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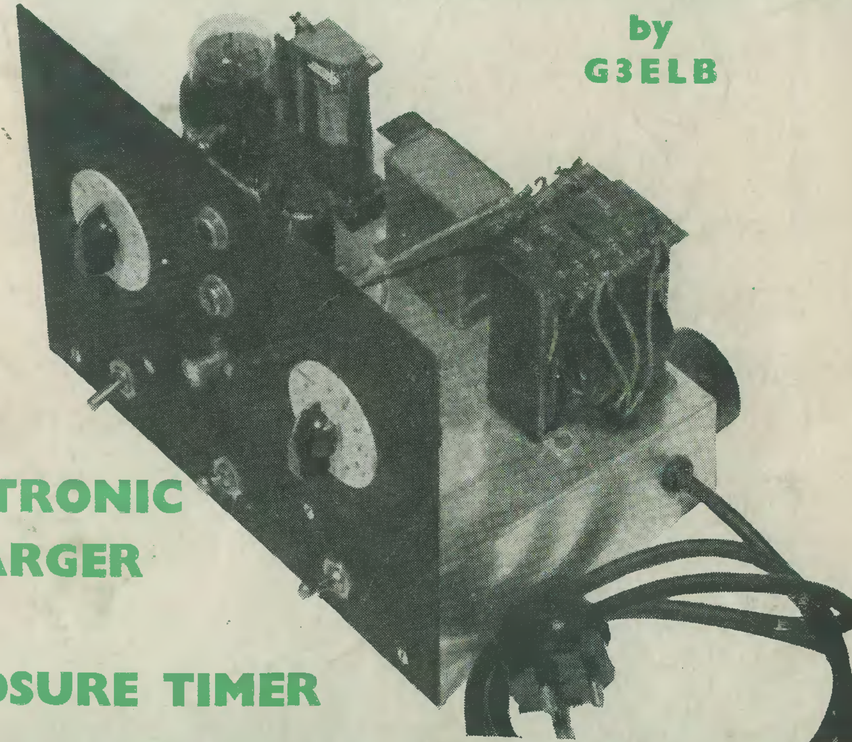
1954

The RADIO CONSTRUCTOR

incorporating The Radio Amateur

for the Radio and Television Enthusiast



by
G3ELB

ELECTRONIC ENLARGER and EXPOSURE TIMER

ALSO IN THIS ISSUE

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EASI-BUILD RECEIVER, Part 3
SYSTEM for AUTOMATIC PICTURE CONTROL
NOTES ON RADIO CONTROL, Part I
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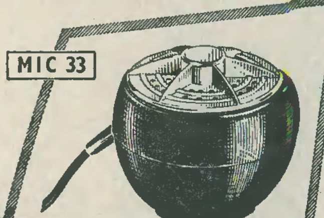

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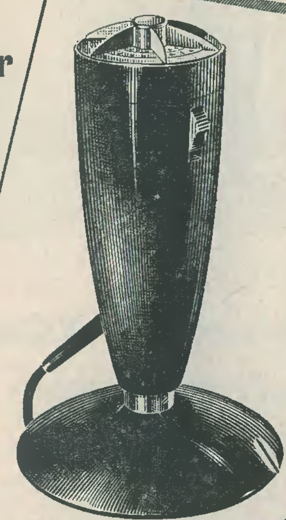

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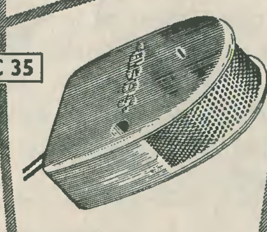

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CONTENTS FOR NOVEMBER

NOTICES

THE EDITOR invites original contributions on construction of radio subjects. All material used will be paid for. Articles should preferably be typewritten, and photographs should be clear and sharp. Diagrams need not be large or perfectly drawn, as our draughtsmen will redraw in most cases, but all relevant information should be included.

All Mss must be accompanied by a stamped addressed envelope for reply or return. Each item must bear the sender's name and adress.

TRADE NEWS. Manufacturers, publishers, etc. are invited to submit samples or information of new produce for review in this section.

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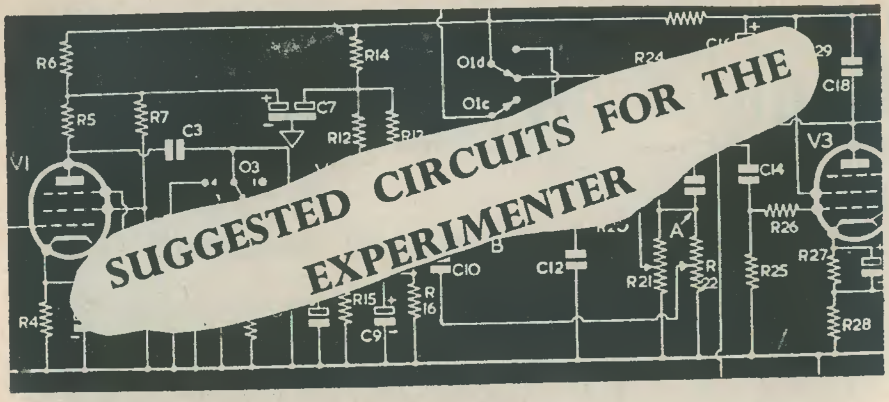


The circuits presented in this series have been designed by G. A. FRENCH, *specially for the enthusiast who needs only the circuit and essential relevant data*

No. 48: A System for Automatic Picture Control

As is well known, the provision of AGC facilities in television receivers confers a considerable advantage on viewers in many districts. This is due not only to the normal fading which is to be expected in fringe areas but, also, to the more severe and irritating effects of "aircraft flutter."

Automatic picture control (as television AGC circuits have nowadays come to be called) is not easy to apply to receivers operating on the British positive modulation standards, owing to the difficulty of obtaining a reliable reference voltage from the transmitted signal. Indeed, the only representative amplitude in the transmitted waveform is given by that of the synchronising pulses themselves. To obtain perfect results, therefore, automatic picture control circuits should operate from the pulse amplitude alone.

In practice, such a scheme has been carried out in the television receivers developed by Pye. The Pye circuit functions by generating a "spike" at the line time-base output stage, this probing the received waveform and meeting it at the back porch of the line sync pulse. The voltage existing at the back porch is equal to the height of the pulse, and thereby provides a very satisfactory reference voltage for automatic picture control.

Other methods of automatic picture control are less complex. They consist of integrating the picture content of the complete signal and applying the voltage obtained to the automatic picture control bias circuits. The time constant of the integrating circuit is usually equivalent to the time taken to transmit a small number of frames, and is therefore capable of minimising the effect of all but the most rapid cases of aircraft flutter, without introducing signal content into the bias control network.

This second method of automatic picture control has the disadvantage of tending to cancel out graduations in scene illumination introduced in the television signal by the programme producer. Thus if, during the transmission of a play, aesthetic considerations render it desirable to change from a well-lit to a darkened stage, the picture amplitude of the transmitted signal drops. This causes the contrast of receivers employing the second method of picture control to be at once automatically advanced, with the result that the dramatic effect of the change in lighting is largely lost. Such shortcomings are especially noticeable during the transmission of films, in which the changes in average scenic illumination are more frequent and more pronounced than occur in the conventional studio production.

On the other hand, this second method of obtaining automatic picture control has the advantage of considerable simplicity.

This Month's Circuit

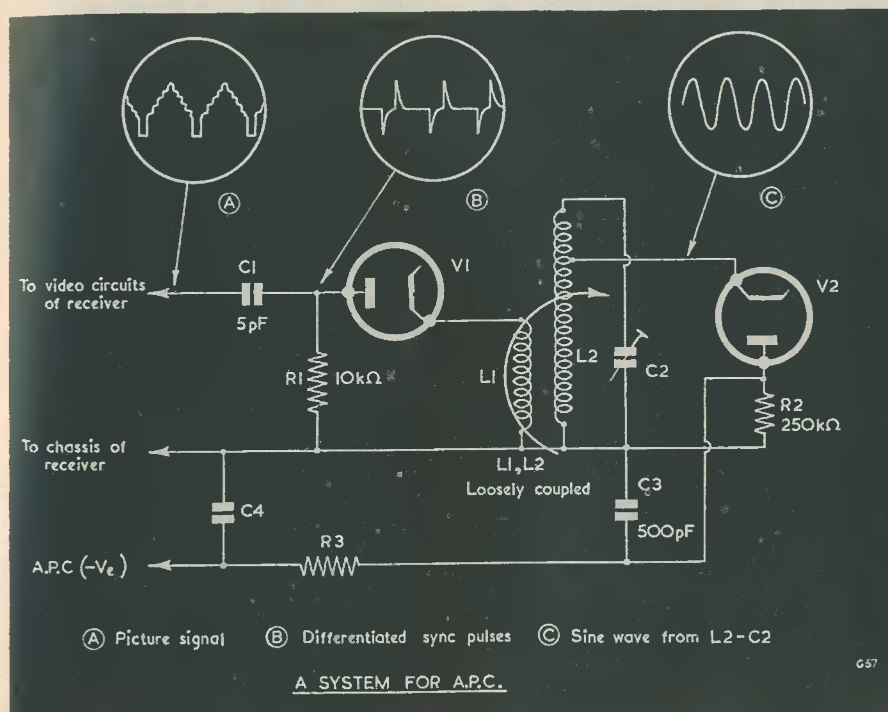
Suggested Circuits, this month, presents an entirely different method of obtaining automatic picture control. As with the Pye system, it depends largely on the amplitude of the transmitted synchronising pulse. Unfortunately, it is not capable of obtaining a reference voltage from the transmitted signal which has the same accuracy as is given by the Pye system, but its response to changes in scenic illumination should, nevertheless, not be so pronounced as occurs with other types of automatic picture control.

