary considerably with temperature. Case resonance often varies even from case to case, and, lastly and most important of all, the ear cavity and the seal vary from patient to patient to a very large degree. It is very disheartening for a manufacturer, after exerting himself to the utmost to level out peaks, to find some users who will not give up their original quite "peaky" instruments. There are many people who seem to need, or who have become accustomed to a hearing aid giving them a "kick," without which they feel it is not functioning. We believe, however, that these exceptions are not sufficiently numerous to justify any diminution of effort in this direction.

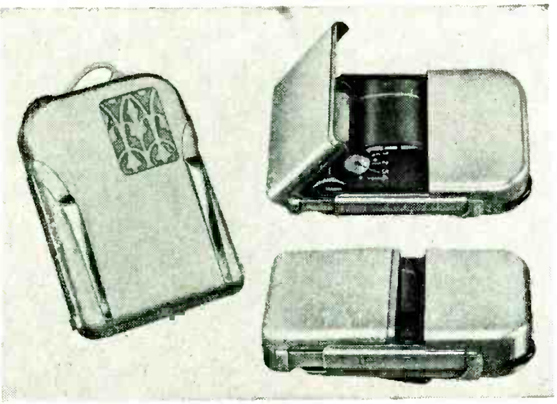
Case Noise

Practically everyone nowadays wears the hearing aid somewhere on the person. The effect of the smoothest response curve and of the best automatic volume control can be completely ruined by the noises and cracklings which the user hears as he moves or breathes if the instrument has bad case noise. Insulation of the microphone by rubber mounting is not in itself sufficient to avoid the case noise. The case has to be acoustically "dead" and its surface exceedingly smooth. On the "Selector," access to the battery compartment is given without the use of hinges by means of a special slide action which has enabled the case to be constructed in a manner combining great rigidity with comparatively low weight. This has been found to give acoustically superior results to the more conventional types of construction. There are no surface decorations; the grille is recessed and the whole is covered with lacquer which is fired on to give the smoothest possible surface.

Response Curve

Our practice now is to modify the response curve in suitable cases by means of earpieces and not by anything done to the amplifier. In addition to the normal earpiece, there is a choice of an earpiece with reduced high-note response and a less efficient earpiece with a continuously rising response curve. The first is required for people who dislike an appreciable output in the high notes, while the second, coupled with the control set to maximum compression, enables us to deal with cases of deafness which have usually been considered to be outside instrumental help.

In the latest Multitone "Selector" hearing aid, special attention has been given to the mechanical design and surface finish to minimize "case noise."



There has been no change in the position with regard to the withdrawal of overtime working by a section of the printing industry. A slight reduction in the number of pages in "Wireless World" is still unavoidable. All journals printed in London are similarly affected, to a greater or lesser extent, but journals printed in the provinces are not affected. It is greatly regretted that publication of our last issue was delayed.

I have now described the methods which have evolved gradually as a result of continuous practical work. All this is applied, however, to monaural aids, and there is no doubt in our minds that every effort should be made to produce sufficient simple binaural aids for similar cases. The advantage of a binaural aid in a resonant building is tremendous. It is really a question of simplifying the apparatus sufficiently and educating the public to the great advantages of the binaural instrument. We have so far done only experimental work, but hope that in the not-too-distant future to make something available to the general public. Meanwhile, the hearing problem in theatres, cinemas and other auditoria remains very difficult. With a monaural aid the best solution is undoubtedly an inductive pick-up from a loop under the carpet, which we introduced in 1937 under the name "Telesonic." The user is provided with a coil to plug- or switch-in instead of the microphone; or the theatre, cinema or hall lends him a special receiver for use while he is there.

It is a curious fact that every two years or so a controversy breaks out in the Press around the prices of commercial hearing aids. Comparisons are invariably made with wireless sets, and suggestions made with a varying amount of delicacy that hearing-aid manufacturers must be in a very good occupation indeed. I have already mentioned that we entered this field believing in very low prices and that our latest instrument, the "Selector," costs 39 guineas. Can such prices be justified? If hearing aids were sold on the same basis as radio sets they could, of course, not bear scrutiny. Most hearing-aid manufacturers and suppliers, however, give service and facilities to their clients which have no parallel in commerce. Further, the quantities are small and changes of design frequent. The continuous miniaturization of the hearing aid will undoubtedly continue at the present, or even a greater, rate and is an exceedingly expensive business. Most manufacturers and suppliers have quite cheap models as well as their more refined ones, and before the advent of the Government aid were used to providing instruments through hospitals at prices as low as 6 guineas, complete, before the war and 9 guineas after the war.

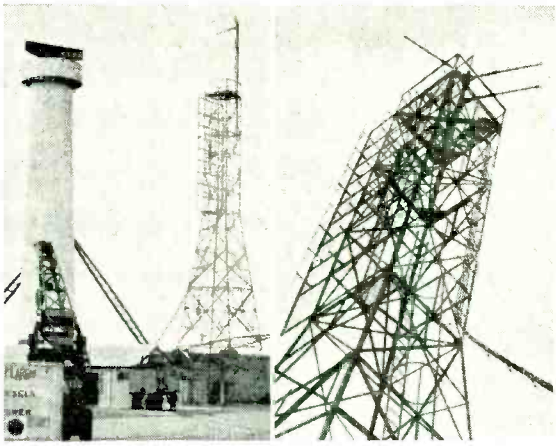
For a long time the fitting of hearing aids has been more of an art than a science. Knowledge and understanding of the subject are accumulating every day, but a great deal of fundamental research remains to be done before the fitting of instruments can become completely systematized.

Liverpool Harbour Communications

New Ship-to-Shore V.H.F. System for Pilotage and Docking Operations

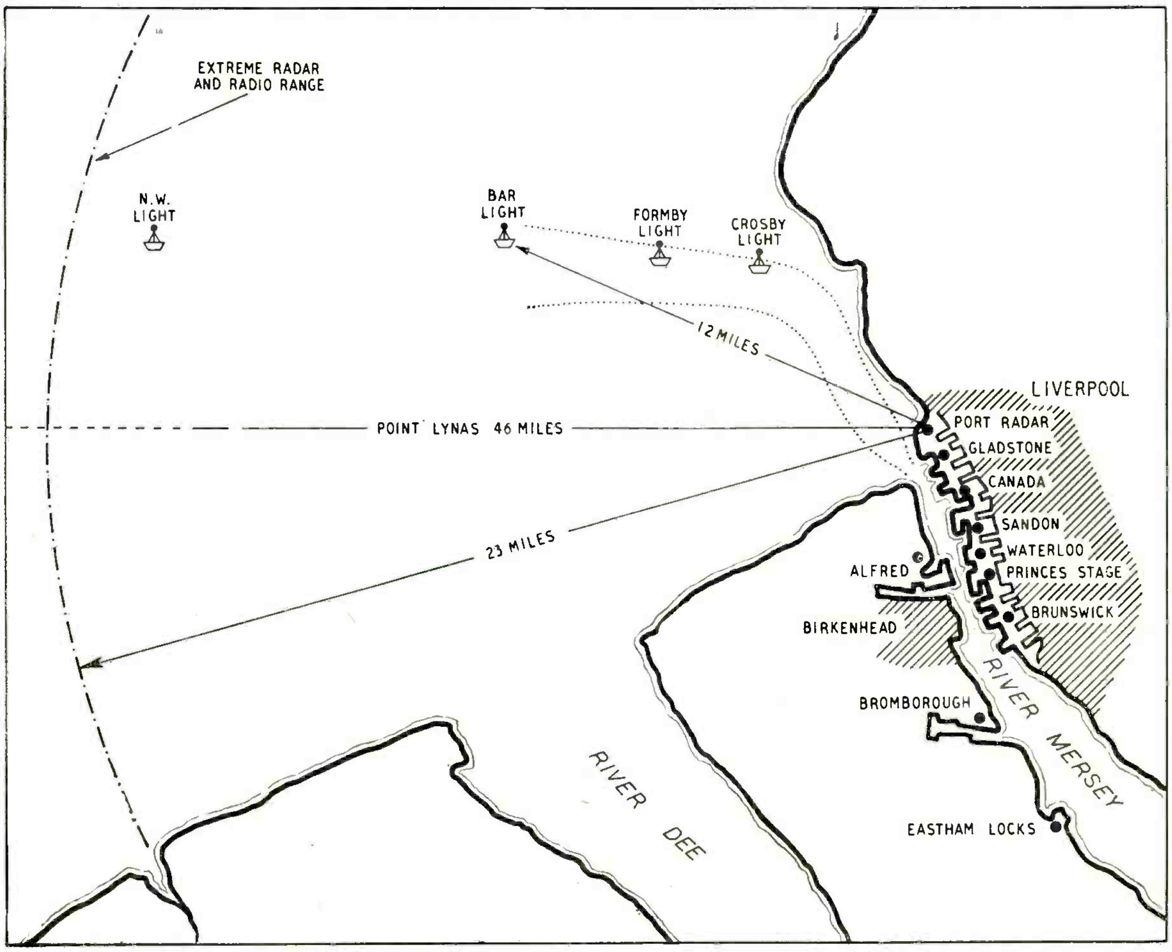
NOW that the marine radio system at Liverpool has completed initial trials and has been handed over to the Mersey Dock and Harbour Board, we are able to supplement the preliminary information given in our August, 1949, issue.

It will be recalled, that to keep pilots in touch with the latest radar information regarding shipping in the approach channel, and to enable shipmasters to get advance information of berthing arrangements, the harbour authorities gave a contract to British Tele-



Aerial arrays at Port Radar (Gladstone Dock). Above the 32-element beam aerial for Channel 1 are seen the Channel 2 Yagi aerial for distances up to the Bar Lightship and two Yagi aerials pointing to dock stations up river.

Fig. 1. Plan of area covered by Liverpool harbour communications.



communications Research for an installation comprising 10 shore stations and 150 portable radio-telephone transmitter-receivers. Research into the problem involved in giving reliable service over the large area covered by the docks and approaches (Fig. 1) was carried out by B.T.R., and the manufacture of the equipment was undertaken by the Radio Gramophone Development Company, who also contributed to the design of the portable transmitter-receivers.

These portables, which weigh 20lb are powered by a 4-volt accumulator and use a vibrator h.t. supply. They are hermetically sealed against total immersion, and now form an essential part of the harbour pilots' kit. The performance of the portable is the keystone of the whole communication system; the receiver sensitivity of 15μV determines the power required at the shore transmitters, and the portable transmitter power of 250mW the height and gain of the aerials and fixed receiver sensitivity necessary for reliable service at the stipulated maximum range of 23 miles.

Figures derived from a paper by T. L. Eckersley (*J.I.E.E.* Vol. 80, March, 1937, p. 286) produced the curves of Fig. 2, from which it was calculated that for an aerial power of 250mW, the signal strength at the land station receiver terminals from a simple dipole would be of the order of 0.3μV.

This level of signal is well down into the noise region, and below a manageable signal strength at the shore station. To this, aerial feeder losses must be added, and to facilitate calculations, these losses were fixed at 3db.

This indicated that a high-gain beam aerial should be employed. It had been ascertained that a signal of 3μV was required at the shore receiver terminals, and this called for an aerial gain of some 20db, not including feeder losses.

Consideration was then given to the transmitter power required at the shore station, utilizing an aerial with a gain of 20db, to produce the required field strength at the portable equipment.

As a 15-μV signal at the input terminals of the portable was considered reasonable for a good signal/noise ratio, it was found that the transmitter power required would be approximately 35 watts.

In practice, somewhat higher aerial powers (45 watts) at the land station were obtainable than were originally thought to be possible, and the portable set's sensitivity was also improved (i.e., 10μV for 10db signal-to-noise). This produced a slight unbalance in signal levels biased in favour of shore-to-ship, but this was considered to be an advantage when operating in bad weather and high winds.

It was decided that the aerial to be employed should be a 32-element centre-fed beam with a meshed metal reflector, which came as near as was practicable to giving the required gain (i.e., 18db) with a theoretical beam width of ±15°. The overall size of this aerial is approximately 30ft long and 12ft wide. It is mounted on an 80-ft tower situated approximately 50ft from Port Radar control room.

Channel 2 at Port Radar, which requires an operational range of 14 sea miles, employs a Yagi type aerial with one driven element and four directors, giving a forward gain of 5 or 6db. This aerial is mounted on a metal pole extending 20ft above the beam aerial on the same tower. At this height (i.e., 100ft + sea wall) it is visual distance to the Bar Lightship, thus eliminating the requirement for a high-gain aerial array.

There are six channels in all, two for navigational

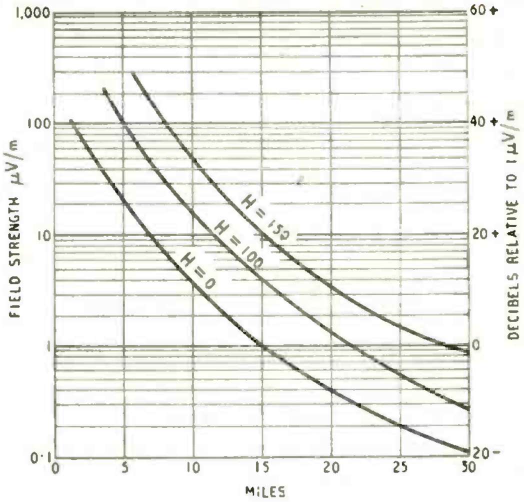
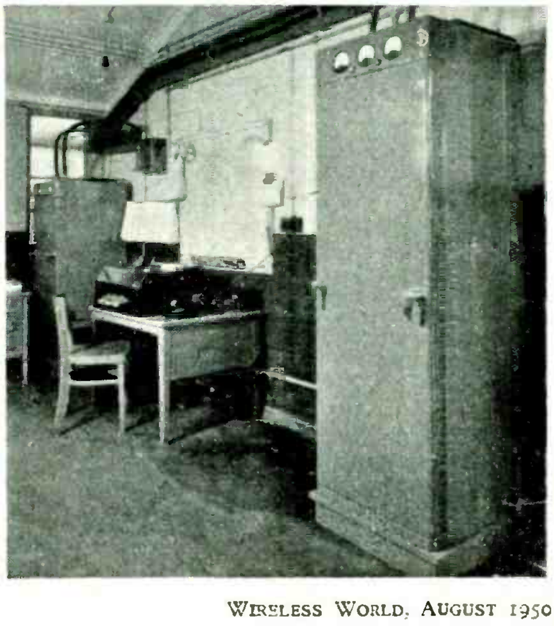


Fig.2. Field strength over water at 150 Mc/s with 250 mW in a single dipole aerial at heights (H) of 0, 100 and 150ft above sea level.

Six-channel crystal-controlled portable transmitter-receiver, Type HPS1, for use by harbour pilots.



Operations room at Port Radar showing Channel 1 and Channel 2 shore station equipment.

aid and harbour supervision, and four for docking communications. The land transmission frequencies are from 163.1 to 163.6Mc/s and the mobile transmission frequencies from 158.6 to 159.1Mc/s. The channels are separated, 100kc/s apart and the "go" and "return" frequencies are spaced 4.5Mc/s apart (at the receiver intermediate frequency). The two frequencies used for navigational and harbour supervision are Channel 1 and Channel 2 and the shore station equipment for these channels is located at Port Radar. The other four frequencies (Channels 3-6) are shared between nine dock stations, each of which has individual shore station equipment. The division is so arranged that docks the farthest distance apart share channels, and a code calling system is used, employing a 1000-c/s note, which permits the portable sets to call the required shore station.

At four-hourly intervals, day and night, the radar equipment is switched on and the positions of all vessels in the seaward direction, both under way and at anchor, are transmitted over Channel 1 for the benefit of any shipmaster who may wish to plot the information. This is then followed by similar information given over Channel 2 to vessels which may be needing it in the river area. After the shipping, a statement of local weather conditions is transmitted over both channels, together with any local navigation warnings.

At all times between these regular transmissions, communications may be established over both Channels 1 and 2 with vessels entering or departing from the Port. The portable sets are taken aboard ships by the pilots at their boarding stations which, inward bound, are off Point Lynas, or at the Bar Lightship. As soon as inward-bound ships arrive within the Port communications area they call up the operation room at Port Radar over Channel 1 and give their name, draught and expected time of arrival at, say, the mouth of the river, or at the Princes Landing Stage, whichever may be appropriate. This information is passed by landline to the departments concerned. When the vessels come within range of the Dock Station equipment the pilot can then communicate direct with the Dock Master for information as to the particular berth the ship is to occupy. This will enable the shipmaster to prepare to rig derricks and remove appropriate hatch covers in advance and so save valuable time in unloading.

Under adverse weather conditions the combined radio and radar equipment operates to enable vessels to enter and traverse the Crosby Channel and proceed to anchorages in the river or directly into dock, as may be required. Likewise, vessels leaving port may seek and obtain information which will give them safe passage to the Irish Sea. In circumstances of particularly heavy traffic on Channel 1, vessels within the shorter range of Channel 2 may be requested to use this channel to free the longer range channel for communications with vessels farther away from the Shore Station.

At the official hand-over ceremony, which took place on 1st June on board S.S. *Galatea* near the Crosby Light Float, all aspects of the service were convincingly demonstrated on the return passage to the Gladstone Dock under shore radar and radio control. As an example of what can be achieved in the economical planning of an installation to serve local geographical and organizational requirements, the Liverpool communication system is a happy augury for the successful extension of v.h.f. radio-telephone service to other large ports in this country and overseas.

Flyback E.H.T.

1. Characteristics of Pulse Systems

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

IT is now the standard practice in television receivers to derive the e.h.t. supply for the cathode-ray tube from the voltage pulse developed in the line-scanning circuits during flyback. The system works exceedingly well; it is inexpensive and, because of the small reservoir capacitance needed, it is a safe one. Its only major disadvantage lies in its rather poor voltage regulation.