The basic arrangement is shown in the accompanying diagram. A connection is made into the television receiver at any point at which the rectified video signal exists with its line sync pulses at full, or nearly full, amplitude. Such a point may always be found at the detector load (assuming that the set is operating correctly), and, in most instances, at the video output anode. The second position is to be preferred, as the total video waveform is then available with a comfortably large amplitude. It also has the advantage of allowing an easily-accessible connection to be made at the base of the CRT.

The composite waveform thus available is then applied to the differentiating circuit given by C1 and R1. The time constant of these two components is such that only abrupt changes in signal strength appear across R1. Such abrupt changes will be provided by the line synchronising pulses, and possibly by part of the picture content itself. (This point is discussed later.)

The positive-going part of the differentiated pulses built up across R1 is applied, via diode V1 and the coupling coil L1, to the high-Q tuned circuit L2-C2. This tuned circuit is resonant at the line frequency, or at a multiple of the line frequency, with the result that it is continually shock-excited by the differentiated pulses from R1. The sinusoidal voltage induced in L2-C2 is rectified by the diode V2, whereupon it becomes available for application to the early control grids of the television receiver.

An automatic picture control loop is thereby set up.



A SYSTEM FOR A.P.C.

Tuned Circuit Frequency

As was mentioned above, the tuned circuit L2-C2 may be tuned to the line frequency or to a multiple of the line frequency. Since the line frequency is fairly low at 10 kc/s (actually 10,125 cycles) so far as the easy construction of high-Q coils is concerned, it will probably be found more convenient to use one of its harmonics. The writer made a mock-up of this part of the circuit to check its practical feasibility, and obtained satisfactory negative voltages from V2 by tuning to both the second and third harmonics. Tuning, incidentally, was very sharp.

Great care must be taken to screen the chassis holding the automatic picture control

[*continued on page 210*

IN YOUR WORKSHOP

In which J. R. D. discusses Problems and Points of Interest based on Letters from Readers and his own experience

JUDGING BY A PROPORTION OF THE LETTERS which have recently arrived at *The Radio Constructor*, quite a few readers are puzzled at the various types of isolation transformer which are now being offered on the market to eliminate the effects of television picture tube cathode-heater shorts. The mystery is deepened further by the widely differing prices quoted by advertisers; these ranging from a few shillings per transformer to well over a pound.

As a typical instance of what has been occurring, one reader fitted an isolation transformer which, he was assured, was of the correct type for his particular receiver. He was very disappointed with the results he obtained. Whilst the transformer enabled the picture to re-appear, its definition was very poor indeed. Similar stories are recounted in other letters.

Two Types of Transformer

The reason for the manufacture of what, at first sight, appears to be a widely diverging range of these components is that, in reality, there are two basic types of isolation transformer. One type, consisting of two simple windings on a small stack of laminations, provides heater isolation which is purely of a DC nature. The other type provides a similarly isolated heater voltage; but, in addition, the transformer is specially made to ensure that the secondary heater winding has a very low capacity to the primary winding and to the laminations. Whilst the capacity inherent in the first type of transformer is unimportant, in the second type it is kept down to approximately 15 pF or even less.

The first of these two isolation transformers is, obviously, the cheaper. In its simplest form it has a 1 : 1 ratio, and its dimensions are equivalent to those of a medium size, single-ended, loudspeaker transformer. Such a transformer may be fitted in AC receivers by connecting it directly between the mains transformer heater winding and the heater of the defective picture tube. If the television receiver is of the AC/DC type with a series heater chain, the primary of the isolation transformer may often be connected into the heater chain in place of the picture tube heater, its secondary being loaded by the picture tube heater itself. In all cases, however, isolation transformers with 1 : 1 ratios should never be fitted into television receivers, especially if AC/DC heater chains are employed, unless it has been ascertained for certain that they have the correct voltage and current specifications for the particular receiver in which they will be used.

Many readers may consider that precautions such as these are far too extensive for a little matter like popping in an isolation transformer; especially when this job is carried out by servicemen all over the country hundreds of times a week without a second thought. This is very true. On the other hand, there are a number of "no-name" isolation transformers knocking around these days; and it would be foolish to burn out a very expensive item like a picture tube merely by omitting to take a few precautions.

Some isolation transformers of the simple type being now described have a step-up ratio between primary and secondary. These are intended to give a higher heater voltage for the purpose of "rejuvenating" old picture tubes which are otherwise useless on account of low cathode emission. "Rejuvenation" should not be used if, apart from the cathode-heater short, the tube still has plenty of life left in it. It is possible, also, for transformers with nominal 1 : 1 ratios to have one or two extra turns on the secondary in order to make up for losses in the transformer.

The second type of isolation transformer, that having a low capacity between its heater winding and the primary and laminations, is a different matter altogether. In a transformer of this type it is usually necessary to employ large laminations in order to obtain the necessary physical spacing between primary and secondary; and the size of the component is, consequently, similar to that of a conventional mains transformer. Because of this wide spacing, the coupling which would be given between primary and secondary windings consisting of a relatively few turns of thick wire each—such as occurs in the simple 1 : 1 arrangement—is too loose to give a satisfactory transference of power. Low capacity isolation transformers, therefore, almost always employ a full mains primary intended for direct connection to the mains.

Grid and Cathode Modulation

After having discussed the transformers themselves, it would now be worth-while to examine what is incurred in curing the effects of cathode-heater shorts in typical television receivers, paying especial attention to the type of isolation transformer which would give the best results.

If a cathode-heater short occurs in a receiver employing grid modulation, the effect usually given is that of uncontrollable brilliance. This is due to the fact that the brilliance network varies the DC biasing voltage on the cathode, with the result that the cathode-heater short brings the cathode down to chassis potential (or to an AC voltage which swings about chassis potential) and the brilliance circuits become inoperable.

In such a case, the simple DC—isolation type of transformer is perfectly satisfactory, since it at once allows the cathode to receive once more the DC voltage applied to it by the brilliance control. At the same time, the relatively high capacity existing in such a transformer does not upset the picture, since no signal intelligence is applied to the cathode.

The situation is very different if cathode modulation is employed, however, and especially if the cathode-heater breakdown is of the "dead-short" variety. In such an instance the picture intelligence applied to the cathode now appears also at the heater pins. What happens if we isolate the tube with a simple, "DC-only" type, isolation transformer?

The answer to that question depends on the capacity existing between the secondary of the transformer and its primary and laminations. In almost every case this capacity is certain to be higher than 60 pF (out of representative transformers which I checked myself before writing this article, capacities varied between 75 and 120 pF).

Now, the reactance of a 40 pF condenser at 3 Mc/s is approximately 1.3kΩ. Also, the impedance at which the cathode of the picture tube is being driven (usually, the impedance of the video output anode load), lies normally between 1.5 and 5 kΩ. It may be seen at once from these figures that, even if the capacity introduced by the transformer is only of the order of 40 pF, there is certain to be considerable attenuation of any 3 Mc/s signal applied to the picture tube cathode. When we consider the more usual capacities in excess of 60 pF the situation becomes far worse. Using one or two of the transformers whose capacities were checked by myself, one would not only kiss good-bye to the 3 Mc/s bars, but to the 2.5, 2 and 1.5 Mc/s bars as well!

It is obvious therefore that, in the case of dead-shorts between cathode and heater, the DC-only type of isolation transformer is not of great help, and we have to use instead one of the more expensive low-capacity models.

Fortunately, cathode-heater breakdowns are not always of the dead-short type; and it is occasionally feasible for the breakdown to take the form of a "leak." If this occurs, and

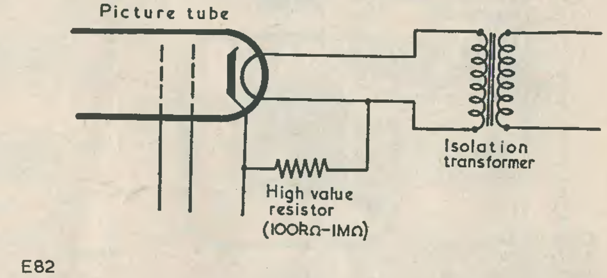


Fig. 1. Fitting a high-value resistor, as shown here, between the cathode and heater of a picture tube with a cathode-heater breakdown can sometimes prevent the fault from becoming progressively worse

the "leak" has a value higher than, say, 10 kΩ, the simpler type of isolation transformer may be used, since its capacity to earth is applied to the cathode in series with the effective resistance of the "leak." The only trouble with this solution is that there is no guarantee that the breakdown will not reduce in ohmic value as the tube gets older, whereupon the inherent capacity of the transformer would cause increasingly severe attenuation of the higher video frequencies as time went on.

Yet another possibility is given by the fact that a "leak" or short-circuit may occur between the cathode and heater of a picture tube only when a relatively high DC voltage exists between them, it disappearing when both electrodes have the same potential. In such an instance, it is possible for the simple isolation transformer to give at least temporary, if not permanent, relief.

manufactured article can be obtained so very cheaply.

The secret of making a low capacity isolation transformer consists essentially of keeping the secondary spaced as far away from the primary winding as possible. Fig. 2 shows a cross-section through a typical transformer of this type, illustrating the various leakage capacities which have to be considered. In practice, the capacity between secondary and laminations is far less than that existing between the two windings themselves, and it is possible to bring the outside of the secondary winding to within as close as three-sixteenths of an inch to the inside surface of the laminations before the capacity between these two becomes really troublesome. On the other hand, *at least* three-quarters of an inch (preferably much more) of space between primary and secondary is

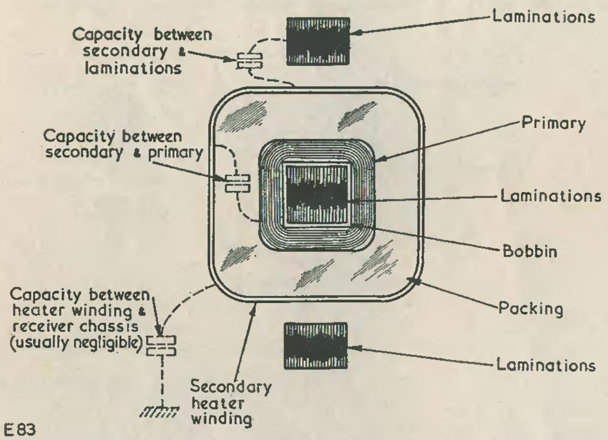


Fig. 2. A cross-section through a practicable low-capacity isolation transformer, showing possible capacities to the heater winding

After an isolation transformer has been fitted, it is a good plan to connect a high value of resistance between the cathode and the heater, as shown in Fig. 1. If the breakdown should happen to clear momentarily, this resistor will then ensure that no potential differences can occur between the two elements due to static charges, with the consequent risk later of even more severe breakdown. Such a resistor is worth while even in the case of a dead-short, as such short-circuits have occasionally been known to clear themselves with time.

A Home-Built Transformer

Before finishing on this subject, I would like to give a few details on the winding of isolation transformers of the low-capacity type by the amateur. The other, "DC-only," type is hardly worth while making at home since the

needed if the capacity is to be kept below 20 pF or so. The spacing between primary and secondary, incidentally, may be obtained by winding the requisite amount of "Lassovic" or similar tape around the primary. If an air-space can be introduced practicably, so much the better.

Fig. 3A shows a cross-section through a low-capacity isolation transformer at right angles to the view of Fig. 2. In this diagram, the heater winding occupies almost the whole width of the bobbin. In Fig. 3B, the heater winding has been halved in width and wound on in two layers. Assuming that the same spacing between primary and secondary is maintained, this method of assembly has the effect of halving the capacity between these two windings. Against this, of course, is the fact that the two-layer heater winding now approaches the laminations more closely, with

the result that the distance between the primary and secondary has to be slightly reduced. About the best practical solution appears to consist of winding the secondary in three layers. After this it is liable to become unmanageable, and the advantages gained by the narrower winding are lost due to the necessarily reduced spacing between primary and secondary.

The primary may either be wound at home, or that of an existing transformer pressed into service. In the case of an isolation transformer which I made some time ago, I started off with a normal mains transformer having a burnt-out secondary. This I removed, retaining the still-serviceable primary. The transformer was then built up with tape as described above.

are liable to crop up now and again which require meticulous attention to dimensions.

A typical instance occurred some time ago when I was making a gadget which incorporated several holes in a heavy piece of brass. These holes had to provide a sliding fit for rods of three-eighths of an inch nominal diameter, and there had to be no side play.

I commenced by carefully drilling out the brass on a power drill, but the holes I obtained were a tiny bit too small for perfect results. They needed opening out by just one or two thousandths of an inch.

It was as I was regretfully thinking of having to do a little "butchering" that I suddenly remembered an old dodge I was shown many years ago. This consisted of re-drilling the hole; inserting also a small

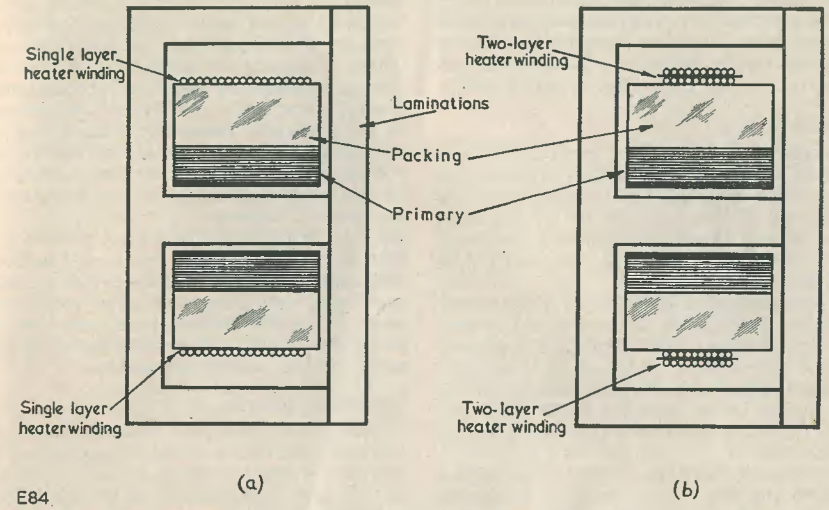


Fig. 3

(a) Another cross-section through an isolation transformer, illustrating a single-layer heater winding

(b) The same transformer with the heater winding wound in two layers. Although this method of winding reduces the capacity between primary and secondary, it has the slight disadvantage of bringing the outside of the heater winding closer to the laminations

Further reductions in capacity may be achieved by winding the secondary with as thin a wire as is practicable for the current it has to carry, and by using only just sufficient laminations to keep the transformer from running too warm.

That Odd "Thou"

Although, in radio, it is not usually necessary to work to high degrees of accuracy so far as "metal-bashing" is concerned, jobs

piece of very thin tissue paper. I tried it in this case and it worked perfectly.

What happens, of course, is that although the tissue paper is mangled up by the drill immediately the latter enters the hole, its pieces still remain *in situ* until finally ejected at the other end. Whilst in the hole they constitute a certain amount of bulk, consequently forcing the drill to bear more forcibly against the side of the hole. The result is a hole that is one or two "thou" oversize. [END

REPAIR and MAINTENANCE of Line Output Transformers

Part 3 *By* **S. WELBURN**

IN THE LAST TWO ARTICLES IN THIS SHORT series devoted to that important component in the television receiver—the line output transformer—the writer described the several different types of circuit in which the line output transformer most commonly appears, as well as giving details of its general construction. Considerable attention was also paid to the question of breakdown and corona.

Over-Drive

Whilst dealing with breakdown and corona, it was pointed out that it is possible to run into quite a lot of trouble with line output transformers simply by driving them more heavily than their designers intended. This trouble occurs far more frequently than is generally realised.

Over-drive of a line output transformer occurs mainly due to three different causes. The first of these is that of too high a drive to the line output valve. The second is given by the application of incorrect voltages to the line output valve, and the third by incorrectly valued components connected to this valve.

The first of these cases, that of too high a drive to the line output valve, is somewhat infrequent nowadays; although it is still feasible when the line timebase is provided with a variable amplitude control. Such controls (which should not be confused with "width" controls connected directly to the line output transformer), are usually found in the older type of receiver, in which the line output valve acts purely as an amplifier and not as a "switch." The grid input, in such a case, consists of a sawtooth.

When an amplitude control is fitted to a receiver, all that is needed to ensure that the drive to the line output valve is not excessively high is to observe the reproduced picture. Assuming that the receiver is working correctly, the condition of excessive over-drive is usually shown by the appearance of vertical white bars down the centre of the picture. It is often stated that the amplitude control should be retarded slightly from the position where these white bars appear.

However, this is not necessarily the best setting for the amplitude control at all. It is frequently found that it is possible to retard the amplitude control over quite a considerable travel from the excessive over-drive setting before the EHT drops, or the picture begins to lose its width or linearity. The best position of the amplitude control is then that which is slightly advanced from this second setting, and *not* that which is slightly retarded from the first, white bar, effect. This method of adjusting the amplitude control has the advantage of ensuring that the line output components are protected from alterations caused by changes in mains voltage and by warm-up variations.

If the line amplitude control is used in a receiver which has just been constructed at home, the control should always be set to its minimum position when the receiver is switched on for the first time, and tests are being carried out. It can then be brought up to its correct position afterwards.