The regulation is important because it affects both picture size and focus. If V_T is the final anode voltage of the c.r. tube, the picture width and height for constant deflecting current are inversely proportional to $\sqrt{V_T}$. Also the current in the focus coil, or the field strength needed for optimum focus, is proportional to $\sqrt{V_T}$. For small changes of voltage the percentage change of picture size is very nearly one-half the percentage change of voltage; thus, a fall of 10% in voltage means an increase of 5% in the linear dimensions of the picture.

On a picture 10 in wide this is an increase of 0.5 in and is quite a lot. Changes of this order do frequently occur between a near-black raster and a near-white one. Their effect is very obvious when the brightness control is operated. Fortunately, such large changes of picture brightness do not often occur in a normal programme. The mean brightness level is remarkably constant and it is rare for it to change sufficiently for noticeable alterations of picture size to occur, even when the regulation of the e.h.t. supply is far from good, except after a break in the programme when the announcer is faded-in following a near-black interval.

The effect of e.h.t. regulation on focus is much more difficult to assess and it obviously depends to a large degree on the depth of focus of the scanning beam. The modern tendency in tube design is to shorten the tube, which not only increases the deflection angle but increases the angle of beam convergence and so shortens the depth of focus. The effect of e.h.t. regulation on focus is, therefore, likely to increase in the future.

Since it is not easy to measure degrees of focus, it is hard to give any figures for the effect of e.h.t. regulation. It has been observed experimentally in a particular case that if the raster is focused with a current of 120 μA at 4.35 kV there is noticeable defocusing when the voltage rises to 4.8 kV, which, in this case, occurred at a current of 45 μA.

Most c.r. tubes are rated for a peak current of about 150 μA but, because of the line and frame fly-back intervals, the maximum mean current on a peak-white raster does not exceed 120 μA. On a black raster the current is zero so that in theory it is necessary to consider current *changes* of 120 μA. However, if the raster is black one cannot see it and it does not much matter what happens to it. In general, it seems reasonable to consider a mean current of 60 μA for an average picture and to assume that normal mean-current changes are restricted to ± 40 μA about this figure. Changes of ± 60 μA are likely to occur so infrequently that some distortion of the picture when they do occur may well be tolerable.

It should be understood that the currents referred to are all mean currents corresponding to the mean picture brightness. The instantaneous currents corresponding to the picture detail are supplied by the reservoir capacitance and do not enter into the present discussion.

One cannot lay down any definite figures for an acceptable standard of e.h.t. regulation, but it is suggested that for current changes of ± 40 μA a change of picture size of ± 2.5% would not be objectionable. With constant deflector-coil current this is 10% regulation for 80 μA change of current. This corresponds to a source impedance at 5 kV of $500/80 = 6.25\ \text{M}\Omega$ and is of the order obtained with the *Wireless World* Television Receiver. Experience with this set indicates that neither the change of picture size nor the change of focus is sufficient to be objectionable. Indeed, neither is noticeable on normal programmes. The change of picture size usually becomes evident only on a change from one programme to another, for which the mean level of brightness may be appreciably different. It only becomes obvious when a programme is faded-in from a near-black raster.

In this article, therefore, we shall take the foregoing figures as representing an acceptable standard of performance but it is, of course, plain that a higher standard is desirable if it can be obtained with reasonable economy.

Line-Scan Circuit

The voltage regulation of a fly-back e.h.t. system depends upon the scanning circuit itself on the one hand and upon the rectifier system on the other. A joint analysis of the two together is impracticably complex. In general, the regulation of the rectifier system alone is, or can be, much better than that of the scanning system. For the present, therefore, only the latter will be considered and it will be assumed to work into an ideal rectifier. That is to say, all rectifier diodes will be assumed to be " ideal " with zero forward and infinite back resistance, and the reservoir capacitance will be assumed large enough to absorb or supply current without the voltage across it changing by any appreciable amount. The voltage across it will be assumed to be capable of changing only over intervals of time which are lengthy compared with the duration of a scanning line.

In order to determine the effect of the scanning system upon the regulation of the e.h.t. supply it is necessary to analyse such a system in conjunction with an ideal rectifier. So far as the writer is aware no such analysis has previously been published. It is carried out fully in the Appendix* and a design procedure is derived from the results.

The analysis is straightforward but its interpretation is difficult because certain equations cannot be brought into suitable form to permit substitution in others. This has made it necessary to present the results in graphical form and involved some rather laborious computation.

Practical line-scanning circuits vary greatly in detail but most arrangements are substantially alike in their fly-back conditions. The deflector coil with the shunt and leakage inductances of the transformer is equivalent to a simple inductance, and the various circuit capacitances to a capacitance in shunt with it. The only variations from this are brought about by some stray capacitances and leakage inductances which cannot always be exactly represented by this simple arrangement. They are often of negligible importance, however.

Power lost to the circuit in various ways is best allowed for by a resistance in shunt with the LC circuit. This is not exact when the damping circuit comprises a series resistor and capacitor across the deflector coil; it is still less exact when a resistor, a capacitor and an inductor, all in series, are used for damping. It is very near reality, however, when damping is provided mainly by iron losses plus, possibly, a shunt resistor. This includes the case of a damping diode, for such a diode is inoperative throughout fly-back.

It is important to realize that the valves associated with the circuit are all cut-off during the entire fly-back period, except, of course, the e.h.t. rectifier. The type of output valve used and the presence or absence of a damping diode thus make no difference to the present discussion.

The basic circuit, shorn of damping arrangements, is given in Fig. 1. In practice, the transformer primary

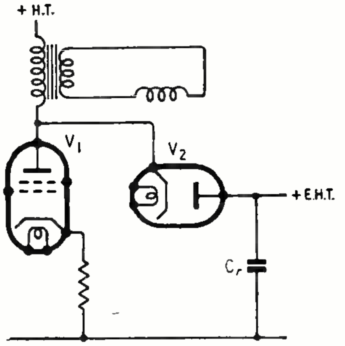


Fig. 1. Basic circuit of typical line-scan stage with e.h.t. rectifier.

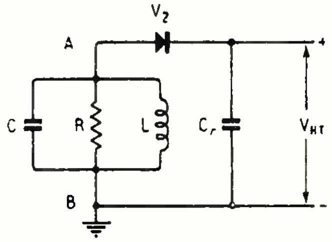


Fig. 2. Equivalent circuit of e.h.t. system.

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* This will be included with the second half of the article.

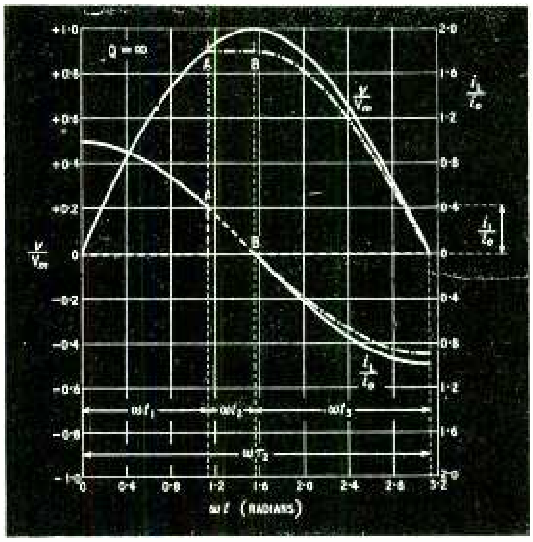


Fig. 3. Variations of voltage and current in an undamped circuit, (solid line) with the e.h.t. rectifier disconnected, (dotted line) with the rectifier connected. The dash-line curve shows the current through the rectifier.

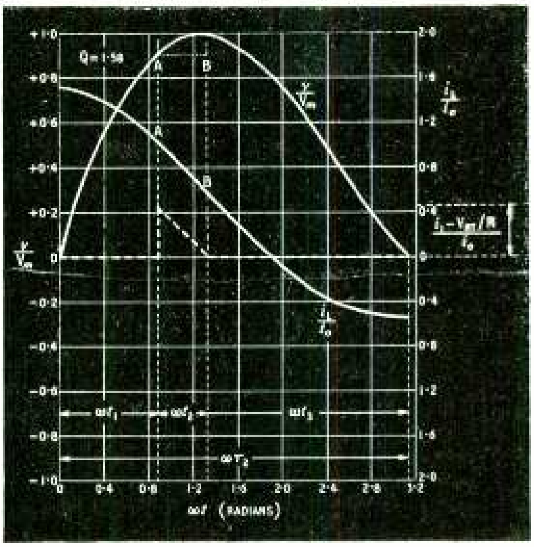


Fig. 4. Variations of voltage and current in a circuit of Q = 1.58 (solid line) with e.h.t. rectifier disconnected. The dash-line curve shows the current through the rectifier and the dotted line the current in L when the rectifier is connected. The curve beyond B is not shown.

is often used as a step-up auto-transformer between V_1 and V_2, but this is immaterial at present. The equivalent circuit has the form shown in Fig. 2. When the valves are cut off at the end of the scan to initiate fly-back there is a current in L which is the peak value of current reached during the scan; this is designated i_0. The energy in the magnetic field of the coil is then $Li_0^2/2$.

Because the scan current varies with time there is a back e.m.f. across L during the scan and so a charge on C. At the instant of fly-back the voltage across C is LI/τ_1 where I is the peak-to-peak scanning current in L and τ_1 is the scan period. The energy stored in C is $Cv^2/2 = CL^2I^2/2\tau_1^2$.

The relation between i_0 and I depends on the circuit damping, as will be shown later; but I can never be less than i_0 nor greater than $2i_0$. For a given value of I the inductive energy is a minimum when $i_0 = I/2$ and taking this value it becomes $LI^2/8$. The ratio of magnetic to electric energy is thus $\tau_1^2/4LC$. It will be seen later that under this condition $LC \approx \tau_2^2/\pi^2$ where τ_2 is the fly-back period; and so the energy ratio becomes $(\pi\tau_1/2\tau_2)^2$ and for the B.B.C. transmissions this has the value 76.5.

The energy stored in C at the end of the scan is thus very small compared with that stored in L and we are justified in neglecting it in comparison. It is to be noted, too, that we have computed the ratio for the worst case of $I = 2i_0$; had we taken the other limit of $I = i_0$ the ratio would have been 306 : 1.

The effect of neglecting the initial charge on C is considerably to simplify the analysis but to make the calculated value of the peak voltage on fly-back in error by the initial voltage on C—a matter of 150—250 V in 3—6 kV.

Taking for simplicity, therefore, an initial condition of a current i_0 in L, C being uncharged, the current in L continues to flow in its initial direction and it flows into C. The voltage across C therefore rises and as it does R draws current. This continues until the energy in L has disappeared, being partly dissipated in R and partly stored in C.

If R were infinite, so that there were no dissipation of energy, all the initial energy from L would have been transfered to C. The voltage across C would then have its maximum value V_m and we could write $Li_0^2/2 = CV_m^2/2$, whence $V_m = i_0\sqrt{L/C}$. This is the maximum possible value of V_m. In practice it is always less because there is always some dissipation of energy.

After the maximum voltage on C has been reached, C starts to discharge and supplies current to R and L. The current in L is zero but is changing at its maximum rate when the voltage on C is a maximum. When C discharges, therefore, the current in L reverses, passing through zero to increase in the negative direction. As the voltage falls R takes less and less current, the current in L increases negatively, and its rate of change falls off. Eventually C is fully discharged, R draws no current, there is a maximum negative current in L and zero rate of change of current. The energy stored in C at the time of maximum voltage has, less that dissipated in R, then been transferred back to the magnetic field of L.

If the circuit were left to itself the whole process would repeat until all the energy had been dissipated in R. If R were infinite it would go on for ever and the current and voltage would oscillate continuously. With finite damping the oscillations become negligible after a number of cycles which depends on the degree of damping.

In the television application the end of fly-back and the start of the following scan are taken as occurring at, or very shortly after, the first half-cycle of oscillation when the current is at, or just beyond, its first negative maximum. When a damping diode is not used this negative current maximum can only be very small—at most 10-15% of the initial current. When diode damping is employed the negative current maximum can advantageously be made as large as possible, for subsequent oscillation is inhibited by the diode.

In all cases we are interested only in this first half-cycle and its duration must coincide with, or be less than, the time allotted in the transmissions for fly-back. The solid-line curves of Fig. 3 show the way in which voltage and current vary during this half-cycle for the ideal case of zero damping and Fig. 4 shows their variations for a degree of damping such that the overshoot is $33\frac{1}{3}\%$. By overshoot is meant the ratio of the magnitude of the first negative current maximum to the initial current. In Fig. 3 the voltage wave is sinusoidal and the current co-sinusoidal; in Fig. 4 they are damped sine and cosine waves.

The E.H.T. Rectifier

Now let us consider the action of the e.h.t. rectifier V_2 in Figs 1 and 2. We assume that the reservoir capacitor C_r is charged to a voltage V_{HT}. Let the voltage across the resonant circuit be v and its maximum value be V_m. Then as long as v is less than V_{HT}, the diode V_2 is non-conductive and v varies in accordance with the normal laws of the tuned circuit alone. It follows the voltage curve of Fig. 3 or 4. This happens until the point A is reached, at which v and V_{HT} are equal. The diode then conducts.

As the diode is assumed to be ideal and as V_{HT} is assumed to be constant, so far as short-term variations are concerned, the voltage across the circuit is now clamped at V_{HT} and cannot rise further. The top of the free voltage curve is thus cut-off. If the voltage is constant the capacitance C can draw no more current and R draws a constant current V_{HT}/R. The current in L, less that drawn by R, thus flows through V_2 into C_r.

In reality, if current flows into C_r the voltage across it must rise, and therefore C must take some current. However, we are assuming that C_r is so large that the voltage rise across it is negligible.

If the voltage is constant the rate of change of current in L must be constant, and so the current must fall linearily with time. This is shown by the portion AB in the curves of Figs 3 and 4. This process goes on until the current in L has fallen to the value needed by R at the voltage V_{HT}. This is zero in Fig 3 and a finite value in Fig 4. There is then no surplus current to flow through V_2.

After this C starts to discharge and supplies current to L and R and so the voltage falls, cutting off the diode. The reservoir capacitance cannot, of course, discharge to supply them for V_2 cannot pass reverse current. After the point B, therefore, we are left with a free resonant circuit and the response can be calculated as one having C charged to V_{HT} and a current in L equal to V_{HT}/R as initial conditions.

Because energy has been abstracted from the circuit during the conductive period of the diode there is this much less energy left in the circuit to be transferred to the magnetic field in the negative quarter cycle. The result is that the overshoot is less than it would be if the e.h.t. circuit were absent This is plainly shown by the dotted curves of Fig 3. The effect of the e.h.t. circuit is thus to damp the resonant circuit.

The current through V_2 has the triangular waveform shown in Figs 3 and 4. It has an amplitude $i_1 - V_{HT}/R$ and flows for a period t_2. The mean current during t_2 is one-half the amplitude and the quantity of electricity passed to C_r is the product of this mean current and its duration t_2. In the equilibrium condition this must equal the quantity of electricity withdrawn from C_r by the demands of the cathode-ray tube during one complete scanning cycle of duration τ. This is the interval between the start of successive fly-backs and is 98.77 μsec for the present transmissions. This mean current is designated i_{HT}. Except when a voltage-multiplying rectifier is used the load current i_{HT} is the same as the tube current i_T and the circuit voltage V_{HT} is equal to the tube voltage V_T.

It is now easy to see how a variation of tube current affects the e.h.t. voltage. If i_{HT} increases a greater quantity of electricity must be passed through V_2 to C_r. Therefore the peak current $i_1 - V_{HT}/R$ or the conduction time t_2 or both must be greater. In practice both increase, for diode conduction must start earlier to permit an increased current to flow. It can start earlier, however, only if V_{HT} falls. With the lower voltage R draws less current and so the time of diode cut-off is a little later.

Increasing the tube current thus inevitably means a fall of V_{HT}. Conversely, decreasing the current causes the voltage to rise to a maximum of V_m at zero current. If it is necessary for the tube current to vary from zero to some maximum value the e.h.t. voltage will vary from V_m to some minimum value. What this is depends only on the conduction time t_2 corresponding to the minimum permissible voltage.

If the regulation is to be good it is necessary to choose this minimum voltage very close to V_m. Unfortunately, this means that there is relatively little current in L at this time. If the peak current through V_2 is to be sufficient, therefore, it is necessary to start with a large value i_0 of initial current. All this means, in effect, is that for good regulation it is necessary for the volt-amperes of the deflection circuit to be large compared with the power drawn from the e.h.t. circuit, which is not a very surprising conclusion.

(*To be continued*)

CLUB NEWS

Birmingham.—Members of the Slade Radio Society are visiting Elmdon Airport on August 18th, and a d.f. test will be held by the club on August 20th. At the meeting on September 1st two members will give their experiences in constructing and operating the "View Master" television receiver. Sec.: C. N. Smart, 110, Woolmore Road, Erdington, Birmingham, 23.

Brighton.—At the meeting of the Brighton and District Radio Club (G3EVE) on August 8th in the Eagle Inn, Gloucester Road, at 7.30, F. How, G3DEU, will describe and demonstrate an amateur communications receiver for a.c./d.c. operation. Sec.: L. F. Hobden, 17, Hartington Road, Brighton.

Coventry.—A lecture on a.c. theory—one of series in preparation for the radio amateurs' examination—will be given to the Coventry Amateur Radio Society (G2ASF) on August 14th. Meetings are held on alternate Mondays at the B.T.H. Social Club, Holyhead Road, at 7.45. Sec.: K. G. Lines, (G3FOH), 142 Shorncliffe Road, Coventry.

Warrington.—Provisional arrangements for the inter-club "top band" telephony contest to be held in the area on September 24th provide for operating periods from 3 to 5 and from 7 to 10 p.m.

Watford.—Meetings of the Watford and District Radio and Television Society are held on the first and third Tuesdays in each month at the "Cookery Nook," The Parade, Watford. There will not be a meeting on August 15th. Sec.: R. W. Bailey (G2QB), 32, Cassiobury Drive, Watford.