Incorrect Voltages

When the line output valve is used as a "switch" and not as a sawtooth amplifier, the question of supply voltages is most important.

This applies particularly to the HT voltage applied to the line output anode, since a very slight increase in this HT voltage can cause a considerable increase in EHT. The most usual cause of too high an HT voltage is an incorrect setting of the mains voltage adjustment panel on the power pack.

Line Output Components

Over-drive may also occur due to the use of incorrectly valued components in the line output stage; this being especially true of those connected to the control grid and screen-grid.

In many cases, the line output grid is fed via a coupling condenser and grid leak, these components providing the necessary line output grid bias. When this arrangement is employed, the cathode is usually connected directly to chassis. It is important that the grid leak and condenser have the values specified for the particular receiver in which they are used, and that the condenser is not leaky.

The line output screen-grid is nearly always fed via a dropping resistor from the HT rail, and is sometimes decoupled to chassis by a condenser. The value of the dropping resistor can have a very marked effect on the EHT developed in the line output transformer. It should never have a value lower than that specified for the receiver in which it is used. The decoupling condenser also has an influence on the EHT voltage. This, however, has less to do with values than it has with the actual presence or absence of the condenser. Thus, if a decoupling condenser is fitted to a circuit which is not designed for it, it can often cause a very considerable rise in EHT voltage.

There is, incidentally, a secondary reason for resisting the occasional temptation to obtain higher EHT by reducing the value of the screen dropping resistor. This is given by the fact that, as soon as the line output cathode has achieved emitting temperature after switching on, the screen-grid has to pass a considerable amount of current until the booster diode has warmed up sufficiently to pass HT to the anode. The booster diode takes a relatively long time to warm up because of the necessarily heavy heater-cathode insulation it requires. The screen-grid resistor limits the current passed by this electrode, therefore, to a safe value during the warm-up period, and, for this reason alone, should not be reduced.

The writer anticipates that there may be an adverse reaction from one or two readers of the above paragraphs; this being to the effect that a line output transformer should be capable of handling over-drive conditions, and that the precautions just mentioned are in consequence somewhat over-fussy. There is, admittedly, quite a lot of truth in such a statement, and it is a fact, also, that a well-manufactured line output transformer is perfectly capable of being over-driven (within reasonable limits) without breaking down. On the other hand, there are a considerable number of cathode ray tubes in working television receivers which are rated at a maximum of 14 kV, but which are actually receiving EHT voltages around the 16 kV mark! This can hardly be described as a state of affairs to be recommended. Furthermore, it is always bad practice to over-run a component when it is capable of working perfectly well within its correct, specified ratings.

Ringing

Another fault which is caused by the line output transformer is that of "ringing" of the EHT over-wind. This results in a velocity-modulated scan on the left-hand side of the picture, giving the impression of one or more parallel vertical bars which are lighter in shade than the general picture.

This fault is not usually evident with the line output transformers sold on the home-constructor market; but it does appear fairly frequently in commercial televisors. Such troubles are inherent in the line output transformer itself; although replacement by a similar model occasionally effects a reduction of the trouble. Failure of any damping components which may be connected to the transformer, or to the line deflector coils, can also cause the ringing to appear. Very slight ringing may usually be ignored.

It should be pointed out at this stage that many cases of "ringing" arise which are not originated by the line output transformer at all. The trouble is caused, instead, by the grid, or cathode, lead to the cathode ray tube being positioned too closely to the line output transformer or its wiring. The cathode ray tube lead then picks up the ringing voltages capacitively. Repositioning the lead usually effects an immediate cure.

Whistle

All line output transformers give an audible whistle at line frequency. This effect cannot be considered as a fault, unless the whistle is excessively loud. It is difficult to define how loud a normal whistle should be, and it is usually assumed that if one gets "used to it" after a short time and forgets its existence, then it is not too loud. (The writer admits that this is an extremely elastic definition).

The whistle is generated by reason of the very high pulse power handled by the line output transformer. In cases where the transformer has been subjected to damage or hard knocks, consequent damage to the core gapping material may cause the whistle to be much louder than it should be. The only cure for a fault of this nature is replacement of the transformer.

Interference

Due to the nature of the waveform appearing across the windings of the line output transformer, this component (with its wiring) is very liable to radiate RF interference at harmonics of the line frequency. One of these harmonics lies close to the frequency of the Light Programme on 1,500 metres, and can manifest itself as a "gurgling" whistle on a sound receiver tuned to this wavelength.

If interference with neighbouring sound receivers occurs, the television chassis should be connected to a reliable earth; this being done via a 0.01 μF condenser in cases when the chassis is "live." This process often

[*continued on page 210*

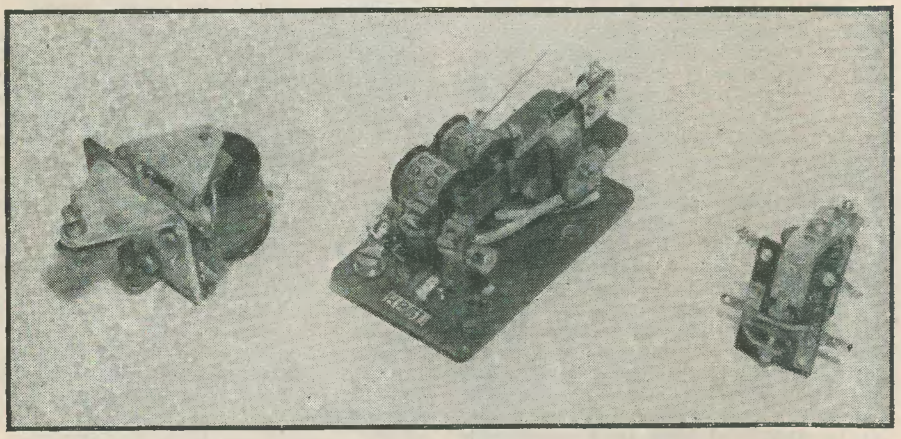
NOTES ON RADIO CONTROL

I. *Valves and Relays*

By **QUENCH COIL**

THE FOLLOWING SERIES OF NOTES IS intended as a guide rather than comprehensive articles on radio control equipment, and is drawn from the author's experience during the construction of R/C apparatus applied to many of his models, these being ships and planes.

To the experienced radio control fan many of his remarks may seem to be superfluous, but as they are intended more for the beginner, he hopes these enthusiasts will bear with him.



Three typical Radio Control Relays. On the left, that used in the Cossor "Mercury" receiver. Centre, the Siemens type 73 (usually ex-WD surplus). Right, the E.C.C. type 5A.

There are many links in the chain of operations between the transmitter control and the final "action" in the model. The two most important, thinking in terms of components, are the *valve* and the *relay*; let us here examine the types of valves and relays which can be used in the receiver.

Valves

We have a choice of two types of valve: the gas-filled triode, or the hard valve, such as the 3S4 and 3A4, as used in many items of radio equipment. The hard valves are especially suitable for radio control owing to their robust construction and long life span; however, they have one disadvantage—their size and the need for a larger holder. This must be considered if the receiver is intended for use in a model plane, where size and weight is a number one consideration. Should the model be a boat of any size, the problem is not nearly as serious.

Personally, I prefer the hard valve, and feel that the size and weight are more than made up for by the long life and robust construction. It is surprising the amount of rough treatment these valves will take.

The gas-filled triode has been designed to operate on a low HT voltage of 45V maximum and a filament voltage of 1.4; this alone reduces the size and weight of the completed receiver to a minimum.

The gas-filled triode must be treated with great care, and under no circumstances must the rated voltages and currents be exceeded even for a short time, if we wish to prolong the life of the valve. It must be borne in mind that it is designed and rated for intermittent rather than continuous use, in applications where appreciable changes in valve characteristics during life are acceptable, or can be covered by appropriate circuit adjustments.

The useful life of the valve is critically dependent upon the peak anode current, which is not readily measurable. However, the mean anode current is, and should be adjusted to 1.5mA or less for long life.

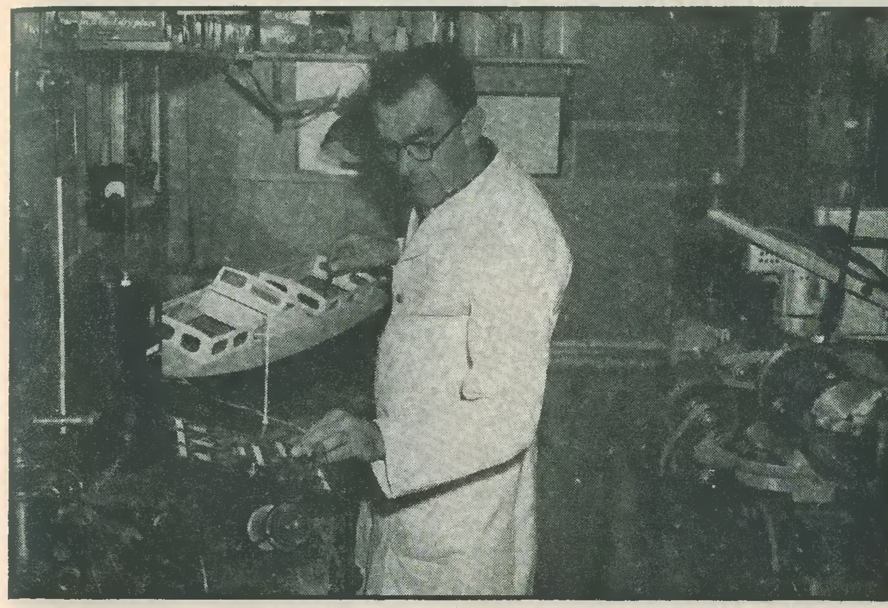
For maximum sensitivity in any receiver there is an optimum value of grid bias, and adequate provision should be made for adjustment, both initially and during the life of the valve.

The XFG1 is a sub-miniature gas-filled triode, and its size—40mm long by 10mm by 7.2mm—together with its low weight, makes it an ideal valve for our purpose. No valve-holder is needed as it has flexible leads which may readily be soldered direct to the other components.

By using other miniature parts we can build a complete receiver (less batteries) weighing only a few ounces. I have, in fact, built a receiver complete with relay weighing under 4 ounces.

Relays

The relay is, I think, the most important item in the receiver. It should always be fitted last and, when possible, on the top of the panel.



Our contributor "Quench Coil" shown in his workshop, with some of the radio control equipment which he will be describing in this series of articles.

There are a number of relays on the market which are suitable, some of these being the ECC5A, the ED, and the Siemens 73. As a point of interest, the ECC5A can be adjusted to move from contact to contact on a current change of less than 50μA; this is the type I would suggest employing when using the hard valve in a receiver.

These relays are very reliable and non-sensitive to vibration. A word of warning is necessary here—handle with great care, and always over a felt pad on the bench. Never twiddle; when once adjusted, leave well alone, as a faulty relay can be the cause of considerable trouble. It is a good plan (if room will permit) to cover the relay with a

[continued top of page 210

small can, which will protect it from dust and knocks.

Note on the Siemens Relay type 73

The bobbins are terminated with red and green leads, which will be seen on removing the plastic covering. For maximum sensitivity, the two red leads must be joined together, leaving the green leads as the open connections to the relay. The DC resistance of both bobbins is 3,400Ω. Great care must be exercised when removing the plastic covering and re-soldering; avoid pulling the leads as they are likely to come away from the bobbins.

The relay is mounted on a paxolin base which, in turn, is fitted to an iron base; this latter should be removed before fitting the relay to the receiver, and again great care must be taken when handling.

SUGGESTED CIRCUITS—*continued from page 201*

components, as well as the input lead connecting into the television chassis. This is due to the fact that the automatic picture control components may pick up radiations directly from the line output transformer and its wiring; these blanketing, or interfering with, the sync pulses present in the video signal. If the video output anode is used as a source of sync pulses, care should be taken to see that the lead to the CRT is screened, or is not in a position to pick up interference from the line output wiring.

Accuracy

The accuracy with which the automatic picture control circuit provides bias relative to the synchronising pulse amplitude should be fairly high. This is due to the fact that the most abrupt changes in signal amplitude should be given by the synchronising pulses themselves. Unfortunately, sharp-fronted changes in signal amplitude are liable to be given at the commencement and end of the picture information in each successive line scan, and these may also excite the tuned circuit via the differentiating network. However, from the writer's experimental evidence, these do not appear to cause by any means such large variations in negative control voltage between bright and dark transmitted scenes as occurs when the picture content is extracted as a whole.

THE REPAIR & MAINTENANCE OF L.O.T.—*continued from page 207*

results in a considerable diminution of the interference, since it is then radiated by the television chassis wiring alone. Persistent interference can be cured only by screening the entire line output stage. Mild interference, however, can often be cleared by repositioning the television receiver in the room in which it is used, so that it is further away from the sound receiver and its aerial lead-in. (Alternatively, of course, the sound receiver, and its aerial lead-in, may be moved further away from the televisor). RF interference from the television receiver is frequently confined to a radius of several yards only.

THE TELEVISION SOCIETY—FUTURE MEETINGS

Friday Nov. 12	**Faulty Interlacing**	Dr. G. N. Patchett (*Bradford Tech. Col.*)
Thursday Nov. 18	**Conversazione at University College to mark the Jubilee of the Invention of the Thermionic Valve**	
Thursday Nov. 25	**European Television Programme Exchanges**	M. J. L. Pulling, O.B.E., M.A. (*S.S.E., B.B.C. Television*)
Friday Dec. 10	**Television Circuit Refinements**	C. H. Banthorpe (*Derwent Radio Ltd.*)
1955 Thurs.–Sat. Jan. 6–8	**The Society's Annual Exhibition** (*Thursday: Members only. Other days by Invitation Ticket*)	*Place to be announced.*

All meetings, unless otherwise stated, are held at the Cinematograph Exhibitors' Association, 164 Shaftesbury Avenue, WC2, and commence at 7 p.m. Non-members of the Society are admitted to meetings on presentation of a signed ticket obtainable from any member or from the office of the Society, 164 Shaftesbury Avenue, WC2.

A DECADE RESISTANCE BOX

By **F. A. BALDWIN** A.M.I.P.R.E.

For those constructors wishing to carry out serious experimental work, the decade box is one of the essential items of equipment that must be to hand. In order to be of real value, the resistances must be accurate and constant, and the resistance windings should be non-inductive.

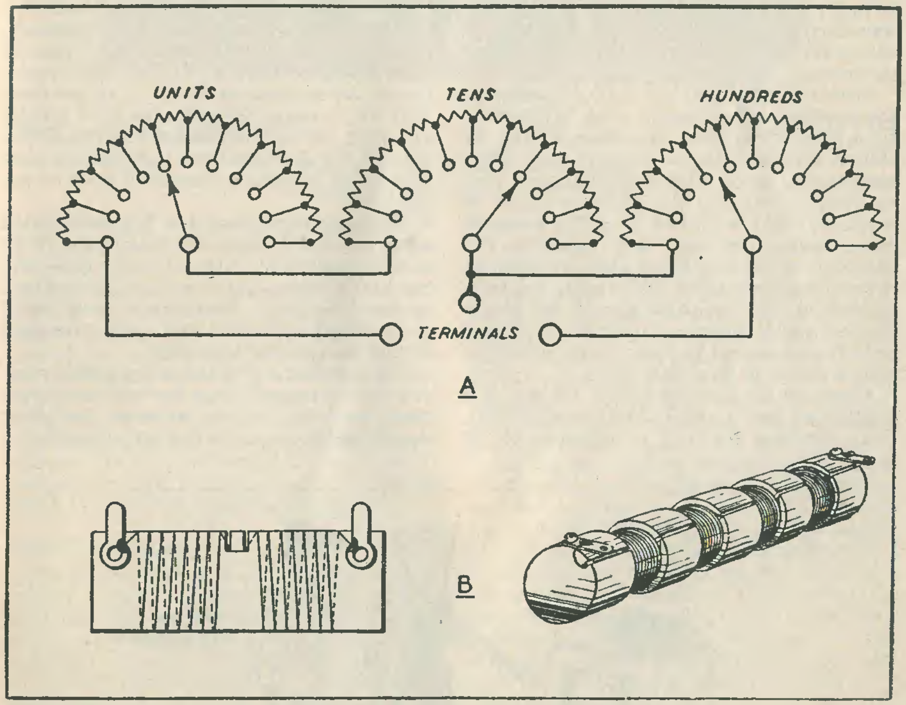


Fig. 1

Circuit

This is shown in Fig. 1A, and it consists of three switched variable resistors in series, any section of which may be switched into circuit as required. In each of the three networks, each resistor has the same value; thus, in that of the Units, each separate resistor has a value of 10Ω. Those of the Tens system each have a value of 100Ω each, while in the Hundreds unit, each has a value of 1,000Ω. It will thus be seen that each of the three units are arranged in ratios of 10 to 1. Arranging things in this manner, it is possible to set the decade box to any value, in steps of 10Ω, from the minimum of 10Ω to the maximum of 11,100Ω.

Construction

The case is made of sheet iron with an

aluminium panel of sufficient thickness to take the fixing screws. The overall dimensions are 9 inches long by 3 inches wide and 3 inches deep. Both the case and panel are finished with a coat of "Panl" black crackle paint. The three sets of resistor graduations and wording are those being currently marketed under the trade name "Panel Signs"; these form an easy and simple method of panel marking, while, at the same time, adding a pleasing and professional appearance to the unit.

The three switches shown are of the Yaxley type and are single-pole twelve-way, each having two banks which are connected in parallel in order to minimise contact resistance. The resistors themselves are wound with 40 swg enamelled Eureka wire, and both methods of winding are shown in Fig. 1B.

Dealing with the 10Ω resistors first, a half-inch wide paxolin strip some sixteenth of an inch thick was employed for the formers. In order to minimise as much as possible the unwanted reactance effects, the direction of the winding should be reversed half-way along the former.