Standing Waves on R.F. Cables

When Travelling Waves Interfere With Each Other

By "CATHODE RAY"

THE introduction to this story appeared last month, so I had better begin by recapitulating. We saw how r.f. cable, such as that used to connect television aerials to receivers or transmitters, is (neglecting loss resistance) electrically equivalent to a chain of series inductances and parallel capacitances, in which these components are infinitesimally small and infinitely numerous; and that on this basis it is quite easy to discover the main facts about such cables. One of these facts is the existence of a continuously growing phase lag along it; which means that if a.c. is put in at one end by a generator (such as a receiving aerial or a transmitter) it takes time to reach the other. Another important fact is that at first, while the current is on its way, the cable appears to the generator to be a resistance having the value $\sqrt{L/C}$, where L and C are respectively the inductance and capacitance of any length. This is the so-called characteristic resistance, denoted by R_0. Since R_0 is a resistance, the current everywhere along the line is in phase with the voltage. If the far end of the cable is closed by a load resistance R equal to R_0, the ratio of voltage (V) to current (I) arriving there satisfies Ohm's Law, and the power is completely absorbed. But if R is greater than R_0, the voltage rises, and in so doing drives part of the current back towards the generator. The ratio of the surplus voltage (v) to the reflected current (i) must of necessity equal R_0; and from this we calculated that

$$\frac{i}{I}=\frac{v}{V}=\frac{R-R_0}{R+R_0}$$

(Although we didn't actually consider what would happen if R was less than R_0, this eventuality is covered if we assume that i and v can be negative. A negative current going backwards is the same as an increase in the forward current.)

As an example of all this we assumed the values shown here in Fig. 1. The 400-V generator with 100-Ω internal resistance, connected to a 100-Ω cable, sends 2 A down it at 200 V. Arriving at the other end, this power finds a 300-Ω load, which does not agree with 200 V, 2 A. By the time the current through it has reached 1 A the voltage across it has risen to 300 V, giving a 100-V surplus back pressure to return the surplus 1 A along the line. So 100 watts is returned to the generator, and is totally accepted by it because the generator resistance is the right value for 1 A at 100 V. The net outgoing power is therefore 400 − 100 = 300 W, the same as is being absorbed by the load.

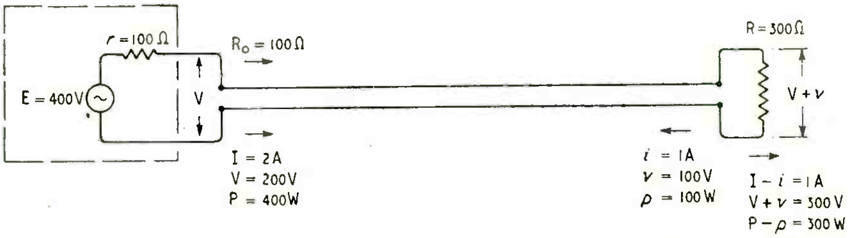


Fig. 1. Numerical example of a cable or feeder line joining a generator (shown inside the dotted line) to a resistive load. I, V and P are the original current, voltage and power travelling towards the load, and i, v and p the current, voltage and power reflected by it.

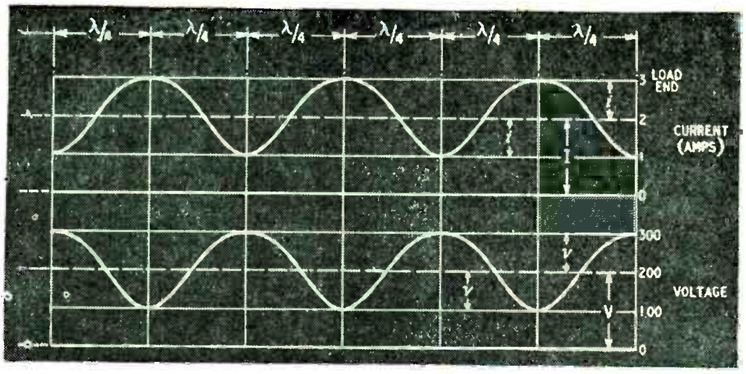
That is as far as we got, with a sinister hint that there were complications in store when we came to consider the current and voltage, owing to the phase lag introduced by the cable.

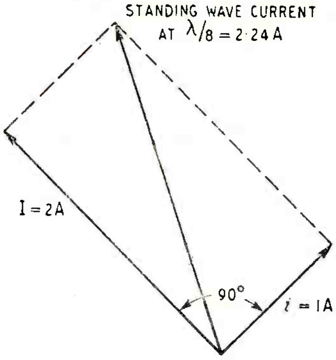
Let S stand for the speed of the waves along the cable, in metres per second. In one second, they would travel S metres (if the cable were long enough). In the period of one cycle, which is $1/f$ of a second, obviously they travel S/f metres, which is one wavelength, denoted as usual by λ. So points on the cable S/f metres (or one wavelength) apart have a phase difference between them of one whole cycle or 360°. Along cables with air-spaced conductors, S is very nearly equal to 300 million—the speed of free electromagnetic waves—but the higher permittivity of solid spacing reduces S, so that λ along such a cable is shorter than in space. If, for example, S is 200 million, and f is 50 Mc/s, λ is 200/50 = 4 metres, compared with 6 metres in space.

Stationary Wave Pattern

The one place where we already know the relative phases of the original and reflected voltage and current waves is at the point of reflection—the load end of the cable. When, as in Fig. 1, R is greater than R_0, the reversal in direction of the reflected current is equivalent to its being exactly opposite in phase to the original (arriving) current; that is to say, the amount going on into the load is less than the original. The reflected voltage is also opposite in phase to the original, but as it adds to the back voltage due to the resistance it increases the voltage across the load.

Now let us move towards the generator end, examining conditions as we go along. We start with 1 A, 300 V at the load end. At a distance of quarter of a wavelength ($\lambda/4$) the original and reflected waves are spaced apart by half a wavelength





Left: Fig. 2. Stationary distribution of r.m.s. current and voltage near the load end, under the conditions specified in Fig. 1. Right: Fig. 3. Vector diagram for calculating current at odd multiples of λ/8 from the load end in Fig. 2.

(λ/2)—that being the total return journey to and from the load—and by 180° in phase. So at that point the two currents are in phase, giving a total of 3 A, and the voltage is 200 − 100 = 100 V. Moving along another λ/4, we are λ/2 from the load, and the phase difference is 360°. So at that point we get back to the same conditions as at the load—1 A, 300 V. Another λ/4 brings us to a 3-A, 100-V point. And so on, all the way. The reflected current and voltage alternately add to and subtract from the 2 A, 200 V travelling from generator to load. At intermediate points there are phase differences other than 180° or 360°, so the net current and voltage vary in the wavelike manner shown in Fig. 2. These are not travelling waves, like those causing them; they are a stationary pattern of steady r.m.s. values, such as would be indicated by meters connected at points along the line. So, not unnaturally, they are called *standing waves*. Incidentally they are not sine waves. If they were, the values at λ/8 intervals would be the same as if there were no reflected wave; but at those points the phase differences are 90° or 270° and, as Fig. 3 shows, the reflected wave raises the value from 2 A to 2.24 A; and the voltage in the same ratio.

Matching and Efficiency

The ratio of maximum to minimum current or voltage is called the standing wave ratio. In this example it is 3/1. It is a thing that can be measured, by running a suitable voltmeter along the line. Obviously, it is a good way of finding out how nearly the load matches the line. If there is a perfect match ($R = R_0$) the standing wave ratio is 1. At the other extreme, if the end of the line is left open ($R = \infty$) or short-circuited ($R = 0$), the whole of the power is reflected, so that at certain points, λ/2 apart, the current or voltage is completely cancelled out, and the s.w.r. is ∞.

From our previous calculations of the amount reflected it can easily be deduced that the s.w.r. in general is equal to R/R_0.

And so we come at last to the generator again. Clearly the state of things there will depend on the length of the cable, in λ units. Fig. 2 shows that if it happens to be an exact number of half-wavelengths the current and voltage will be the same as at the generator—1 A, 300 V. Since the generator e.m.f. is 400 V, that means a drop of 100 V in the internal resistance (100 Ω), which is right for a current of 1 A. So far as the generator is concerned it is now feeding a load of 300 Ω, just as if it were connected direct to R. So the original input resistance of the line—100 Ω—is raised to 300 Ω directly the reflected wave reaches the generator. The original "error" in the amount of power issued is exactly corrected. Even this "error" is right, really; because a temporary over-issue was necessary to fill up the line with waves of energy. I don't know what you think, but this always strikes me as a very pretty example of how natural laws always win, even when we think we have caught them out.

But what if the cable length is not an exact multiple of λ/2? Suppose we knock off λ/4, so that the generator connects at a 3-A, 110-V point? The cable will then look to the generator like a 100/3 = 33.3-Ω resistance. If such a load resistance were connected directly to the generator, the total resistance in circuit would be 133.3 Ω, the current would be 400/133.3 = 3 A, the terminal voltage would be 400 × 33.3/133.3 = 100, and the power into the load would be 3 × 100 = 300 W. Which all agrees perfectly with the cable figures. So again everything is completely legal; there isn't a loose end anywhere.

At intermediate cable lengths the current at the generator is not in phase with the voltage, so the input impedance includes reactance as well as resistance; but the outgoing power is still the same, and everything sorts itself out.

This does not mean that the exact cable length is unimportant. At a λ/2 point the power lost in the generator is $1^2 \times 100 = 100$ W. But at an odd λ/4 point it is $3^2 \times 100 = 900$ W. Rather a difference in the efficiency! At the λ/2 point it is 300/400 = 75%; at the λ/4 point it is 300/1200 = 25%. If the load resistance were a perfect match to the line—100 Ω—the power supplied would be a maximum—400 W—but the efficiency would be only 50%. So it might well be considered better to arrange for a deliberate mismatch and get 300 W for a loss of 100 W rather than 400 W for a loss of 400 W. But the great advantage of working under matched conditions is that the exact length of cable doesn't matter, and the frequency can be varied without upsetting things. For instance, suppose the cable is 25 wavelengths long, and operated under 300-W, 75% efficiency conditions. If the frequency increased by 1%, the cable would then be 25¼ wavelengths long and the efficiency would fall to 25%, if indeed the generator managed to survive its load falling from 300 Ω to 33.3 Ω and its dissipation going up from 100 W to 900 W. So in such a case it would be better to use 300-Ω cable, so as to have no standing waves.

Reverting to Fig. 2, suppose we knock off the 300-Ω load and the λ/4 length of cable nearest it, and substitute a 33.3-Ω load. This fits the 3-A, 100-V conditions at the point where it is connected, and the generator will not know what we have done. The input end of the line still looks like a 300-Ω resistance. What we have done, therefore, is to take advantage of the peculiarities of standing waves for the purpose of feeding a 33.3-Ω load under 300-Ω conditions. The cable is acting as a 3 : 1 transformer as well as a transmission line. But there is no need to have standing waves along the whole of it. Fig. 2 shows that a single λ/4 section is enough. A 1% change of frequency will not cause an appreciable difference in the working conditions over such a short length. For the rest of the distance 300-Ω cable should be used.

From our study of Fig. 2 the principle of the quarter-wave transformer just described should be clear. A load resistance of 3 R_0 at one end is transformed to $R_0/3$ at the other. If we multiply these end values together we get R_0^2. The same result would be obtained no matter what load resistance was used. Call it R, and the resistance to which it is transformed at the other end R′. Then $R'R = R_0^2$, so the required R_0 is $\sqrt{R'R}$. To make a 2,000-Ω load look like 80 Ω, then, what we want is a quarter-wave length of line having a characteristic resistance equal to $\sqrt{80 \times 2{,}000} = 400\ \Omega$.

Reactances Made Here

But what if the load includes some reactance? This can be brought within the foregoing scheme, because a mixed impedance can always be represented as a pure resistance in parallel with a pure reactance. And the reactance can always be cancelled out by connecting in parallel an equal reactance of the opposite kind.

This is where we can be very cunning, taking advantage of the fact that lengths of line other than multiples of λ/4 are reactive. I have already pointed out that if they are either open- or short-circuited they are bound to be pure reactances, because there is nowhere for power to be dissipated. Suppose we short-circuit the end of our 100-Ω cable with 2 A at 200 V coming along it. No voltage can be established across a short-circuit to oppose the arriving 200 V, so the whole of it occupies itself by driving −2 A in the opposite direction. Now 2 A arriving and −2 A going is equivalent to 4 A arriving, so that is the current flowing through the short circuit. The reflected wave is equal to the original wave, and at the shorted end the voltages cancel out and the currents double. At a distance of λ/4 the opposite takes place; the voltage is 400 and the current is 0, so the input impedance of a quarter-wave "hairpin" is infinitely great (or, in practice, very large). In fact, it can be used as an insulator for that particular frequency, notwithstanding that its d.c. resistance is negligible.

These facts can be shown with vector diagrams, as in Fig. 4. The condition at the end is at (a), with the reflected voltage *v* cancelling V, and the reflected current *i* doubling I. At a λ/4 distance, V is quarter of a cycle earlier and *v* is quarter of a cycle later, so they add up to double, as at (b), where the situation is reversed. The diagram for half-way between, at λ/8, is like (c), where the resultants or net voltage and current are shown dotted. The thing to note is that they are exactly at right angles to one another, which is what happens with a pure reactance. And the current is lagging the voltage, which means the reactance is inductive. If you draw the vector diagram for other intermediate points you will find that they all indicate pure inductive reactances, but that the value varies from 0 to ∞ as you move from the shorted end. Similarly an open-circuited piece of cable not exceeding λ/4 in length gives every possible value of capacitive reactance. These "stubs" are very much used in feeder systems for cancelling unwanted reactances.

Loss Resistance

One could go on *ad lib* about the various practical devices and dodges based on standing-wave phenomena, but let us give some attention to one aspect of the matter we have conveniently ignored hitherto—the loss resistance. Part of it is contributed by the actual resistance of the wires or tubes, but of course the usual sources of r.f. loss such as dielectric loss

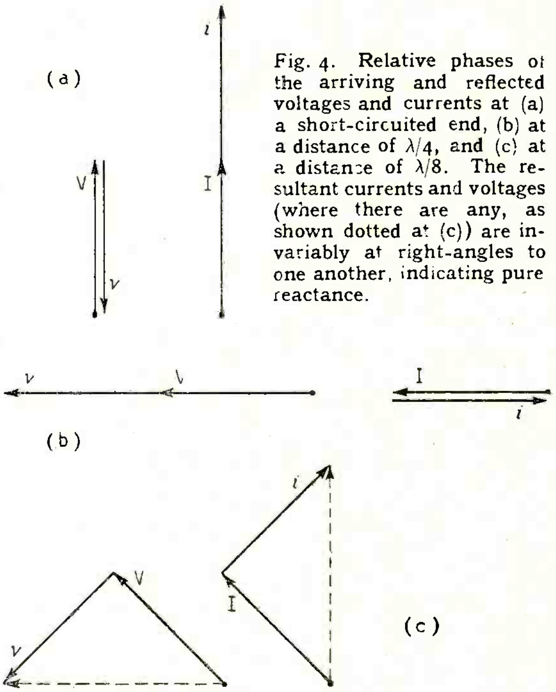
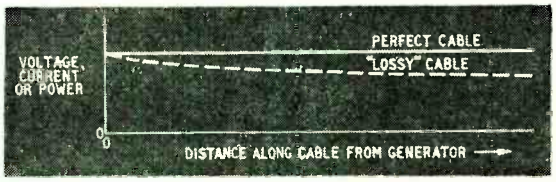


Fig. 4. Relative phases of the arriving and reflected voltages and currents at (a) a short-circuited end, (b) at a distance of λ/4, and (c) at a distance of λ/8. The resultant currents and voltages (where there are any, as shown dotted at (c)) are invariably at right-angles to one another, indicating pure reactance.

Fig. 5. The full line represents the constant signal level along a loss-free perfectly matched cable, and the dotted curve shows the exponential fall-off due to uniformly distributed loss.



and radiation can be represented in an inclusive resistance figure. Fortunately, the cable has to be very bad before loss resistance makes much difference to R_0, except perhaps to throw in a little reactance. But although the loss resistance of reasonably good cables can usually be ignored in connection with R_0, it does not follow that it can be ignored altogether. Its most important effect is to take a rake-off from the power flowing along it. This is usually expressed in db per 100 feet. If, say, 20% of the power (approx. 1 db) is absorbed in the first 100 feet, the second 100 feet absorbs 20% of that, or 16% of the original, and so on, giving an exponential die-away curve, like the dotted line in Fig. 5, compared with the straight and level line representing a theoretical perfect cable. The reflected waves, if any, also decline in this way, so that if the cable is long their effect by the time they reach the generator may be a good deal less than in the foregoing theoretical calculations.

Another simplifying assumption we have been making is that the resistance of the generator is equal to R_0, so that reflected waves are completely accepted by it. The generator resistance affects the reflected wave just as the load resistance affected the original wave; so if it is not equal to R_0 part of the reflected wave will be reflected again; part of that will be reflected at the load, and so on. If there is a big mismatch ratio at both ends, and the line is low-loss, and of such a length as to bring all the travelling waves more or less into phase with one another, very large voltages and currents can build up at $\lambda/2$ intervals. If a transmitting aerial becomes disconnected in a gale, the first symptom may be sparking across the line due to this build-up. The phenomenon is analogous to the signal magnification obtained with a low-loss tuned circuit.

It is very easy to get the idea that mismatching at the generator end would alter the standing wave ratio. But this is quite wrong. The waves reflected at the generator travel down the line towards the load at the same speed as the original waves; and, depending on their phase, have the effect of increasing or reducing the total voltage and current going in that direction. But the same thing could be done by altering the generator voltage, and nobody who has studied the thing at all would imagine that doing so would alter the proportion reflected by the load. So the standing wave ratio still depends only on R/R_0, except of course in so far as it is reduced towards the generator end by line loss, which causes the reflected wave to become weaker in proportion to the original wave.

Lastly, for the benefit of readers who disapprove of the "it can be shown" style of these two articles, I have provided an appendix (left) setting out the calculations in full.