With the 100Ω and the 1,000Ω resistors, the previous method would result in unwieldy sizes, and these were therefore wound in slotted formers. In the present case, these were turned up in a lathe from ebonite rod, or, alternatively, old RF chokes stripped of windings could be utilised. In each former, an even number of slots are required, the direction of winding being again reversed at every other slot. Once the winding has been completed, the resistors should be finally checked for accuracy before applying Denco polystyrene cement in order to firmly secure each winding in its proper place.

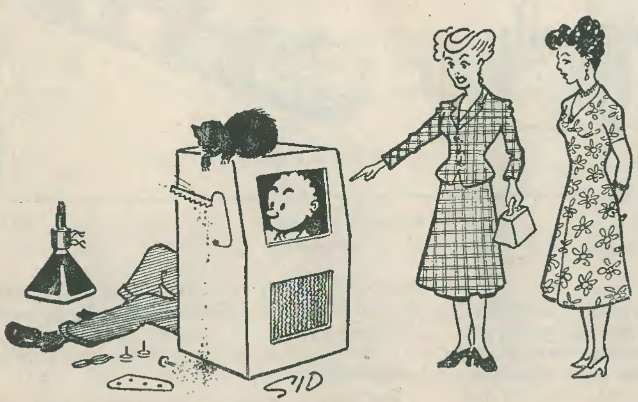
Checking is carried out with the aid of a bridge and two "standard" resistors of 100Ω, thus enabling the 1–1 ratio point to be accurately determined. Having done this, it is a comparatively simple matter to wind ten further 100Ω resistors. With these ten in series, together with one of the "standards," connect to the "Match" terminals of the bridge and establish the 10–1 and the 1–10 ratio positions. From these it then becomes possible to construct the 10 and 1,000Ω resistors. Each of the 1,000Ω resistors were further checked in the "Match" terminals of the bridge against the ten 100Ω resistors, and the ten 1CΩ resistors against one of the standards.

Should a bridge not be available, these resistors may be measured with fair accuracy by means of an ohmmeter. If this is decided upon, it would be advisable to procure a "standard" for each of the ranges required, and to use an applied voltage of such a value that an almost full scale reading is obtained.

For those who do not wish for various reasons to wind their own resistors, these may be purchased in the normal manner provided the higher cost of close-tolerance components is not a deterrent. The wirewound type of close tolerance resistors of reputable manufacture are accurate to within ± .01 per cent. This latter course will probably be of greater appeal to the vast majority of readers; nevertheless, the close tolerance specification must be adhered to if the instrument is to be of any real value.

The instrument described has been tested on a Sullivan bridge, and was found to be accurate within ± 1 per cent on the 100Ω and the 1,000Ω units, and to within ±2½ per cent on the 10Ω unit. Altogether a most useful piece of test equipment that every enthusiast should have in the workshop.

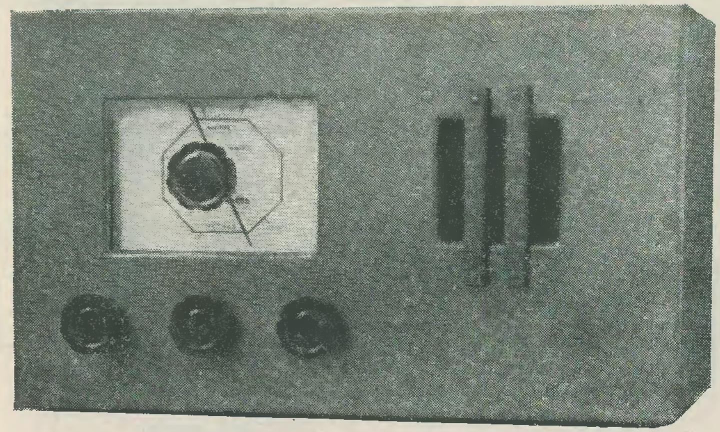
The bringing out of the centre switch rotor to a third terminal makes the instrument even more versatile. It then becomes possible to use the decade box as a test potentiometer.



Rufus

"Good Heavens, there's nothing in the *Radio Times* about Rufus being on TV tonight!"

THE EASI-BUILD RECEIVER



Part 3: THE CABINET

By **M. HARVEY**

Details of a simple cabinet which may be built in the home at little cost

In the last two issues of *The Radio Constructor* full details and wiring diagrams were given for the construction of the Easi-Build. As was mentioned in these articles, this set is very simple to make; so simple, indeed, that it can be confidently tackled by the beginner who has never built any radio gear before. It was felt that the series would not be complete unless it included constructional details of a cabinet which could be made in a similarly simple manner. As with the Easi-Build chassis itself, this cabinet requires few tools that cannot be found in the usual handyman's tool-kit.

Basic Construction

The basic method of making the cabinet consists, firstly, of constructing a framework with normal, easily-obtainable, 5-or 7-ply wood; and of then covering this with leatherette cloth. When properly applied, a leatherette finish can impart a very professional appearance to a job, and it has the further advantages of reasonable cheapness and of not requiring any special skill for its application. Also, of course, leatherette is obtainable in a wide range of hues, extending from very bright colours to subdued pastel shades, with the result that the completed cabinet can be made to fit into any colour scheme already in existence.

Dimensions

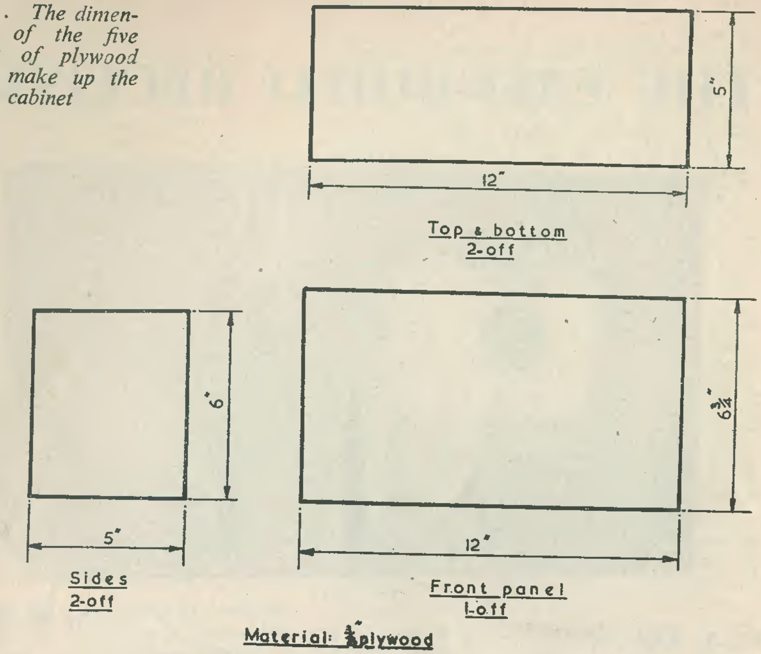
One of the best materials to use for the cabinet is three-eighths-in 5-or 7-ply. (Wood of this thickness is sometimes available in 9-ply, and this could also be used, if desired). This type of plywood is very easy to handle and is capable of allowing the simple butt-joints used in this cabinet to be made rigidly and reliably. The diagrams which accompany this article show dimensions which are based on wood of this thickness.

For the main part of the cabinet five pieces of plywood are needed, these being the top and bottom, the two sides, and the front. Fig. 1 shows their dimensions. It is a good plan to get the supplier of the wood to cut it into the sizes required, as this will save a lot of time and trouble in cases where the available equipment in the constructor's home is limited. Most suppliers will provide this service at nominal cost, and will ensure also that the wood is cut accurately and at a correct right angle.

Having proceeded so far, the top, bottom, and two sides are now complete and ready for assembly! However, before the cabinet can be put together, a little carpentry still remains to be carried out on the front panel.

Fig. 2 shows the cutting-out necessitated on the left-hand side of this panel in order to take the three lower control spindles and to

Fig. 1. The dimensions of the five pieces of plywood which make up the cabinet



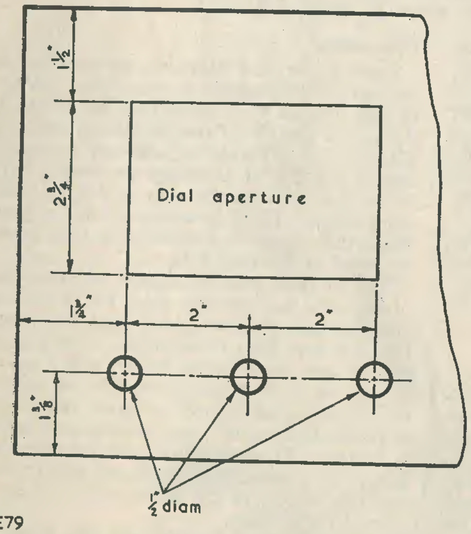


FIG.2

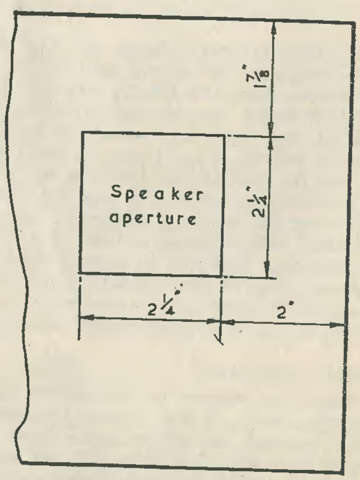


FIG.3

Fig. 2. Illustrating the drilling and cutting-out required at the left-hand side of the front panel

Fig. 3. A loudspeaker aperture which allows the speaker to be mounted directly behind the front panel

provide an opening for the tuning dial. The surface shown in this diagram is that which will be at the front of the completed cabinet.