APPENDIX

E = e.m.f. of generator
r = internal resistance of generator
V = voltage across } line, in the original wave
I = current in } line, in the original wave
v = rise in voltage due to mismatch at load end
i = current returned to line by v
R_0 = characteristic resistance of line
R = load resistance
ρ = standing-wave ratio
R_1 = input resistance of quarter-wavelength line terminated by R.

Line losses are neglected, and the authority for statements (1)—(4) below is Ohm's Law. It may be helpful to take another look at Fig. 1.

$$V = \frac{ER_0}{R_0 + r} \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

$$I = \frac{V}{R_0} \text{ and } \frac{V}{I} = R_0 \quad \ldots \quad \ldots \quad (2)$$

$$\frac{v}{i} = R_0 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

$$\frac{V + v}{I - i} = R \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

Substituting $\frac{V}{R_0}$ for I (2) and $\frac{v}{R_0}$ for i (3) in (4):—

$$\frac{V + v}{\frac{V}{R_0} - \frac{v}{R_0}} = R$$

$\therefore \frac{V+v}{V-v}$ (which, by definition, $= \rho$, and, since the currents are proportional to the voltages, $= \frac{I+i}{I-i}$)

$$= \frac{R}{R_0} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

Standing-wave Ratio

$$\therefore (V + v)\, R_0 = (V - v)\, R$$
$$\therefore v\,(R + R_0) = V\,(R - R_0)$$

$\therefore \frac{v}{V}$ (which from (2) and (3) $= \frac{R_0\, i}{R_0\, I} = \frac{i}{I}$)

$$= \frac{R - R_0}{R + R_0} \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

Reflection Coefficient

Repeating (4), $R = \frac{V + v}{I - i}$

Owing to 180° phase displacement along the $\lambda/4$ line,

$$R' = \frac{V - v}{I + i}$$

From (5) $V - v = \frac{R_0}{R}(V + v)$ and $I + i = \frac{R}{R_0}(I - i)$

$$\therefore R' = \frac{V + v}{I - i} \cdot \frac{R_0}{R} \cdot \frac{R_0}{R}$$

$$= \frac{R_0^2}{R}, \text{ and } R_0 = \sqrt{R'\,R} \quad \ldots \quad (7)$$

Quarter-wave Transformer

NEW TEST RECORDS

A SERIES of special recordings, pressed in material with low intrinsic background noise, has been issued by the British Sound Recording Association for test and demonstration purposes. The subjects are as follows:

PR100. History of the gramophone, a concise summary by Leo Watts.

PR101. Unaccompanied violin, without distracting rhythmical pattern or melody, for judging quality of reproduction at high frequencies

PR102. Unaccompanied bass viol (bowed and plucked strings) for low-frequency tests.

PR103. Test frequency record with bands at 1 kc/s intervals from 10 kc/s to 1 kc/s, 500 c/s, 200 c/s, 100 c/s and 50 c/s, each of 12 seconds' duration, preceded and followed by 20-second 100 c/s reference bands.

Enquiries should be addressed to the Hon. Librarian, B.S.R.A., 9, Stanton Road, West Wimbledon, London, S.W.20.

New Scanning Circuit

Line-Scan Current Generator

By **P. R. J. COURT,** Grad.I.E.E. (Pye, Ltd.)

ONE of the major advances in the design of domestic television receivers in recent years has been the introduction of a.c./d.c. technique, thus permitting the elimination of the bulky and expensive mains transformer. This is now almost universal practice, together with the technique of deriving e.h.t. for the c.r. tube from the line-scanning circuit.

For the line time base to function satisfactorily with the limited h.t. voltage imposed by a.c./d.c. operation, and at the same time to supply e.h.t., it is generally necessary to use an energy-recovery stage employing an "efficiency diode" (or triode). The diode converts some of the energy stored in the inductance of the deflection system after the trace period, into useful deflection power. It contributes approximately the first 20 per cent to 40 per cent of the trace current, the actual proportion being a function of the losses of the system. The theoretical limit for an ideal system with no losses, is 50 per cent.

In order to realize maximum efficiency and optimum linearity, the output valve should be "cut off" for the period during which the efficiency diode is operating. When the diode portion of the trace is complete, the output valve is arranged to start conducting, and supply the remainder of the trace current.

Although such circuits have already been treated very fully by other writers,[1, 2] it is of advantage at this point to describe briefly the operation of a simple sawtooth-driven line-scanning circuit, employing an efficiency diode, as in Fig. 1.

A positive-going sawtooth voltage, generated by some external oscillator, is applied to the grid of the output pentode V_1 which works into a load consisting mainly of the deflector-coil inductance, reflected back via the output transformer T. V_1 is biased so that the first part of the sawtooth waveform, which corresponds to the diode portion of the trace current, is beyond "cut-off." This is illustrated in Fig. 2 (a).

The anode current, and hence the current in the deflector coils L_1, L_2, increases linearly at a rate governed by the linear rise of grid voltage. Under these conditions, the pentode is working as a "constant-current" generator, the current rise being substantially independent of the load impedance. The current increases until the grid is rapidly returned beyond cut-off by the sawtooth flyback. The stored magnetic energy causes a free oscillation to ensue, at the natural resonant frequency of the system, the first half-cycle of which provides the current retrace. The deflector-coil current reverses, reaching a maximum value in the opposite direction, determined by the Q factor of the resonant circuit.

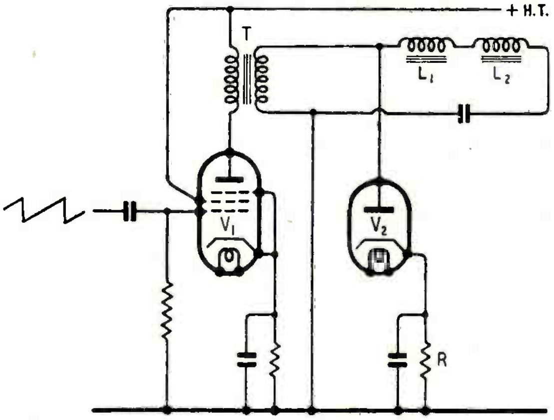
At this point, the free oscillation is halted by the action of the efficiency diode V_2, the anode of which is driven positively as the second half-cycle commences. The diode then presents a low impedance in parallel with the deflection system, through which the current decays exponentially. It is this decay of current, the greater part of which approximates to a linear change, which provides the first part of the trace. As it approaches the minimum value, the output valve takes control once more, supplying the balance of the trace current. Fig. 2 (b) shows the approximate current relationships in the deflection system.

Corresponding to the linear rise of deflection current, a steady positive voltage is developed across the major inductive component of the deflector-coil impedance, plus a small sawtooth voltage due to the minor resistive component. During the current retrace, a large amplitude negative pulse of approximately semi-sinusoidal form occurs. The deflector-coil voltage waveform is shown in Fig. 2 (c).

The diode conducts during the trace period, developing a steady automatic bias across its by-passed cathode-load resistance R, the voltage being approximately equal to the anode potential during the mean trace period. It is, of course, cut off during the retrace period.

The average diode conduction is controlled by the value of the cathode-load resistance. Ideally it is

Fig. 1. Simple sawtooth-driven line-scanning circuit employing an efficiency diode to start the deflection.



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[1] A. W. Friend, "Television Deflection Circuits" (Parts I and II), *R.C.A. Review*, Vol. VIII, No. 1, March, 1947

[2] O. H. Schade, "Magnetic Deflection Circuits for Cathode-ray tubes." *R.C.A. Review*, Vol. VIII, No. 3, September, 1947.

O. H. Schade "Characteristics of High Efficiency Deflection and High-voltage Supply Systems for Kinescopes," *R.C.A. Review*, Vol. XI No. 1, March, 1950.

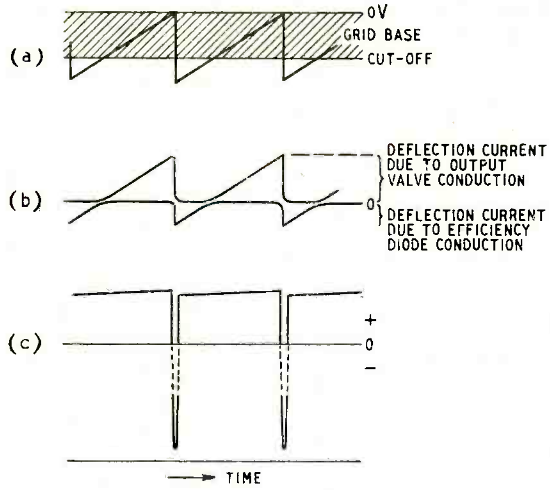
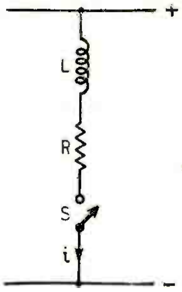


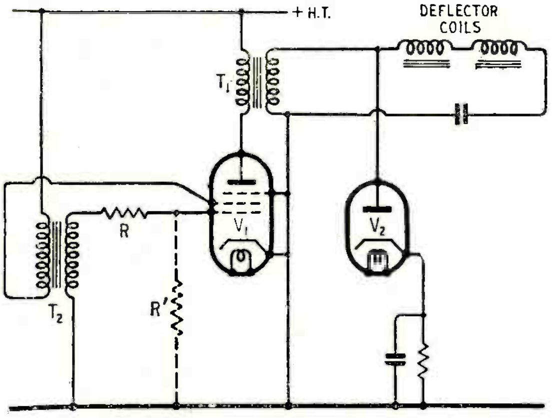
Fig. 2. (a) Sawtooth driving voltage in relation to grid base. (b) Current relationships in the deflection system of Fig. 1. (c) Voltage waveform appearing across the deflection system.



Right : Fig. 3. Basic circuit of a self-driven line-output stage.

necessary to control the instantaneous conduction during the trace period, otherwise the diode will tend to maintain a constant voltage across the deflection system; i.e., to eliminate the sawtooth component which must be present if the current waveform is to be acceptably linear. Better results are obtainable with a triode rectifier (for example the 6AS7G, which was specially developed for this purpose), the conduction of which is readily controlled by the application of a suitable waveform to its grid. If, for reasons of economy, it is necessary to employ a diode, a compromise may be made by inserting a controlling voltage in series with it. The voltage may be developed by the output valve and transferred by a suitable impedance network to the cathode of the diode. By suitably adjusting the magnitude and phase of the controlling voltage, the linearity of the trace may be adjusted to the optimum. The circuit of Fig. 7 employs a diode controlled in this manner.

Fig. 4. Basic diagram of the new scanning circuit.



For economic reasons, it is clearly advantageous to dispense with the separate sawtooth generator needed for the arrangement of Fig. 1 and to employ a self-driven circuit. The omission of a separate oscillator valve and its associated components contributes materially towards reducing the overall cost of the television receiver, and if this can be achieved without sacrifice of performance, the economy is entirely justified.

The design of a self-driven line-scanning circuit is attended with three additional problems which must be overcome if its performance is to be not inferior to that of a conventional separately-driven circuit.

With the latter, it is a relatively simple matter to achieve the desired balance between diode and output valve conduction. For example, it is apparent from Figs. 1 and 2 (a) that the instant at which V_1 starts to conduct may be readily controlled by a simple adjustment of its bias and/or the amplitude of the applied sawtooth waveform. In the case of a self-driven circuit however, this constitutes an important design problem.

Self-driving Operation

In general, the self-oscillating type of line-output stage is arranged as a switching device, as in Fig. 3. L represents the inductance of the deflector coils reflected back via the output transformer. R represents the total circuit resistance including the internal resistance of the valve, while S represents the valve acting as a switch. When S is closed the current through L rises exponentially in accordance with the expression :—

$$i = I\,(1 - e^{-tR/L})$$

For the current rise to be substantially linear, the time constant of the circuit, L/R, must be long compared with t, the time duration of one scanning cycle. The limiting factor is R, which consists mainly of valve resistance, and which should clearly be as low as possible. This imposes rather severe limitations upon the choice of valves which may be satisfactorily used in such a circuit, unless considerable non-linearity is tolerable.

The tendency for the controls to be interdependent (i.e., amplitude control affecting frequency, etc.) is a difficulty common to all self-driven circuits. It is very desirable that this disadvantage should not be present in a commercial receiver, for in the hands of a non-technical viewer, the setting up of such controls can be very exasperating.

The circuit described below is a self-driven line-scanning output stage, for use in conjunction with an efficiency diode, which overcomes all of the problems outlined above, and which has a performance at least equal to that of an equivalent, separately driven circuit.*

The basic circuit of the time base is shown in Fig. 4. The oscillatory circuit is between the screen and control grids of the output pentode V_1. The turns ratio of the oscillator transformer T_2 is approximately 1:1. This transformer has a low Q at its

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* Patent Application No. 11409/49.

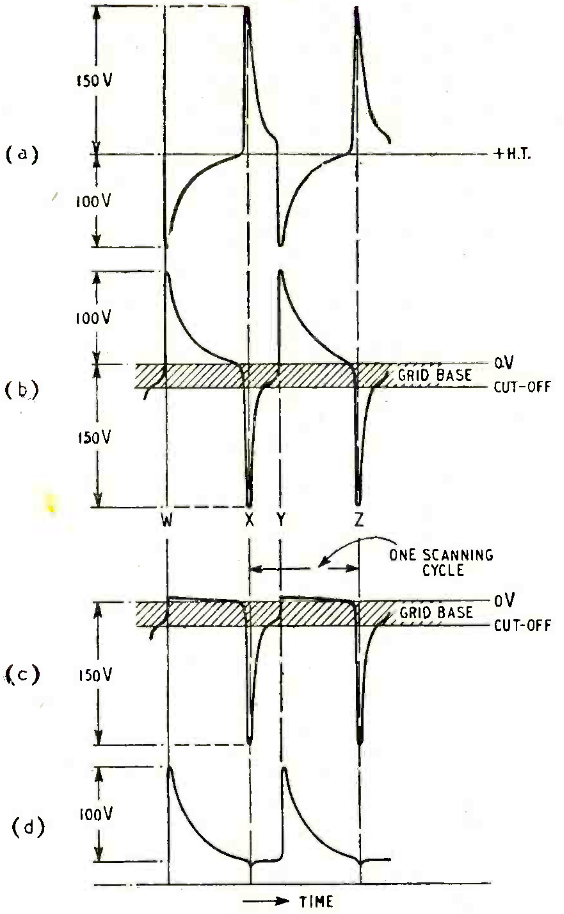
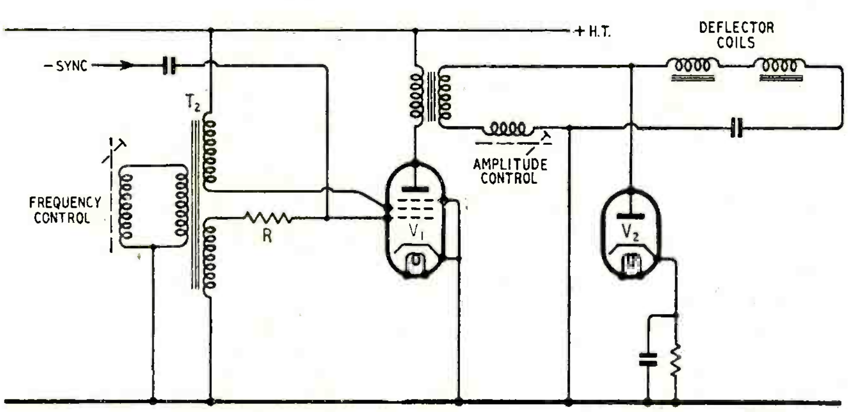


Fig. 5. Voltage waveforms encountered in the oscillatory circuit of Fig. 4. At (a) is shown the voltage at the screen-grid (that is, across the primary of T_2), at (b) the secondary voltage of T_2, at (c) the grid voltage and at (d) the voltage across R. This last is the difference between the voltages of (b) and (c).

Fig. 6. Method of controlling amplitude and frequency by inductances, and of applying sync pulses.



natural resonant frequency, which is in the region of 40 to 50 kc/s. V_2 is the efficiency diode.

The operation of the circuit may best be understood from a study of Fig. 5, which shows the voltage waveforms encountered in the oscillatory circuit, commencing at the point where the grid approaches the potential at which the valve starts to conduct (point W along the time axis). The screen-grid current will cause that electrode to go more negative, while the voltage across the transformer secondary will consequently become more positive and so on. The valve will thus rapidly reach an unstable limiting condition, with the screen grid at a low potential, and the voltage across the transformer secondary highly positive.

The control grid will endeavour to follow the positive excursion of the secondary of T_2, but due to grid current flow, will have a low impedance represented by R′. R and R′ form a potential divider, where $R \gg R'$, so that the grid potential will remain almost constant at slightly above zero volts during the positive excursion of the transformer secondary. With the grid slightly positive, the primary circuit appears as an inductance, L_p (the primary inductance of T_2), in series with a resistance, R_i (the internal screen-cathode resistance of the valve), and the voltages developed across the windings of T_2 will decay at a rate controlled by the primary "time-constant," L_p/R_i. (R_i will actually vary during this period, so the term time-*constant* is perhaps a misnomer.) The screen-grid potential will rise, and the secondary potential will fall. The control grid potential will also fall, only very much more slowly due to the effect of $R - R'$.

A condition is reached when the grid potential falls below zero volts, and the grid impedance R′ becomes very high. The screen-grid current then rapidly falls to zero, and a large positive potential appears across the primary of T_2, the rate of rise being controlled by the resonant frequency of the transformer. Correspondingly, a large negative potential is developed across the secondary. The grid is able to follow the negative excursion of the secondary, because it now has a high impedance, and the valve is thus cut off.

These voltages actually represent the first half-cycle of a heavily damped oscillation which follows from the instant of cut-off. The return function is rather complex, being partly sinusoidal, modified by the heavy damping across the windings due to the low circuit Q. As the grid voltage enters the conducting region, the waveform flattens off as the additional damping of the output valve comes into play.