The three control holes should be drilled out at a diameter of ½ in. To avoid the risk of accidentally splintering the plywood at any point where it would spoil the appearance of the completed cabinet, drilling should always be done from the front side of the panel. If splintering then occurs it will do so at the back. It is not worth while cleaning up the holes, after drilling, at this stage.

The position of the dial aperture is shown also in Fig. 2, and this should be cut out next.

Fig. 3 shows the dimensions of a suitable aperture employing the first method. No baffle-board is needed if a speaker aperture of this size is used, of course, since the speaker is then mounted directly against the back of the front panel.

Fig. 4, illustrating the second method of mounting the speaker, gives the maximum recommended dimensions of any speaker aperture which the constructor may wish to design himself. These dimensions allow a minimum of half an inch all round the opening to enable the baffle-board to be screwed to the back of the front panel. The dotted

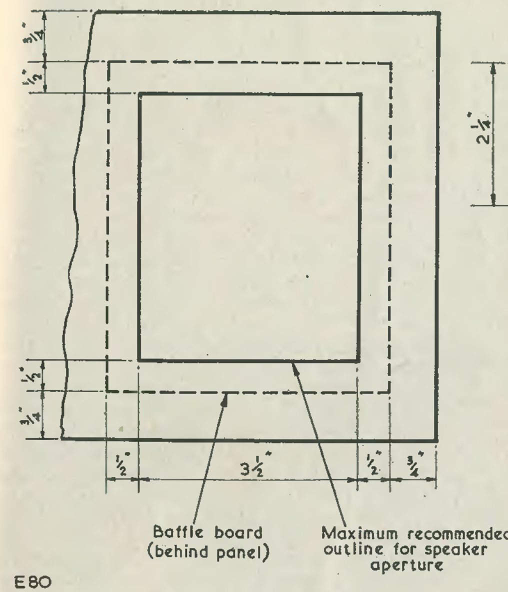


FIG.4

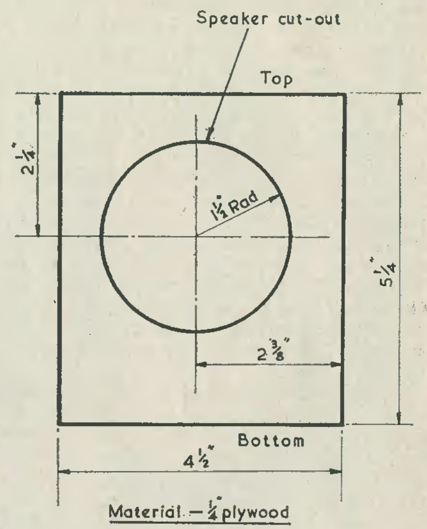


FIG.5

Fig. 4. Maximum recommended dimensions for an alternative aperture employing an internal baffle-board

Fig. 5. The baffle-board used with the arrangement of Fig. 4

Care should be taken to see that the edges of the aperture are cleaned up square and evenly, as a rough finish here can spoil the appearance of the finished cabinet.

The Loudspeaker

There are two ways of cutting out the aperture for the loudspeaker. The first method consists of cutting out a rather small hole against which the loudspeaker can be mounted directly. The second consists of cutting out a much larger aperture, behind which can be mounted a baffle-board holding the speaker.

line shows the position which the baffle-board should occupy in the cabinet; whilst Fig. 5 gives the dimensions of the board itself (looking at the front). The baffle-board should be made from ¼-in plywood.

All the dimensions given in Figs. 3, 4 and 5 are based on the assumption that the W.B. Stentorian loudspeaker recommended in the constructional articles describing the chassis is employed with the finished cabinet.

Assembly

As was mentioned above, the cabinet is assembled by means of simple butt joints.

These are strengthened by ⅝-in panel pins, and glue. The panel pins should be spaced at 1½-in intervals, their main purpose being to assist in the location of the various parts whilst the glue is setting. Before commencing the assembly, it is advisable to drive these pins into the wood just sufficiently far for their points to protrude. These points may then locate on the edge of the second piece of wood completing the joint, and the pins can be driven home quickly and accurately after the glue has been applied. See Fig. 6.

So far as the glue is concerned, nothing is as good for this application as the old-fashioned type which has to be heated up in a glue-pot. If a glue-pot is not available, a serviceable makeshift may be obtained with the aid of a tin and saucepan. With this arrangement, the tin holds the glue and water mixture, and is immersed in a saucepan half-filled with water. To keep the tin at the bottom of the saucepan a few small weights should be placed in it. (It does not matter if these become mixed up with the glue, although they may afterwards be rendered irredeemable when the glue in the tin has set!) The tin, with the glue in it, is then placed in the saucepan, water is added, and the whole heated up. Theoretically, the bottom of the tin should not be in contact with the bottom of the saucepan, but it will not make much difference in practice if the temporary "glue-pot" is in use only for short periods of time.

A fairly thick solution of glue is needed for the butt joints, and it should not be applied until it is really hot, fluid, and free from lumps. The glue should be brushed liberally onto the wood before joining, taking especial care to ensure that it soaks well into the end-surfaces. If possible, pressure should be applied to each joint after the glue has been applied, until all joints are properly set.

The chassis may now be "tried for size." It should be possible to insert the chassis into the cabinet such that the projecting bushes of the three lower controls lie snugly in the three half-inch holes in the front panel. These three holes may now be cleaned and "trimmed up."

Next, the surface and corners of the cabinet should be treated with sandpaper to ensure that they are clean and smooth. Any irregularities will show themselves through the leatherette covering. If there is any pitting in the surface of the wood, this may be filled in with plastic wood or a similar material.

The Leatherette

The process of applying leatherette to a wooden cabinet of this nature is very simple and gives effective results so long as two essential rules are observed. The first of these is that only one surface should be glued at one time. No attempt should be made to glue the leatherette to a second surface until the first has set firmly. In practice, the observance of this rule does not involve the constructor in any considerable delay, since thin glue only is needed for securing the leatherette to the cabinet and this usually sets sufficiently hard for the purpose in twenty minutes or so. The second rule is to make no attempt to cut out the leatherette into a shape which will fit the cabinet before glueing. Such a course usually ends in failure because the leatherette is liable to stretch when the hot glue is applied.

Before applying the leatherette, the corners of the speaker opening, and the four corners of the tuning scale aperture, should be covered with small strips of leatherette, as shown in Fig. 7. It is necessary to do this as these corners would otherwise be left uncovered by the main piece of leatherette.

The front panel may now be covered. This panel should be painted liberally with thin glue and the leatherette applied to it immediately. (Remember that the centre of the piece of leatherette used should be glued to the front panel, so that adequate material from the same piece is available for the sides, top and bottom). Whilst the glue is still fluid, the leatherette should be smoothed over with a damp cloth and gently stretched in all directions to ensure that no wrinkles or ridges are left. The leatherette should then be held against the panel under pressure until the glue has set. Several thicknesses of newsprint should be inserted between the leatherette and the surface which applies the pressure since some of the glue may seep through the pores of the leatherette. Any small pieces of newsprint sticking to the leatherette can be removed later with soap and water.

After the front panel, the top, and then the bottom of the cabinet should be covered, using the same uncut piece of leatherette and keeping it gently stretched away from the front panel.

Next required is a little detail work at the four corners of the cabinet. This is shown in Fig. 8. After this part of the job has been completed, the side pieces may then be cut and affixed as illustrated in Fig. 9.

The hardest part of the job is now over. The next process consists of trimming the leatherette and taking it round the inside back surfaces of the cabinet to ensure that complete coverage is obtained.