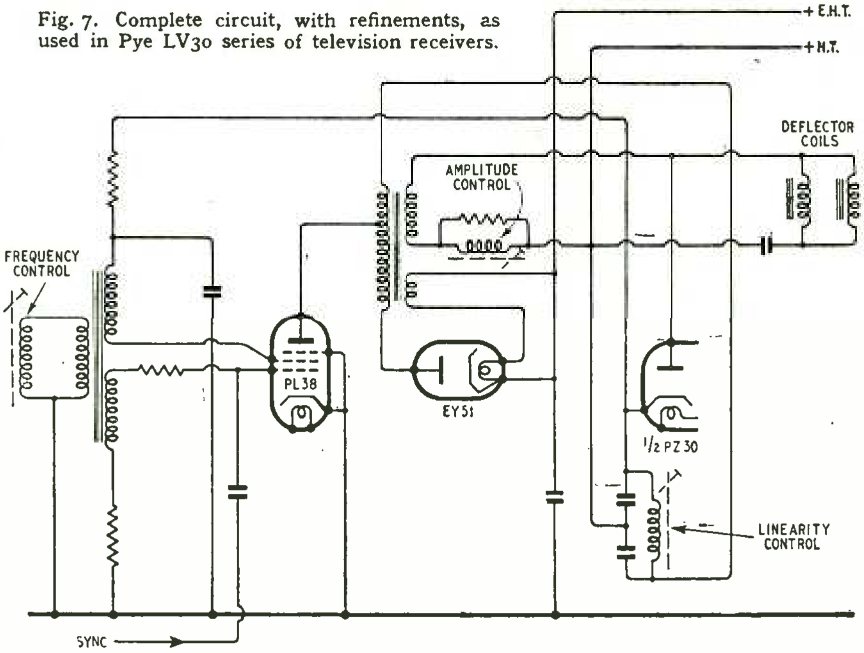
A condition is finally reached when the output valve takes control once more, and the operation repeats itself (point Y).

The complete cycle, so far as the actual scan is concerned, is from X to Z, with the valve cut off from X to Y, and conducting from Y to Z.

The relative durations of the periods of conduction and cut-off are governed by a number of factors, including the negative bias due to the d.c. component of the grid current flowing through R_1 and the turns ratio of the oscillator transformer T_1.

By a suitable adjustment of these factors, the valve conduction time may be made exactly correct to suit the losses of a particular deflection system, and a satisfactory balance made between the portion of the trace supplied by the output valve and that furnished by the diode.

Fig. 7. Complete circuit, with refinements, as used in Pye LV30 series of television receivers.



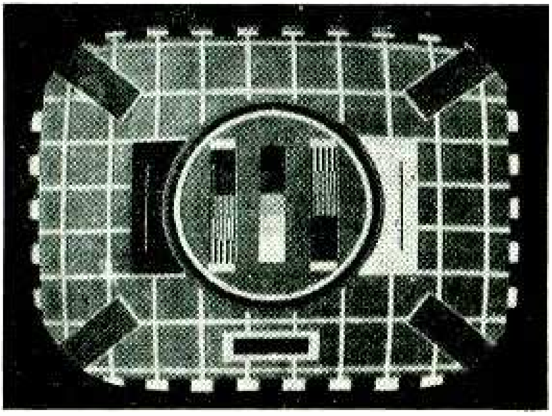
It will be seen from Fig. 5 (a) that during the conduction-time of V_1, the screen-grid potential is rising. This has a very desirable effect upon the anode current, compensating to a large extent for the non-linear rise of current which would otherwise occur. This linearizing effect of the screen-grid waveform considerably eases the impedance requirements for the output valve and permits the use of almost any type of line output pentode or tetrode.

Any other irregularities in the scanning waveform are reduced by the action of the efficiency diode, and the sawtooth current delivered to the deflector coils is linear within 5 per cent. A fair impression of the degree of linearity can be obtained from Fig. 8, which is a photograph of a familiar test pattern displayed on the screen of a receiver incorporating the circuit.

More Efficient

The repetition frequency is governed mainly by the "time constant" of the circuit during the conduction period, and control of frequency is effected by varying the inductance of the windings of this transformer. This may be achieved either by varying an air gap in the magnetic circuit or, preferably, by varying an inductance in parallel with one of the windings. The variable inductance may be made of smaller and more practicable proportions, if it is connected across a separate small winding arranged on the oscillator transformer, as in Fig. 6. The variable inductance may be a simple wave-wound coil with adjustable dust-iron core.

Fig. 8. Photograph of a test pattern on the screen of a television receiver incorporating the new scanning circuit, indicating the degree of linearity obtained.



The scan amplitude is preferably controlled by means of a variable inductance in series with the deflector coils as in Fig. 6. The two inductances may be made of identical construction. As the oscillatory circuit is apart from the anode, variation of amplitude in the anode circuit has no appreciable effect upon the frequency.

Synchronizing is effected by feeding negative-going pulses into the grid circuit as shown in Fig. 6. These initiate the negative grid excursions at points X and Z in Fig. 5.

It is found that this type of scanning circuit is about 25 per cent more efficient than an ordinary sawtooth-driven output stage, using identical power valves and energy recovery circuits, due to the fact that the grid is slightly positive during the entire conduction time of the valve; the circuit is therefore particularly suitable for use in an a.c./d.c. television receiver, where the h.t. voltage is limited.

The bias voltage developed by the efficiency diode may be used to boost the h.t. supply to the output valve by any of the usual methods, and e.h.t. may be derived from the flyback voltage developed across the scanning output transformer in the conventional manner.

Fig. 7 shows the complete circuit, including refinements such as h.t. boost for the output valve, flyback e.h.t. supply, and a linearity control as used in the Pye LV30 series of television receivers.

Acknowledgment: The author would like to thank L. Lax, D. Ing. A.M.I.E.E., (Pye, Ld.) for his valuable technical advice during the development of the circuit.

WORLD OF WIRELESS

Another Frequency Conference ◆ Radar Volunteers Radio or Cable? ◆ Wrotham Television Station?

Frequency Allocations

A GIGANTIC task faces the delegates attending the Extraordinary Administrative Radio Conference which, opening at the Hague on 1st September, will be attended by representatives of the 64 member countries of the International Telecommunication Union. They have to complete and approve frequency allocation plans for the majority of services—aeronautical, maritime, broadcasting, etc.—in the various bands throughout the spectrum.

The Atlantic City Conference of 1947 divided the spectrum between the various services and made provisions for the setting up of planning bodies to prepare schemes for the allocation of frequencies within these bands to individual countries or users. It was originally intended that the task of the Hague Conference would, in general, be limited to approving these plans, but it now appears that in some cases completely new schemes will have to be drawn up at the Conference.

With some services it is possible for allocations to be made on a regional basis, but with h.f. broadcasting (extending from 5.95 to 26.1 Mc/s), for instance, it has to be global. A plan has, however, been drawn up on a frequency-sharing and time-sharing basis as a result of conferences held in Mexico, Florence and Rapallo. One of the main difficulties, however, with this and other such plans, and especially that for the fixed services, is that they are based not on present needs but on anticipated requirements for some years to come.

It should be pointed out that the Conference will not be considering the European medium- and long-wave broadcasting bands, which were, of course, covered by the Copenhagen Conference.

Radar Reporting

THE formation of a Radar Reporting Unit, with its headquarters in London, is announced by the Air Ministry. This Unit, which will be known as No. 3700 (County of London) R.R.U., is being raised as part of the R.A.F. Control and Reporting System, and will be concerned with the operation and maintenance of "Chain Home" radar stations.

Men and women living in London and the Home Counties with some technical knowledge of radar, and especially members of the Radar Association, who are prepared to devote a few hours a week to training, are invited to call at, or write to, the Unit's headquarters at 77, Hallam Street, London, W.1. The commanding officer is Group Capt. E. Fennessy, O.B.E., director of the Decca Navigator Co., whose wartime service was largely devoted to the development and operational problems of radar navigational aids. He will hold the R.Aux.A.F. rank of Wing Commander.

Extending Television

THE site has now been chosen for the last of the chain of five high-power television stations. The transmitter to serve the Bristol Channel area will be erected at St. Nicholas, near Cardiff, Glam, and will be linked to the London studios by cable.

The laying of a co-axial cable between Birmingham and Manchester, where it is to be extended to Holme Moss, has led to the rumour that future stations will not be linked by radio. The fact is that a co-axial cable linking Birmingham and Manchester was planned by the Post Office for telecommunications, and it was therefore decided to add the necessary circuits to provide the television link. It is understood that the link between Holme Moss and the Scottish transmitter will be by radio.

New London Station?

WHEN originally announcing the plan for extending the television service, London was included in the chain of high-power stations. By comparison with the Sutton Coldfield station, and those planned for Holme Moss, Kirk o'Shotts and Cardiff, the Alexandra Palace transmitter is of low power. This fact has prompted the South Coast Televiewers' Association to start a campaign for a new high-power transmitter for London. The proposal is that the station erected at Wrotham, Kent, for experimental e.h.f. transmissions on both a.m. and f.m., should be equipped for television. The 470-foot mast, which is similar to that in use at Sutton Coldfield, is over 1,200 feet above sea level.

It is also stressed by the campaigners that the B.B.C.'s lease of the Alexandra Palace expires in 1956, by which time part of the new White City studio centre will be in use, but that will not solve the transmitter problem for which no provision is made in the White City plans.

The fact that Wrotham was recently used to provide the radio link between Southend and London for a television programme adds weight to the argument that the proposed station could readily be linked by e.h.f. radio with the studio centre.

Training Servicemen

WITH the object of assessing the need for service technicians in the television areas a census of servicemen on the staffs of dealers is being undertaken by the British Radio Equipment Manufacturers' Association. Having assessed the need, suitable action can then be taken by the association to stimulate the provision of training facilities.

Meanwhile the R.I.C., in co-operation with the Ministry of Education, is organizing a short course at the Regent Street Polytechnic for full-time and part-time teachers of radio and television servicing in technical colleges—64 of which run courses at present. The lectures, which have been arranged with a view to increasing teachers' background knowledge of the industry, will be given mostly by well-known members of the industry. The course will also include visits to factories and manufacturers' training centres.

PERSONALITIES

Frederick E. Terman, Dean of Engineering at the Stanford University, U.S.A., and author of a number of books including "Radio Engineering," has been awarded the Medal of Honour of the American I.R.E. "for his many contributions to the radio and electronics industry as teacher, author, scientist and administrator."

J. H. D. Ridley has been appointed head of the B.B.C.'s Engineering Secretariat, the section dealing mainly with the control of expenditure in the Engineering Division, in succession to F. Williams, now Superintendent Engineer (Studios).

F. Butler, B.Sc.(Hons.), M.Brit.I.R.E., has been appointed in succession to J. W. Whitehead, M.Brit.I.R.E., as examiner in radio transmission by the British Institution of Radio Engineers. They are both known to readers of *Wireless World.*

E. T. A. Rapson, M.Sc., M.Brit.I.R.E., has been appointed by the Brit.I.R.E. as examiner in mathematics which is to be a compulsory subject for graduateship from May, 1951. Since 1933 he has been on the staff of the Southall Technical College, first as head of the radio engineering department and for the past five years as head of the combined radio and electrical engineering departments.

OBITUARY

Alfred Clark, who was one of the founders of the group of companies controlled by Electric and Musical Industries, died on June 16th at the age of 76. He was an American by birth and commenced his career in the organization set up by Edison to start the American gramophone industry in 1890. From 1900 until his retirement in 1946 he held responsible positions in the Gramophone Co. (H.M.V.), being chairman or managing director for 38 years. He became a British subject in 1928.

IN BRIEF

Broadcast Receiving Licences current in Great Britain and Northern Ireland at the end of May totalled 12,219,250, including 386,750 television licences.

Australian Television.—Approval has been given by the Australian Government for the provision of an experimental 625-line television station in Sydney preparatory to establishing a television service in the Commonwealth. It is understood that the Government has approved in principle the participation of private enterprise in the development of television.

Increased Power.—The maximum power (150 kW) permitted under the Copenhagen Plan for the medium-wave (1,088 kc/s) B.B.C. Home Service transmitter at Droitwich is now being used instead of 60 kW as heretofore. The power of the Norwich transmitter radiating the same service has also been increased; from 2.5 to 7.5 kW. The permitted power for Norwich is 20 kW. The transmitter now being used at Droitwich is that which, prior to the introduction of the Copenhagen Plan, radiated the Light Programme on 1,500 metres.

Scientific Instruments.—During the annual exhibition organized by the Scientific Instrument Manufacturers' Association, which is being held from September 5th to 8th at the Examination Hall, Queen Square, London, W.C.1, a series of technical papers covering the development and use of a variety of scientific instruments will be read. Details of the lectures and tickets for admission are obtainable from the Scientific Instrument Manufacturers' Association, 17, Princes Gate, London, S.W.7.

I.E.E. Council.—As a result of the ballot for the vacancies occurring on the Council of the I.E.E. on the 30th September, the following members of the Radio Section have been elected to serve:— Sir Archibald J. Gill (Engineer-in-Chief G.P.O.), President; Harold Bishop (Chief Engineer B.B.C.), Vice-President; C. E. Strong (Standard Telecommunication Laboratories) and Dr. R. A. Smith (Telecommunications Research Establishment), ordinary members.

Committee of the I.E.E. Radio Section for the coming session, which begins in October, is announced by the Institution. The new Chairman is C. F. Booth (Staff Engineer-in-Charge of G.P.O. Radio Development Branch); Vice-Chairman, Dr. E. C. S. Megaw (Engineer-in-Charge of Radar Research at the Admiralty Signal and Radar Establishment); ordinary members, E. C. Cherry (City & Guilds of London Institute), C. W. Oatley (Engineering Laboratory, Cambridge University) who for the past few months has filled the vacancy caused by Dr. Booker's resignation, M. J. L. Pulling (B.B.C. Senior Supt. Engineer, Television) and P. H. Spagnoletti (Kolster-Brandes Ltd.).

Fellowship of the American Institute of Radio Engineers has been awarded to Prof. Willis Jackson, head of the Electrical Engineering Dept. of the Imperial College of Science and Technology "for his service as an educator and his many contributions to the literature in both the radio and electrical fields." It has also been awarded to Rudolph Kompfner "for his research in electron tube theory and particularly for his original contributions to the concepts of the travelling-wave amplifier." It was on this subject that he contributed to *Wireless World* in 1947.

Evening Classes.—Five courses of evening study for amateurs are to be held during the coming autumn and winter at the Literary Institute, Cranbrook Road, Ilford, Essex, by an arrangement between the R.S.G.B. and the Essex County Council education authority. The syllabus includes a six-months' course in preparation for the Radio Amateur's Examination (Wednesdays); refresher courses for newly licensed amateurs (Mondays and Tuesdays); a course covering television receiving technique (Mondays), and a class for morse and operating procedure. The fee for each of the courses is 5s for students living in the administrative area of the Essex County Council and 7s 6d for others. Applications must be made in the first instance to C. H. L. Edwards (G8TL), 10, Chepstow Crescent, Ilford, who is a member of the R.S.G.B. Council.

Development of a multiple aerial system for television and e.h.f. broadcasting for erection at the top of the Empire State Building in New York is being undertaken by R.C.A. The plan provides for the erection of five television aerials and three f.m. aerials on a 199ft column, bringing the overall height to 1,450ft above street level. Tests will be undertaken to ascertain the effects of simultaneous transmissions from all the aerials. The television aerials will transmit in the 60, 70, 80, 180 and 200-Mc/s bands.

Raw Materials.—We hope readers will forgive us for referring to our basic raw material—paper—but the annual report of the Waste Paper Recovery Association stresses that the recovery of waste paper—a prime contributor to the supply of paper-making raw materials—is a "permanent national need." During the war the paper salvaged rose to 61 per cent of the total paper consumed, whereas last year it dropped to 29 per cent.

Interference Suppression.—The British Automobile Association has asked its 920,000 members to "help in eleminating interference with television by fitting suppressors as soon as possible." The Association adds that the effect on the engine is almost negligible.

Plastics Exhibition.—The date and further details of the British Plastics Exhibition and Convention to be held at Olympia, London, next year, are announced by our associate journal *British Plastics*, which is organizing the show. The date is 6th to 16th June. The exhibitors will be British and Commonwealth firms who produce, mould or make plastics materials or supply raw materials or equipment to the plastics industry. The Convention will include lectures for technicians and the chemical and consumer industries, as well as lectures on such subjects as the use of plastics in the home.

BUSINESS NOTES

Decca Marine Radar, Type 159A, has been granted the Ministry of Transport's Certificate of Type Approval. Among the 200 ships fitted with this equipment since its introduction last September is the South-Eastern Gas Board's new collier *Mitcham*, on which the scanner had to be fitted to a special mast permitting it to be lowered when the vessel passed under the Thames bridges.

Ediswan exhibited for the first time their new Mark II 8-channel electroencephalograph at the technical exhibition held in connection with the Sixth International Congress of Radiology held in London in July. A feature of the model is the new design of moving-coil pen recorder.

Tannoy.—The assets, undertaking and goodwill of Tannoy Products have been acquired by Sound Rentals, Ltd., who have previously installed and rented Tannoy equipment. Guy R. Fountain, the founder of Tannoy, is chairman and governing director of the organization which will operate under the title Tannoy Products (Sound Rentals, Ltd.). The address is Canterbury Grove, West Norwood, London, S.E.27 (Tel.: Gipsy Hill 1131).

Midlands television service depot has been opened by A. C. Cossor, Ltd., in Baker Street, Handsworth, Birmingham, 21. The manager is R. G. Colby. It is planned to inaugurate a training school for television servicemen in the near future. The depot will not handle repairs to broadcast receivers, which will continue to be dealt with at the company's main service depot at 31, Corsica Street, London, N.5.

Philco-Thorn Agreement.—Under an arrangement recently made between Thorn Electrical Industries and the Philco Corporation of Philadelphia, radio and television sets will be manufactured in this country by Thorn to designs provided by Philco (Overseas), Ltd., who will distribute them.

Aerialite, Ltd., have brought into service vehicles equipped for undertaking field-strength tests, specially in television "fringe" areas, and for demonstrating television aerials.

G.E.C.—Three changes in the staff of the Radio Department, of which M. M. Macqueen is manager, are announced by the G.E.C. W. A. C. Maskell, who has been assistant manager for four years, is now deputy manager, R. G. E. Mayo is now assistant manager (broadcasting) and A. E. Potton, assistant manager (batteries).

Marconi's W.T. Co. announce that R. P. Raikes has been appointed Publicity Manager in succession to the late W. G. Richards.

Ediswan announce the appointment of R. K. Cox as manager of its Sheffield district office.

Belling & Lee have acquired a factory on the Netherton Trading Estate, Liverpool, for the manufacture of television aerials.

Aerial Installation Company, of which V. E. Hands, late of the B.B.C. Engineering Division, is director, has been formed to provide an aerial erection service in East Anglia. The address is Harvey's Yard, Rawstorn Road, Colchester, Essex (Tel.: Colchester 3288).

ELECTRONIC CIRCUITRY

SELECTIONS FROM A DESIGNER'S NOTEBOOK

By J. McG. SOWERBY

(Cinema-Television. Ltd.)

Reducing Drift in D.C. Amplifiers—1

THE interpretation of the letters " D.C." in the heading does not yet seem to be universally agreed. By some it is taken to mean " direct current," and by others " direct coupled," while others use both interpretations indiscriminately. However, all such amplifiers are intended to accept signal inputs down to zero frequency, and thus differ from the ordinary audio amplifier in which the amplification begins to fall off below some low frequency—generally in the region of 50 c/s.

The need to amplify signals well below 50 c/s arises in all sorts of applications as, for example, when it is required to record the variation of daylight falling on a photocell, or when studying the vibrations of a large mechanical structure such as a bridge or road. In such applications the signals may be so low in frequency as to be stated in cycles per hour or cycles per minute, rather than cycles per second. At the same time the same amplifier may also be called upon to amplify signals up to or exceeding 10 kc/s in some applications. In such cases it is only safe to assume the worst and build an amplifier capable of accepting zero frequency if necessary.

It is an unfortunate fact that all straightforward d.c. amplifiers suffer from " drift," or a more or less slow change in output even when no input is applied. The magnitude of this drift varies with different circuits, and a few of the well established anti-drift arrangements will be discussed here. As the subject is a large one and space is limited, it will only be possible to touch on a few major points, and there can be no pretence of completeness.

The way in which drift arises can be seen by considering the triode amplifier stage of Fig. 1. The valve is supplied with grid bias by a suitable battery and with h.t. by another (both assumed of perfectly constant voltage). An anode load R_a is provided and the voltage drop across it, due to the anode current I_a, is $I_a R_a$. The resistors R_1, R_2 are chosen so that the p.d. across R_1 is the same as that across R_a when no input is applied. It follows that initially there is zero p.d. across the output terminals 1, 2. When an input signal is applied, an amplified version of the instantaneous input p.d. appears across 1, 2; to which a c.r.t., a further amplifier stage, a microammeter, etc., may be connected. Provided the resistors remain perfectly constant in value there is perhaps no very obvious reason why the p.d across 1, 2 should not remain zero in the absence of any input. Unfortunately it does not, and more or less slow fluctuations of p.d. are found at the output, and these are termed drift. This difficulty does not arise if the stage is used as an audio amplifier because the output is then taken from the terminals 3, 4 coupled through the time constant CR. This time constant rarely exceeds one second, so that any slow changes at the anode are not transmitted to terminals 3, 4. It is the requirement to extend the frequency response to zero frequency, and the consequent need to dispense with C, that leads to drift being observed in d.c. amplifiers.

The drift may arise from a number of causes such as changes in the resistors with temperature and/or time, and changes in potential of the sources of supply. With sufficient care, drift from these causes can be almost eliminated, as constantan or manganin resistors can be used, and modern voltage stabilizers can be very stable indeed. Probably the most prolific source of drift is changes of temperature and/or emission of the cathode. The filament or heater could, of course, be supplied from a stabilized source, but high-current low-voltage stabilizers tend to be rather uneconomical unless a number of similar d.c. amplifiers are to be used simultaneously—as in multi-channel vibration recording, for example. For this reason a good deal of work has been done at various times and places, aimed at reducing the drift experienced with fluctuating cathode temperature or emission by the use of special circuits. In the best apparatus, or when the gain of the d.c. amplifier is very great, these circuits are often used together with a stabilized heater supply.

It was pointed out[1] some years ago that the cathode fluctuations of a practical valve can be represented by assuming it perfect—as far as its cathode is concerned—and inserting a fictitious generator (v in Fig. 1) in series with its cathode lead. Over a reasonable range about the rated heater supply voltage, the value of v is nearly proportional to the applied heater voltage. In Fig. 1 the heater is operated directly from the a.c. mains via a transformer, so that mains fluctuations will produce proportional fluctuations in the heater supply potential. The

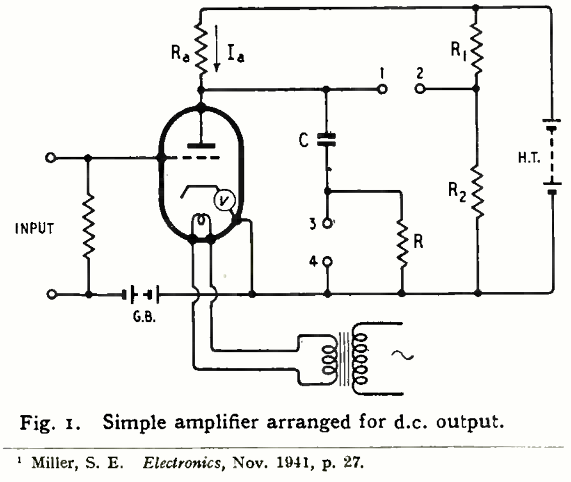


Fig. 1. Simple amplifier arranged for d.c. output.

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[1] Miller, S. E. *Electronics*, Nov. 1941, p. 27.

magnitude of the effect is considerable, and in Fig. 1 it might well be found that $v = 0.1$ volt for a 10-percent change in mains supply potential—this being a typical figure which varies somewhat from valve to valve. In Fig. 1, v appears directly between grid and cathode, and so a mains supply change of 10 percent is equivalent to a change of input of 0.1 volt. As this is subject to the full amplification of the valve (say 30) the drift at the output reaches the not inconsiderable figure of 3 volts. If a second stage with the same amplification were added the drift at the output would be 90 volts, in an amplifier with an overall amplification of only 900. Such drift is rarely tolerable, but by the use of special circuits the effect can be markedly reduced.

Bridge Circuits

Probably the simplest—and historically the first[2]—method of attacking this difficulty is by the use of a second valve to form the bridge circuit of Fig. 2. In this arrangement V_1 corresponds to the valve of Fig. 1, and V_2 is a similar dummy valve. If the anode currents in the two valves are equal, and if the anode loads are equal, there will be zero p.d. across 1,2 in the absence of any input. If now the heater potential changes slightly, a small voltage v will be introduced into the cathode lead of V_1, and a small voltage v' into that of V_2; in consequence the anode currents of the two valves will change. If $v = v'$ the changes in the anode currents will be the same in the two valves and the p.d. across 1,2 will remain unchanged. If, however, v and v' are unequal, the potential arising across 1,2 will be that corresponding to an input signal of $(v - v')$. As v and v' are unlikely to differ by more than 20 percent, the circuit reduces the effect of cathode fluctuations by a factor of at least five.

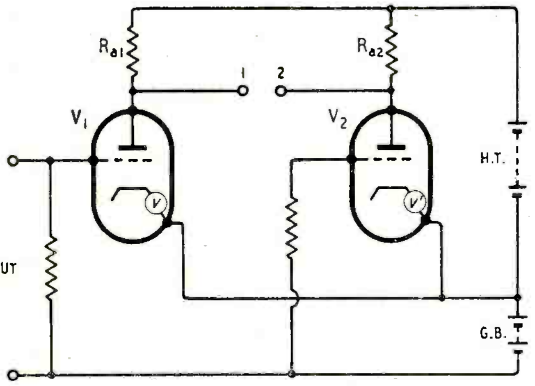
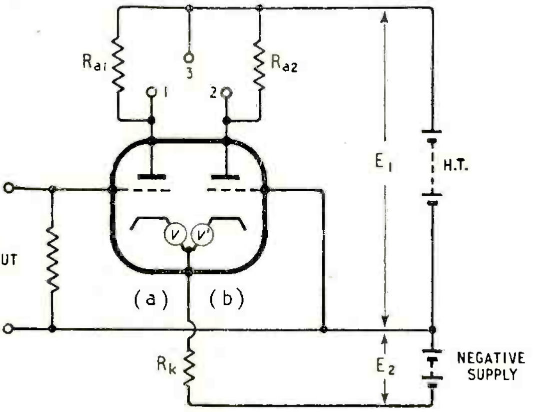


Fig. 2. Using a dummy valve (V_2) to form a bridge.

Fig. 3. Cathode-coupled double valve as a bridge.



By adjusting the operating conditions of the two valves this result could be improved, but another difficulty arises owing to the use of two separate valves having separate heater-cathode assemblies. With two such assemblies, there is no guarantee that the thermal time constants will be equal, so that a sudden small change in heater potential can lead to a transient drift lasting seconds or minutes. This may ultimately dwindle to zero as v and v' become equal after a period, but the transient drift that takes place during this equalizing process is nearly as troublesome as a steady change. The difficulty can be partially eliminated by the use of a double triode where two separate triodes are placed in the same envelope. Much better still is the use of a double valve arranged round a genuinely common cathode. There are few such valves available, but good results have been obtained with the American types 6SC7 and 12SC7. Not only does the common cathode ensure equal thermal time constants in the two valves, but also increases the likelihood of equality between v and v'. With such valves the effect of heater fluctuations can usually be reduced by a factor of 20 (or more, although this may necessitate selection of valves).

Single-ended Output

A similar anti-drift circuit is the cathode-coupled phase splitter shown in Fig. 3. In this circuit a stabilized negative supply, E_2, is provided to which the common cathode is connected through a large resistance R_k. When an input is applied, a nearly balanced push-pull output is obtained at the terminals 1,2. Like the previous circuit, that of Fig. 3 is a form of bridge, and if $v = v'$, the p.d. between 1,2 is not affected by heater fluctuations. If v and v' are unequal, the p.d. produced at 1,2 is that which would be obtained if $(v - v')$ volts were applied at the input. In a common-cathode valve, v and v' are not likely to differ by more than 5 percent in practice, and the amplification between input and output is:

$$A_{1,2} = \frac{\mu R_a}{r_a + R_a}$$

$$\text{Where } \left.\begin{array}{l} \mu = \text{amplification factor} \\ r_a = \text{anode resistance} \end{array}\right\} \text{of one section.}$$

$$R_a = R_{a1} = R_{a2}$$

So far the performance of the circuit in Fig. 3 is the same as that in Fig. 2.

It has been pointed out,[1] however, that the circuit in Fig. 3 also discriminates against heater fluctuations even when a single-ended output is taken between terminals 1,3 or 2,3, provided $v = v'$. The reason for this can be seen in the following way. The total cathode current of the valve is approximately E_2/R_k if E_2 is large compared with the grid base of the valve. If the heater supply voltage is changed it gives rise to an equivalent voltage v in the cathode lead, and this merely adds to E_2, so that the cathode

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[2] Brentano, J. C., and Ingleby, P. *J. Sci. Inst.*, Vol. 16, p. 81 (1939) and earlier references to work by J.C.B. given therein.

current increases to $(E_2 + v)/R_k$. If $E_2 = 100$V, and $v = 0.1$V (likely values) the cathode current changes by only 0.1 percent. Analysis shows that the factor by which the effect of heater fluctuations is reduced, as compared with the circuit of Fig. 1, lies between $g_m R_k$ and $(1 + g_m R_k)$, where g_m is the mutual conductance of one triode. If—as is usually the case—v is not quite equal to v' then, as before, it is as if $(v - v')$ were applied to the input. The amplification when used single-ended is about half that for the push-pull case, so that the expression above now becomes:

$$A_{1,3} \simeq A_{2,3} \simeq \frac{\mu R_a}{2(r_a + R_a)}$$

This circuit is particularly useful, as it can be used as a single-ended or push-pull stage; and in addition to the signal input grid, a second grid is available for zero setting or the injection of negative feedback.

(To be concluded)

SHORT-WAVE CONDITIONS

June in Retrospect: Forecast for August

By T. W. BENNINGTON

(Engineering Division, B.B.C.)

DURING June the average maximum usable frequencies for these latitudes decreased considerably during the day-time, and increased slightly by night. This is in accordance with the normal seasonal trend, which should, now that the summer solstice has been passed, undergo a reversal.

Day-time working frequencies for long-distance communication continued relatively low, though not perhaps so low as might have been expected. The higher short-wave frequencies, whilst they were seldom or never usable in east-west directions, continued to be well received over north-south paths. For example amateurs on the 28-Mc/s band, whilst not receivable from North America, came in well from South America and Africa, and the 26-Mc/s broadcasting band continued to give good service in many distant localities to the south, south-east and south-west of this country. Medium high frequencies were usable over a large part of the day and the lowest frequency necessary for night-time working was of the order of 12 Mc/s.

Medium-distance communication by way of Sporadic E continued to be very prevalent, and the 28-Mc/s amateurs made almost daily use of this phenomenon for "short skip" contacts with practically every country in Europe. Sporadic E was also responsible for the London television on 41.5 Mc/s being heard in Czechoslovakia and other of the more distant countries of Europe and for Swedish and Russian v.h.f. stations being frequently receivable in this country.

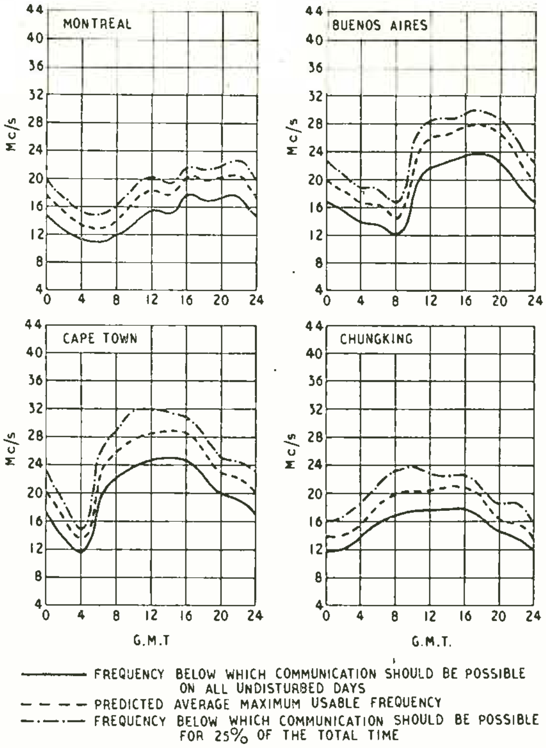
Sunspot activity was, on the average, much lower than during the previous month. The sunspot number for June was about 79, as compared with 122 for the same month of last year.

June was an exceptionally "quiet" month, the only severe ionospheric storm occurring on 24th-25th. Minor storms took place on 2nd, 6th, 9th-10th and 29-30th.

Forecast.—During August day-time m.u.fs should increase a little and those for night-time decrease somewhat, as compared with those for July.

Working frequencies for long-distance communication should, however, still be relatively low by day and high by night, and long-distance propagation on the higher short-wave frequencies is likely to be rare, except over north-south paths. Medium high frequencies should remain usable for a large proportion of the total time, and frequencies below 11 Mc/s should seldom be really necessary at night.

Medium-distance communication will be by way of the regular E and F, layers for a considerable part of the day, and relatively high frequencies, having regard to the distance, should be usable both by day and night. Sporadic E should continue to be prevalent—though somewhat less so than during the past two months—and medium-distance communication by way of it should frequently be possible on the higher frequencies. Ionospheric storms are not usually prevalent in August.



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

MECHANO-ELECTRONIC TRANSDUCER

AUTHORITY has been given for the importation of a limited stock of R.C.A. Type 5734 triode transducer valves. This valve, in which the anode is formed by a shaft projecting through a flexible metal window in the end of the tube, is a device for translating small mechanical displacements into current or voltage variations. With an anode load of 75,000 Ω the sensitivity is 40 volts per degree of deflection; the mechanical resonance of the free cantilever structure inside the valve is 12 kc/s.

It is intended that the valves should be used by research organizations and colleges, and many applications are being found for them in surgery, as well as in optics and vibration studies. Enquiries should be addressed to R.C.A. Photophone, 36, Woodstock Grove, London, W.12.

From Television Aerial to Receiver

Relation Between Field Strength and Receiver Sensitivity

By F. R. W. STRAFFORD, A.M.I.E.E. (Belling & Lee, Ltd.)

THE B.B.C. has published a contour map[1] of television field strengths covering the area served by the Alexandra Palace transmitter. In fact, field strengths have been recorded beyond the normal service, but good care has been taken to indicate that reception in such districts may be variable and/or uncertain.

The published field strengths for a given locality are average; that is to say, a continuous record of field strength in a particular location has been taken, and a mean is drawn through the chart. Also, the field strength is corrected to that which will obtain at a height of 30 feet from the ground to the centre of a dipole. The meaning of field-strength figures in terms of receiver sensitivity depends on the type of aerial and the length and kind of feeder used for connecting to it and it is not always clear how the one can be interpreted in terms of the other. A simple formula connecting the two can be derived and in what follows it will be assumed that the field strength given in the final empirical formula is that obtaining at a height of 30 feet. Generally, outdoor television aerials are installed at a greater height, but as the variation of field strength with height is by no means linear in built up areas it is hopeless to introduce an appropriate correction factor.

The Simple Dipole

Experience has shown that, generally, the formula provides a somewhat lower figure than that obtained by measurement; this is all to the good, however.

The simple conventional dipole consists of a cylindrical conductor nearly one half-wave in length at the operating frequency. Its length is great compared with its diameter and it is split at the centre, the e.m.f. generated between the tips being transferred, by means of a low impedance feeder, to the receiver.

Although we visualize tuned circuits as combinations of coils and capacitors in the strictly physical sense in which we know them, the dipole is a sort of tuned circuit in which the inductance, capacitance and resistance is distributed as indicated in Fig. 1, this immediately suggests transmission-line theory to the reader and, indeed, the dipole is a special form of transmission line possessing high characteristic impedance and radiation loss.

Providing the electromagnetic field is uniform, and its electric vector lies parallel to the axis of the dipole, the magnitude of the e.m.f. generated between the inner tips of the aerial can easily be calculated to a close degree of approximation. That this is so is confirmed by various experiments details of which need not be given here.

It will be noted from Fig. 2, that the current and voltage induced in the dipole are distributed in amplitude somewhat as shown by the dotted curves. One would expect this, because it would be surprising to find current at the outer tips. On the other hand one would expect these tips to be "hot" in the voltage sense.

If, by some miracle, the current distribution could be maintained constant throughout the length of the dipole then a field of E volts per metre would obviously generate an e.m.f. equal to the field strength multiplied by the length of the dipole. For the half-wave dipole the generated e.m.f. would be given by:

$$e = \frac{E\lambda}{2} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

wavelength λ (of course) being given in metres.

Now, if the diameter of a half-wave dipole is quite small compared with its length, the classical theory shows that the current and voltage distribution are almost exactly sinusoidal in amplitude over its length. Therefore, the e.m.f. generated must be the mean value of this sine curve which is given by:

$$e = \frac{1}{\pi}\int_0^\pi \sin\theta . d\theta = \frac{2}{\pi} \quad \ldots \quad \ldots \quad (2)$$

Hence, the e.m.f. generated in the dipole, in terms of the incident field strength, is obtained by multiplying equations (1) and (2) which gives:

$$e_D = \frac{E\lambda}{\pi} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

Now this is the open-circuit e.m.f. which would exist between the adjacent points at the centre of the dipole if it could be cut and the parts separated without altering the current. The dipole, however, must be terminated by a resistance equal to the resistance (at the centre) of the dipole and, as is well known from elementary theory, the voltage will then fall to half the value when matched for maximum power transfer.

The matched output from the dipole is that which will obtain when a resistive load of about 73 ohms is connected across the inner tips (Fig. 3).

This provides the basic formula:

$$e_M = \frac{E\lambda}{2\pi} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

Now, the aerial physicist must not be too unkind to the writer at this stage. This article is directed to the practical engineer who uses formulae without always possessing the ability to derive them from first principles. The writer has thought over several ways of "putting it over," and the foregoing treatment, while lacking rigour and the inclusion of all the variables—and there are many—gives a close first approximation, and a derivation which should make fairly simple reading.

A more rigorous analysis leading to Equ. (3) is

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[1] B.B.C. Leaflet IE/12 and Map R.H. 5298M

TABLE 1

Type of Aerial	K_A
V	0.5
Dipole	1.0
H	1.8
3-element Yagi	2.5
4-element Yagi	3.0

TABLE 2

db Loss	K_E	db Loss	K_E	db Loss	K_E
0.5	0.95	3.0	0.71	6.0	0.50
1.0	0.90	3.5	0.67	7.0	0.45
1.5	0.85	4.0	0.63	8.0	0.40
2.0	0.80	4.5	0.60	9.0	0.35
2.5	0.75	5.0	0.56	10.0	0.32

given in the Appendix. This, as before, assumes sinusoidal current distribution through the aerial, and a uniform field.

Equation (4) provides the first approximation to the correctly terminated output from a half-wave dipole. Two factors K_A and K_F must be included to allow for the type of aerial employed and the losses introduced by the length of feeder inserted between the dipole and the receiver. It must be assumed that the characteristic impedance of the feeder is chosen to match the radiation resistance of the dipole and the input resistance of the receiver. A figure of 75 to 80 ohms is usually taken. When an "H" type aerial with $\lambda/4$ spacing is employed, the radiation resistance is lower, and is of the order of 50 ohms. If the spacing is reduced to $\lambda/10$ the radiation resistance may be as low as 10 ohms. Providing the matching precautions are taken the formula is still valid—indeed moderate mismatching does not have a great effect.

The value of K_A is given in Table 1 for certain popular outdoor television aerials of half-wave dimensions.

The feeder attenuation factor K_F is obtained by taking the manufacturers' attenuation loss in db per 100 ft at the television frequency and adjusting it, *pro rata*, for the length employed. K_F is given in Table 2 in terms of the db loss for the type and length of feeder employed.

The final formula for estimating the e.m.f. at the input of a receiver matched throughout to the aerial via a feeder is:

$$e_R = \frac{E\lambda\, K_A\, K_F}{2\pi} \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

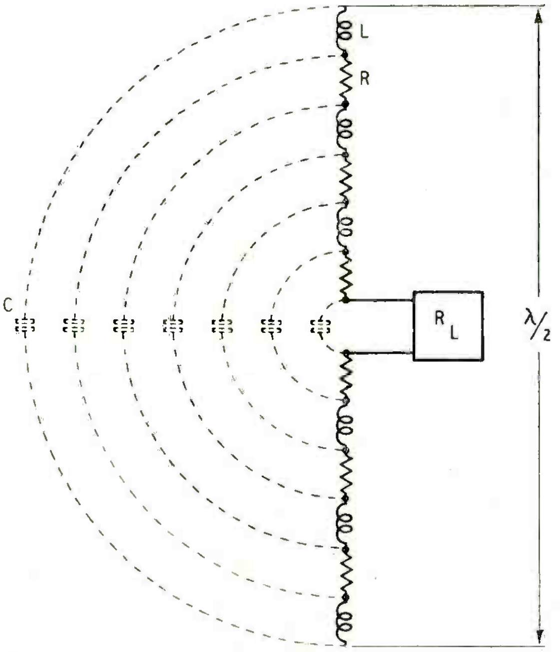


Fig. 1. The dipole is an incompact tuned circuit in which L, C and R are distributed.

Example: Given a field strength of 200 μV/m, and 'H' aerial, and 75 ft of feeder whose loss is 4 db per 100 ft, we work as follows:

K_A (Table 1) = 1.8
K_F (Table 2) = 0.71
λ = 6.67 metres (London vision).

$$\text{then } e_R = \frac{200 \times 6.67 \times 1.8 \times 0.71}{2\pi}$$

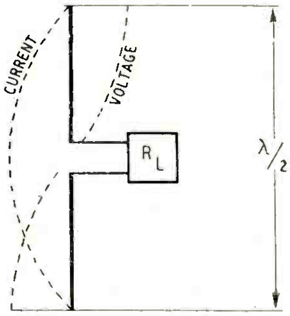
= 270 microvolts (slide rule).

A field strength of 100 μV/m would provide an input e.m.f. of 135 microvolts and so on.

The reader may be assured that if he uses this formula and, in addition, knows the sensitivity of his receiver for peak white picture, he will be able to decide the type of aerial and permissible feeder loss having regard to the local field strength.

Naturally, the results will be more accurate when the site is free from surrounding buildings, trees, etc. The B.B.C field-strength contours cannot include every contingency, and there will be badly sited cases where the formula fails because the field strength differs very considerably from that given on the map.

Fig. 2. Voltage and current distribution along a simple half-wave dipole.



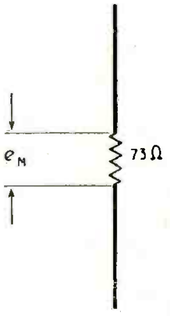


Fig. 3. "Matched" dipole.

APPENDIX[2]

The total effective e.m.f. induced in an earthed vertical wire of height h on the assumption of a uniform vertically-polarized electromagnetic field is given by:

$$E_e = \frac{E}{\sinh Ph}\int_0^h \sinh P(h-x).\ dx$$

$$= \frac{E}{P}\tanh\frac{Ph}{2} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1.0)$$

In the above formula E is the field strength and P is the

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[2] "An Experimental and Analytical Investigation of Earthed Receiving Aerials," by F. M. Colebrook, *J. Instn elect. Engrs*, July 1932, Vol. 71, No. 427.

propagation constant of the wire in terms of ordinary transmission-line theory.

Now P is of the form $a + jb$ and may be written as

$$P = a + \frac{j2\pi}{\lambda}$$

In the special case where $h = \frac{\lambda}{4}$ (quarter-wave element only) we obtain from Equ. (1.0).

$$e_e = \frac{E}{a + \frac{j2\pi}{\lambda}} \tanh \frac{\lambda}{8}\left(a + j\frac{2\pi}{\lambda}\right) \quad \ldots \quad \ldots \quad (1.1)$$

In these circumstances a is negligibly small compared with $\frac{2\pi}{\lambda}$ so that by simplification we arrive at

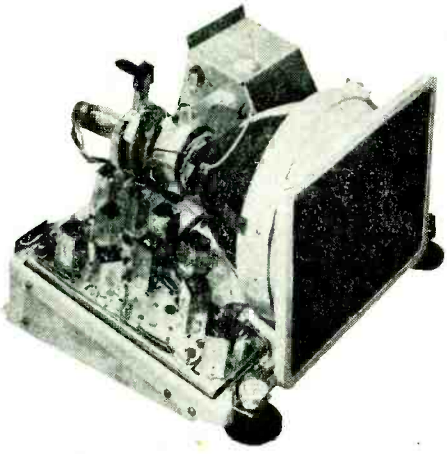
$$e_e \approx \frac{E\lambda}{j2\pi} \tanh j\frac{\pi}{4}$$
$$= \frac{E\lambda}{2\pi} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1.2)$$

This is the effective e.m.f. generated in a quarter-wavelength wire with respect to earth. A half-wave dipole is obviously two of these elements in series, since the mid-point is at earth potential.

Hence, the open circuit effective e.m.f. at the centre of a half-wave dipole is double that given by equation (1.2), which is $E\lambda/\pi$ and agrees with Equation (3) in the text.

Black Screen Television

New Pye Receivers



Chassis of Pye LV30 receiver showing the "dark screen" attached to the mask of the C.R. tube.

In order to improve the contrast of television pictures under conditions of high ambient lighting, the new Pye receivers are provided with a grey-coloured screen in front of the cathode-ray tube. This screen is of tinted plastic material and has a 50 per cent light transmission. Because of the loss of light in it the picture produced by the tube must be twice as bright as usual for the same final brightness.

The improved contrast comes about because room lighting must pass through the screen twice. It must pass through it to reach the c.r. tube and be reflected from its face, and it then passes through it, again with the picture. Therefore, only 25 per cent of the externally incident light appears and there is a 2:1 improvement in the ratio of the picture brightness to external light.

Normally, the "blackest" black is the white face of the c.r. tube and a true black is obtainable only when viewing in darkness. With ambient lighting the "black" is the tube face and it only appears black in contrast to the brightness of the whiter parts of the picture. When the dark screen is used the tube face is effectually darkened and the blacks in the picture are improved.

The receivers incorporating this screen have a 9-in tube operating at about 6.8 kV. For the line time base a single-valve generator is used* and it is completely screened to reduce radiation. The frame time base is more conventional, but its two valves are combined as a triode-pentode. A permanent magnet is used for focusing and has a simple adjustment. For picture-centring two other magnets fitted between the focus magnet and the deflector coils, are employed. This is an unusual arrangement which permits very simple adjustment.

The receiver proper is a straight set and separate r.f. chassis are available for the London and Birmingham areas. Four-circuit filter-type couplings are used and are claimed to give unusually high selectivity. There are only two panel controls, Brightness and Sound Volume. As a table model (LV30) the set costs 39 gns, and as a console (LV30C) 45 gns, including purchase tax; in both cases the cabinets are of wood.

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* See page 287.

NEW BOOK

A Home Built F.M. Receiver. By K. R. Sturley, Ph.D., M.I.E.E. Pp. 85+ix; figs. 57. *Electronic Engineering*, 28, Essex Street, Strand, London, W.C.2. Price 4s 6d.

Experimenters and music lovers with a flair for building electrical reproducing equipment will find this book a valuable guide if they should contemplate assembling an f.m. receiver for the forthcoming 90-Mc/s transmissions from Wrotham. It is essentially practical, but as frequency modulation is new to broadcasting in this country, some space is devoted in the early chapters to explaining how f.m. differs from a.m. and the new problems it creates in the design of a receiver.

The set described is built in unit form, an ideal arrangement since individual units can so easily be modified, or changed, to a new design should the need arise. A separate chapter is devoted to each unit.

Basically the set consists of an r.f. stage, frequency changer with separate oscillator, automatic frequency control, four i.f. stages (including two limiters), Foster-Seeley discriminator and a high-quality audio amplifier. It is a.c. operated.

As an aid to aligning the i.f. amplifier and discriminator a small oscillator covering 8 to 9Mc/s is described. The procedure is quite adequately explained.

The book is well illustrated with photographs, circuits and practical wiring diagrams.

H. B. D.

M.K.S. System of Units

Discussion at the I.E.E.

ALTHOUGH the m.k.s. system of units was adopted internationally no less than 15 years ago, many of the people who are (or ought to be) concerned seem to have only a very hazy idea of what it is all about. Very briefly, it is a system designed to put an end to the confusing mixture of three systems of electrical and magnetic units: the c.g.s. electrostatic and electromagnetic systems, and the practical system that includes the familiar volts, watts, farads, etc. By substituting the metre for the centimetre and the kilogramme for the gramme in the c.g.s. systems, and making an appropriate choice of a fourth quantity, a single absolute system of units is established which has the great advantage of including all the existing practical units and of rendering the two c.g.s. systems redundant.

Notwithstanding international adoption of the m.k.s. system, there is still room for local discussion of such matters as how it should be brought into use, or indeed whether it should be brought into use at all. And apart from that, one important question was left open—the question of whether the m.k.s. system should be employed in its rationalized or its unrationalized forms.

Rationalization

The object of rationalization is to make the appearances of 4π in fundamental formulæ correspond more closely to their geometry. It is a question that has to be settled before one can seriously go ahead with the m.k.s. system at all, because it affects the size of the units of magnetic field strength and magnetomotive force and a few others, as well as the so-called permeability and permittivity of free space. So it was not before time that the whole subject was laid open for discussion by the Institution of Electrical Engineers, on the basis of four short papers read on 30th March.

The first paper was devoted to the system itself, with the pros and cons of rationalization confined to a more or less objective appendix. The other three papers frankly advocated rationalization.

In spite of this lead it was rather surprising—considering the reluctance of even such people as engineers to alter the habits of a lifetime—that not one of the many who took part in the discussion offered any real resistance to the new system, or even to the more debatable rationalization. Some accepted it without enthusiasm, but they accepted it. Since the m.k.s. system has hardly made any headway yet in British text-books, another surprise was to hear so many professors and lecturers claiming to have taught it for a considerable time. American text-books, on the other hand, have gone over almost entirely to m.k.s., with a majority in favour of rationalization. The contrast here may be due not so much to British conservatism as to difficulties and delays in the British publishing trade.

Almost the only objections that can be raised against the m.k.s. system are that certain c.g.s. units, notably gauss and oersteds, are so well established that they will be difficult to displace; and that in some situations the m.k.s. units are of awkward sizes. Thus, designers of small radio equipment may find it inconvenient to think of flux densities per square *metre*; and in the fundamental Coulomb formula for the force between charged bodies, the force set up by unit charges (each 1 coulomb) unit distance apart (1 metre) amounts to about a million tons. It was generally conceded, however, that such criticisms are nothing to the inconveniences of the mixed systems, and though physicists will probably cling to the c.g.s. system, so that engineers (especially in electronics) will not be able to be entirely ignorant of it, the basing of electrical engineering courses from the outset on the m.k.s. system is both practicable and desirable. The last of the four papers dealt particularly with this aspect, and proposed a teaching sequence.

With regard to rationalization, its more logical relationship to the geometry of electromagnetic relationships was brought out in the papers and discussion. Tables of fundamental formulæ were shown in rationalized and unrationalized forms. The two crucial ones appeared to be the inverse-square law (referred to above), into which rationalization introduces a 4π, and the m.m.f. formula, from which it removes a 4π so that the official unit of m.m.f. becomes what engineers have long unofficially used—the ampere-turn. Whereas the former is of theoretical interest, the latter is in everyday practical use in both light and heavy electrical engineering; so that apart from considerations of logic there is little doubt as to which system renders 4π the less inconvenient. Dr. Booker's 1946 I.E.E. paper emphasizing the value and appropriateness of the rationalized m.k.s system in electromagnetic wave theory was referred to by several authors and speakers.

The Fourth Quantity

There was some difference of opinion as to whether μ_0 or the coulomb was the fourth quantity defining the m.k.s. system, though μ_0 has official recognition. It was pointed out that the name "permeability of free space" for μ_0 is misleading and ought to be displaced by some such name as "magnetic space constant"; and similarly for κ—the permittivity or "dielectric constant."

If this discussion was at all representative, it showed electrical engineers to be overwhelmingly in favour of the rationalized m.k.s. system. The moral would seem to be that all concerned (and especially those in the magnet industry) should familiarize themselves with it as rapidly as possible, so as to reduce to a minimum the duration of the changing-over period.

UNBIASED

By FREE GRID

The Radiokelemeter

NEXT spring we shall be celebrating two momentous events, namely this journal's fortieth birthday and the opening of the Festival of Britain. The Government has asked everybody to do something out of the ordinary in honour of the Festival and I think that *Wireless World* ought to comply with the wishes of Whitehall. I suggest that this journal should use its influence to rescue the racing world from the thorough mess into which it has been plunged by the introduction of the photo-finish camera.

Before the introduction of this highly controversial device nobody thought of disputing the judge's word, but such uncertainty exists nowadays that many a welsher has given the crowd a totally unnecessary run for its non-existent money. I am not, of course, trying to suggest that these cameras are inaccurate, for the opposite is the case. It is, however, common knowledge that in many cases the photo is difficult to interpret and has led to a lot of genuine ill-feeling culminating in the unprecedented act of the judge, at the Sandown Park meeting in June, of calling upon the stewards to help him to "read" the photograph.

Now I feel sure that by the adoption of radio principles this vital problem of "Wots won?" could be solved, and the camera relegated to the Science Museum; but it is not an easy problem to tackle. It would be simple enough if the Jockey Club would permit us to fit each horse with I.F.F. which would be automatically touched-off as the leading horse thrust its nose through an e.h.f. beam positioned horizontally across the track in line with the winning post.

But the Jockey Club is not likely to permit any horse-borne apparatus. We have until next April to get the problem solved, but at present I can only suggest the erection of a bridge across the track level with the winning post. On this could be mounted a series of radar transmitters, one for each horse, radiating vertically downwards. Obviously the nose of each horse as it passed would cause a split-micro-second shortening of the "there-and-back" beam between its respective transmitter and the ground. Unfortunately, however, horses don't run with neat spacing between them and often finish with a klystron-like bunching. Horse-borne I.F.F., therefore, seems the only solution, and I have already sounded a well-known jockey as to the attitude of his club in the matter but he treated me with such unseemly levity that I was left wondering if there was not some vital point which I had overlooked.

Your help is earnestly requested, as the radiokelemeter must be ready by April for the first Newmarket meeting of 1951.

Unseemly levity.

Radiotelearchics

A READER writing from wildest Westmorland, says I have shown myself to be a complete back number in demanding that manufacturers supply us with a simple radiotelearchic unit for the fireside operation of our receivers.

From the documentary evidence which my correspondent—who has helped me on a former occasion—has sent me, it appears that an apology is due from me to at least one well-known radio manufacturer who marketed such a device before the war. Unfortunately the Editor is as adamant as the B.B.C. about advertizing. Perhaps it will be sufficient if I say that the set which featured this magic unit was one to which, so its makers used to allege, people were always going home to. No doubt the war was responsible for causing the unit to go into temporary oblivion, but surely it is about time for it to reappear.

Information Please

"Words, words, words."

BEING a married man words have always had a snake-like fascination for me and it is hard to get away from them; in fact I don't think I want to do so, my sentiments being much the same as those of the sailor when an eminent medical dipsopractor offered to cure him permanently of his desire for a pint.

But to return to words; some time ago I set out to find the origin of the termination "tron" which we and the nuclear physicists use such a lot in words like magnetron and cyclotron. I felt sure that it was not merely the hindquarters of "electron," lopped off and put to other uses, and I sought your aid. By the kindly help of one of you I found that I was quite right in my surmise.

The word I'm now tracking is "radio." Its origin is, of course, fairly obvious even to those of you who played noughts and crosses when you ought to have been reading about the radii or rods of light which used to emanate from the heads of the ancient classical deities. What I seek to know is when the word radio was first used as a synonym for wireless. It was firmly established at the time of the Berlin conference in 1903 but it was, of course, shamelessly stolen from the X-ray people who used it before Marconi filed his first patent. Can any of you tell me who stole it and when?

This brings me to the word "radiogram," which we older wireless men often self-righteously allege was deliberately filched, by the makers of radio-gramophones, from the radio-telegraphic world where it had long been established as the recognized abbreviation for radiotelegram. Maybe this was so, but it does not alter the fact that we in our turn stole it from the X-ray people who coined it to describe the first crude X-ray pictures they made. Nowadays, I believe, they use the totally incorrect word radiograph, being led astray by the evil example set by the photographic world which, with the exception of the well-known publication "Photograms of the Year," employs the misbegotten noun (?) "photograph."

LETTERS TO THE EDITOR

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

Preferred Valves

AS a remedy for the confused valve situation in this country, I would like to commend to all radio trade organizations the excellent example set by the Scientific Instrument Manufacturers' Association in preparing a short list of preferred types for use in all new designs of instruments. This body, at least, has seen the advantage of restricting the variety of valves in circulation when it comes to capturing the world's markets, and the list contains no more than 230 types with only two main bases, international octal for normal-sized valves and B7G for miniatures.

If more lists of this type were in force, the commercial competition between manufacturers (which is responsible for the present position) would perhaps turn towards producing only the limited number of preferred types, but at keener and keener prices. Classification would become a dream and there would be no further need of those vast encyclopædias that announce with evident satisfaction that they contain sixty thousand valve characteristics and have more to follow. But perhaps this is all heresy and bad for business?

JAMES FRANKLIN.
London, S.W.4.

Pickups and Hum

AS a mere amateur I hesitate to cross swords with the professionals on the question of liability of ribbon and moving-coil pick-ups to hum pick-up, but the explanation is, I think, so simple that it may have been overlooked by the experts. More than anything else, hum pick-up depends on the alternating magnetic field in which the coil is situated. In the moving-coil, unlike either the moving-iron or the ribbon, the coil is virtually completely screened by the magnet and polepieces. Proof that this is, in fact, the reason for the coil's superiority in this respect is obtained by removing the polepieces from the magnet with the coil left in position; the hum then becomes comparable with—or even worse than—that of the ribbon.

N. M. REDDINGTON.
Barnstaple, Devon.

Tungsten Carbide

CONCERNING B. E. Berry's letter in the June *Wireless World* on the suitability of tungsten carbide for gramophone record reproduction, I should like to add to this controversy by stating my own experiences on the matter.

I agree with Mr. Berry's statement that pitting due to faulty sintering should be observed during the polishing operation on the needle, and rejected at that stage, but I have found that no matter how carefully this operation is carried out it is impossible to obtain a finish equal to that of corundum. It would appear logical that if hard metal-like substances were equal in finish to corundum, instrument and watchmaking concerns would have switched to bearings of this material long ago. It can be pressed to the required shape say, of a cup or "V" jewel, leaving only the final grinding and polishing operation to be done. With sapphire, on the other hand, we have to begin by slitting plates from irregular pear-shaped boules; between this first operation and the last much waste of material occurs, but it is still used for the simple reason that next to diamond there is nothing better.

E. R. WALLWORK.
Colton and Company
(Lapidaries), Ltd.,
London, S.W.18.

Low-Power Broadcasting

DESPITE the introduction of new frequencies, there are still a number of areas in the U.K. where reception of either the B.B.C. Home or Light Programme is unsatisfactory. Typical examples of such areas are East Anglia, and parts of the South Coast.

Concurrently with the expansion of the Television Service, surely the B.B.C. can undertake the straightforward task of providing an adequate sound coverage for the whole country. I say straightforward, as the development of low power, synchronized, and remotely controlled transmitters removes any question of technical or manpower difficulties being put forward as reasons for inactivity.

Mention of these low-power transmitters leads me to question whether the present policy of endeavouring to cover relatively large areas by single, high-power, medium-wave sets is the most advantageous from the Home listener's point of view. Black spots, or should I say, "black areas" are bound to occur, and large sections of the community may be without a service in the event of local power failures or faults on the transmitter.

In addition, there is also the point that transmitters on high-power probably cause just as much interference to Continental programmes, as similar Continental transmissions cause to us here in the British Isles.

Would it be asking too much to suggest that the Government and the B.B.C. examine the possibilities of future replacement and development programmes being based on the lower-powered transmitter; i.e., of not more than 20-kW output, not only in this country, but also in all the countries of Western Union? The implementation of such a plan would cost money, but it is better to have really good interference-free broadcasting services, covering the whole country, and pay extra for them, than allow the present unsatisfactory trend to continue unchecked. P. A. WORSNOP.

Thorpe-le-Soken, Essex.

Bridge Modifications

WHEN constructing the Wide Range R-C Bridge described by H. E. Styles in your March number, I found that I did not possess a single-pole, 6-way, rotary switch but had several 2-pole, 6-way switches. In order to make the fullest use of the switch I made the small modification to the original circuit shown in the accompanying drawing and I think this may be of some interest to your readers.

The advantage of this modification is that it enables resistors and capacitors to be measured on the same scale without reversing any external switch.

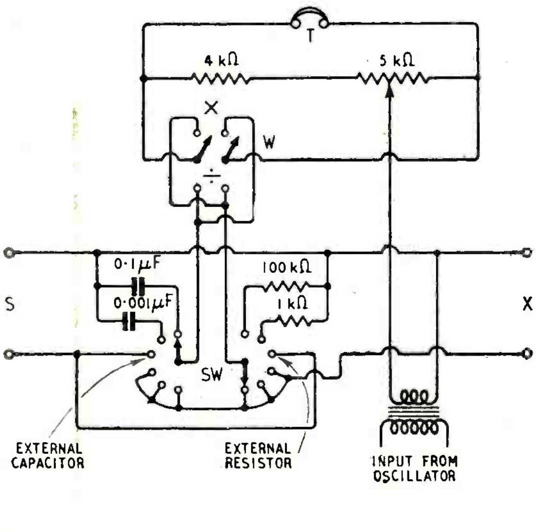
In my own instrument I use a single scale calibrated in "factors" by which the value of the standard resistor or capacitor is multiplied or divided, according to which position switch W is in, to obtain the value of the unknown component. Positions of switch W are simply marked × and ÷ on the panel.

This modification necessitates *two* switch positions for matching an external "standard" but I find internal standards as shown in the circuit diagram quite adequate to cover all ordinary requirements.

The instrument, either modified or unmodified, works extremely well and, given good ears and a quiet room, is capable of giving very accurate results.

J. A. L. GORRINGE.

Chesham Bois, Bucks.



Curious Effect

I HAVE noticed a similar effect to the one mentioned by A. F. Davidson (*W.W.*, May, 1950). My television receiver is built around the *Wireless World* time base and I use a 12-in tetrode tube.

Recently, about fifteen minutes after switching off, I noticed a steady flash of light on the screen at the bottom left-hand corner. I checked e.h.t. and power supplies to confirm that no voltages were applied to the tube. To make doubly sure I disconnected the set from the mains, also aerial and earth, but the streak persisted.

Suddenly the streak moved and I found it was caused by my hand moving near the tube face. This gave me a clue to the cause. The "Perspex" screen which I use in front of the tube had attained a high electrostatic charge—in fact, sparks could be drawn from the screen. Rubbing the "Perspex" with a cloth caused the streak to jump violently and lengthen to more than two inches. Eventually quite a bright flash covering a large area of the screen occurred and the effect could be produced no longer.

Apparently the charged "Perspex" induced an opposite charge on the tube front face and the electron movement in one particular part of the screen was sufficiently violent or intense to excite the screen to luminosity. I have never noticed the effect during a programme—the beam current and screen brilliance would probably mask any flashes due to electrostatic charge.

It would be interesting to know if Mr. Davidson is using a similar type of protective screen. Probably the surface of glass is sufficiently hygroscopic to prevent the accumulation of a high charge under normal circumstances; thus the effect may rarely be produced by a glass screen.

D. W. E. WHEELE.

Grantham, Lincs.

Slow Starters

IN his article in the June *Wireless World,* Free Grid refers to a radio-operated remote control unit for armchair adjustment of radio sets.

While I should not like to discourage the manufacture of such an original accessory, I believe that the listener of to-day is oppressed by a greater evil than the lack of remote control.

I refer to the infuriating half minute that we have to endure while an a.c. set "warms up." Many is the time that I have missed the time signal or the announcement of the title of a piece of music due to this defect.

The mind of the listening public has to be half a minute in advance of true time.

Could not the efforts of manufacturers be diverted a little to research into methods of improving upon this half-minute?

PHILIP A. C. MORRIS.

Manchester, 13.

Superhet Radiation

IT seems that radio listeners in the North of England are fated to a particular form of radio interference: superheterodyne local oscillator radiation.

This now makes itself apparent when a neighbouring receiver with i.f. of, say, 460kc/s, is tuned to the 692-kc/s transmission. The local oscillator operates on 1,152kc/s which, when radiated, effectively heterodynes the 1,151-kc/s North transmission.

One remedy is obvious: completely re-align the offending receiver with the i.f. about 470 kc/s, making the heterodyne whistle 11 kc/s, not usually troublesome. But further troubles rear their heads when the neighbour, with carefully re-aligned receiver, listens to the 692-kc/s transmission and decides that he likes the reproduction best with the radio a little off tune!

Suggestion to radio designers: screened oscillator circuits and r.f. stages. H. R. McDERMOTT.

Branch Secretary, Radio and Television Retailers' Association.

Darlington, Yorks.

Williamson Amplifier

THERE seems to be a greater risk of h.f. instability in the output stage of a Williamson amplifier when using 6L6's, and I would suggest to builders who suspect this fault, to try neutralizing the stage. In my own case, a pair of 4-$\mu\mu$F ceramics cross-connected directly between pins 5 on one holder and 3 on the other transformed an uncertain 4 watts into a rock-steady 15. But test your condensers on a megger before fitting, or the cure will be much worse than the disease.

H. C. MANNING.

Lisburn,
Northern Ireland.

MANUFACTURERS' LITERATURE

Portable Wire Recorder, the "Wiramphone," is marketed by Geo. C. F. Kauderer, Muiden, Holland, and described in an illustrated leaflet in English.

Yachtsman's Receiver; descriptive leaflets of the Eddystone "720," made by Stratton & Co.

"Pioneering in Space," a review of research and development since 1922, by the Radio Division, Standard Telephones and Cables, New Southgate, London, N.11.

Television Test Gear; descriptive catalogue from Marconi Instruments, Ltd., St. Albans, Herts.

Iron Dust Cores in "Caslite," a brochure containing design information from the Plessey Co., Ltd., Ilford, Essex.

R.F. High-Voltage Units catalogued in a set of technical leaflets from Hazlehurst Designs, 186 Brompton Road, Knightsbridge, London, S.W.3.

Switches for mains voltages catalogued in a booklet from Arcolectric Switches, Ltd., Central Avenue, West Molesey, Surrey.

Electronic Instruments, test gear and laboratory apparatus described in leaflets from Labgear, Ltd., Willow Place, Cambridge.

"Asbestos Textiles and the Electrical Industry," a well-illustrated booklet on the various forms and uses of asbestos, from Turner Brothers Asbestos Co. Ltd., Rochdale.

Industrial Battery Chargers described in an illustrated catalogue from G.E.C., Magnet House, Kingsway, London, W.C.2.

Television Pre-amplifier; a technical specification from Rainbow Radio Manufacturing Co. Ltd., Mincing Lane and Mill Lane, Blackburn, Lancs.

Communication Receiver Type CC150 described in a technical specification from Hamtune Communication Receivers, 10 Elm Street, Wellingborough, Northants.

"The Home Constructors' Handbook," containing eleven circuit diagrams, price lists and a catalogue, can be obtained from Roding Laboratories (Electronics), 70 Lord Avenue, Ilford, Essex, price 1s 6d.

Williamson Amplifier and other products described in a brochure from Radio Trades Manufacturing Co. (Ealing) Ltd., 141 Little Ealing Lane, London, W.5.

Capacitor Price List, issued in May, 1950, by Claude Lyons Ltd., 180-182 Tottenham Court Road, W.1, cancels all previous lists.

RANDOM RADIATIONS

By "DIALLIST"

Scra-a-tch

THE B.B.C. justly prides itself both on the technical excellence of its recording department and on the vastness of its library of gramophone records. Having spent many interesting hours in the company of members of its recording staff and having read not a few of the excellent papers they have written on their own pet subject, I know what a high standard they strive to maintain and how critical they are of shortcomings. That's why I don't understand how it is that there is not far stricter vetting of the records used to fill in the gaps that occur when programme items pan out at something less than their scheduled time. To say that the reproduction from some of these is appalling is to speak over-kindly; one's candid opinion of it can hardly be expressed on the chaste pages of *Wireless World*.

Missing Link?

One can't help feeling that there must be a lack of liaison between the engineers of the recording (and reproducing) department and those who are entrusted with the choice of records. It is of little use to design the best possible reproducing gear if it is to be fed with worn-out disks. To overhaul the whole library of records might be a task too big to be considered; but couldn't each day's quota of stand-by records be critically tested before being passed to the people responsible for using them? If something of the kind is already done, then, either, the tests are not sufficiently thorough, or the standards by which records are judged are not very exacting. If worn or otherwise faulty records were ruthlessly scrapped and replaced by new ones all would soon be well.

Some Time to Wait

IN THE TRAIN the other day I heard the question: "When are you going to get a television set?" put by one man to another. The answer was: "When the programmes go on all day, when it's in colour and when sets cost half what they do now." Somehow, I can't regard any of these conditions as likely to be realized in the immediate future. I sincerely hope that television never will "go on all day," for nobody would ever get any work done! I'm sure that receivers costing under £20 won't come along, unless some entirely new technique is developed. Colour television certainly will arrive and it may do so fairly soon. In America the F.C.C. turned down both the 4-channel system and that using a revolving disk with coloured "windows" in the receiver. It also laid down that to be acceptable a colour system should (1) give a good monochrome image on an existing receiver, (2) enable a full-colour image to be received with reasonably inexpensive gear and (3) occupy a channel no wider than that needed by a monochrome system. It is reported that a method based on a form of pulse modulation has been perfected; but the F.C.C.'s judgment upon it will not be published for a month or two.

International Television

THE OFFER of the Radio Industry Council to install at its own expense temporary apparatus suitable for providing a television link between this country and France is a noble one and it is to be hoped that the P.M.G. will see his way to accepting it. It was announced some time ago that the authorities of both countries had agreed to the exchange of television programmes; the snag which has so far hindered progress seems to have been the cost of the cross-channel link, which would have fallen on our G.P.O. and the French P.T.T. Now that the R.I.C. has offered to foot the bill for a temporary link one trusts that all may be plain sailing. Not the least of the advantages of putting up a temporary link is that it would enable a thorough try-out of the exchange system to be made, only if it were found completely satisfactory would ways and means of erecting a permanent link need to be considered.

Mutual Benefit

Both we and the French have, I believe, much to gain from television programme exchanges. On our part, we could expect an increase in the number of those "actual event" items which are the life-blood of television. France stands to benefit even more than Britain. Getting French television going has proved a very sticky business so far; on the one hand the present rather scrappy programmes can't be improved or extended until there are more viewers to justify the expense; on the other, there won't be any rapid increase in the number of viewers unless the fare provided is more satisfactory. Programme exchanges with us would enable this