The dial and speaker apertures have next to be tackled. This is done by carefully cutting the leatherette covering these apertures in the manner shown in Fig. 10. The four one-inch strips of leatherette formed can then be taken around the sides of the aperture to the back surface of the front panel, and firmly glued. As may be seen, the small strips previously fitted to the corners of these apertures prevent

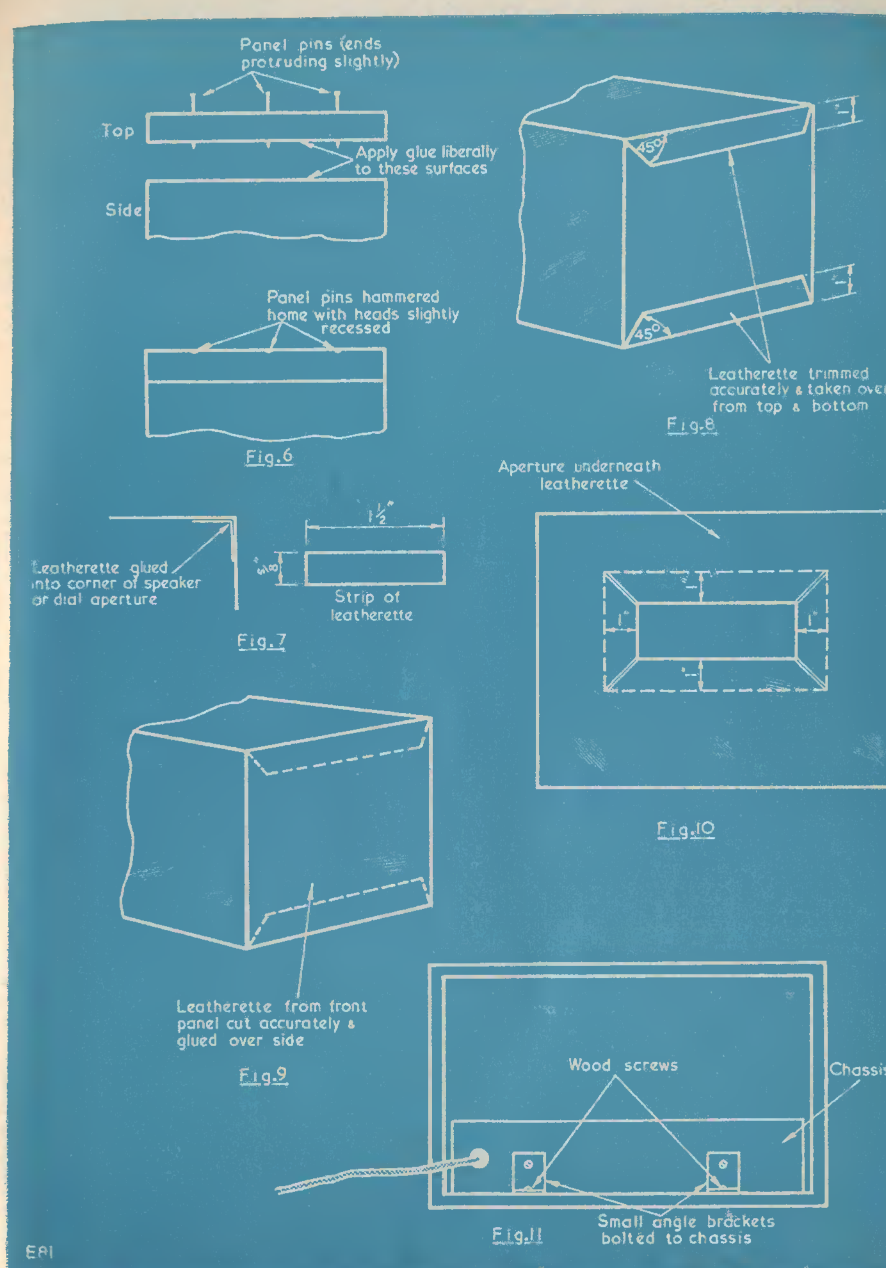


Fig. 6. Showing how the panel pins assist in the location and assembly of the butt joints Fig. 7. Applying small strips of leatherette to the corners of the speaker and dial apertures Fig. 8. First step in covering the sides of the cabinet. Fig. 9. Finishing off the covering of the sides. Fig. 10. Cutting the leatherette at the dial aperture. A similar procedure is required for the speaker aperture. Fig. 11. Showing the simple method of mounting the chassis

any bare wood being visible. The leatherette covering the three control holes may also be carefully removed at this stage.

The Dial Aperture

All that now remains is to fit a perspex insert into the dial aperture and to fix four small rubber feet to the cabinet. These latter may be obtained at most branches of the popular chain stores.

The perspex for the dial aperture is cut such that it is a push fit in the aperture, its front surface lying flush with the front of the cabinet. A hole has to be drilled in it to take the central tuning spindle.

If the cabinet has been made accurately, the three lower control bushes will locate comfortably into the three half-inch holes in the front panel. To lock the chassis in position, all that is then needed are two small brackets at the rear. These may be fitted as shown in Fig. 11.

Making a Back

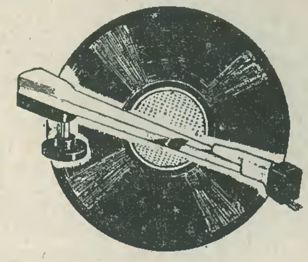
Since the chassis of the Easi-Build is "live," many constructors may decide to fit a protective back to the cabinet. Instructions have not been given for this as the work involved is, of course, very simple and straightforward. It must be emphasised, nevertheless, that it is essential that ventilating holes are drilled in the back; as, otherwise, overheating of the power components in the chassis may occur with consequent breakdown.

The Photograph

The photograph accompanying this article illustrates a typical cabinet of the type described here. As has already been stated, the method of construction used gives considerable latitude for those who wish to implement their own cabinet designs. Also, ornamental bars, etc., may easily be fitted over the loudspeaker aperture or glued to the surface of the front panel.

The red leatherette cloth for the prototype was obtained from Messrs. E. D. Pimble, 12 Liverpool Road, Newcastle, Staffs., at 6s. per yard, the width being 28 inches. One yard was ample.

MORE ABOUT REPRODUCING RECORDS



By **O. J. RUSSELL** B.SC., A.INST.P., G3BHJ

FROM SEVERAL LETTERS AND QUERIES FROM readers it is clear that there is a great interest in Hi-Fi reproduction. There are also indications that many readers are interested in obtaining reasonable results without undue expense. In fact, there seems to be little or no gap between the indifferent reproduction given by the average domestic receiver and the high-priced high-fidelity units. Indeed, at some £20 or so for the average domestic receiver it is a moot point whether this can be described as cheap!

Certainly it *is* possible for the home constructor to work up in easy stages to a good high-fidelity reproducing set-up without spending large sums, or without having to pay out a lump sum at one go. It is only fair to say also, however, that the path to reasonable Hi-Fi results is strewn with pitfalls, and the intention in future articles is to make the way easier for the home constructor to obtain worthwhile results as simply and economically as possible.

The "equaliser" circuits given recently do enable the listener—at the cost of a few resistors and condensers—to make a considerable improvement in reproduction. In fact, it is useless to start on the Hi-Fi road *without* first equalising record response! Let the reader consider the thirty decibels difference between mass and treble levels found on LPs and some 78 rpm records . . . not to mention the EP (extended playing) 45 rpm records. Some exceptional records recently heard have had top of such a degree of recorded boost that they were painful to listen to without equalising. The fitting of the recently described equalising circuit produced a marked reaction from the owner of one of these records recently!

However, due to individual preferences, and also due to the deficiencies of some domestic speakers, some form of variable tone control is often requested. In the case of any tone control worthy of the name, separate treble and bass control is a "must." The mass-produced receivers use simply a vicious form of "top-cut" control labelled "tone." This is virtually useless as a real tone control.

To simplify "tone control" problems, an attractive proposition is to make the "equaliser" circuit for record reproduction variable. This eliminates the need for making both equalisers and tone controls, and is useful for the enthusiast who wishes to obtain an added measure of control over the over-all balance of reproduction. Fortunately, the present-day record characteristics do enable this to be done to an appreciable extent.

To see how the idea operates, consider the bass boost first. If we provide for an amount of "boost" variable from more than that needed to equalise the recording bass drop, then we have in effect an over-all "bass boost" above a straightline curve. Thus by "over equalising" we get in effect an actual accentuation of bass. If we make the degree of equalising variable, then bass can be controlled from accentuated bass, straightline or bass attenuation.

Similarly, we can consider the treble control. Here the manufacturers nearly all record with accentuated treble, so that with a control giving more or less attenuation about the correct equalising level, we can lift or cut the top response about the "straightline" position. In fact, by building in top boost on the actual recording, the makers have simplified our "top control" problem! Also the "top cut" control of a domestic receiver does often provide the "top control" necessary for controlling the treble end.

Fig. 1 shows the simplest tone control unit based upon these ideas. It is intended for working into the pick-up terminals of a domestic receiver of the type fitted with a "tone control" of the "top-cut" variety. The variable control in the circuit then gives control of bass response, while the domestic receiver "tone" knob is used to control the treble levels. This is particularly effective on LP recordings, and does enable the owner of a crystal pick-up to obtain control independently of both bass and treble.

For those using small home-built amplifiers, or domestic receivers not fitted with top-cut knobs labelled "Tone," the circuit of Fig. 2 is suggested. This provides for both top and bass control, so that a crystal pick-up of the Acos Hi-G 39 types, or the popular Philips type "Disc Jockey" units equipped with crystal pick-ups, may be employed with a domestic receiver and have independent treble and bass control. It should be noted, of course, that like all circuits of this type, the "boost" is obtained at the expense of over-all output. However, the high output of these crystal pick-ups enables such tone control systems to be used satisfactorily. Moreover, when, for example, the bass boost control is turned to reduce bass, the output level increases, so that a compromise can easily be arrived at. Most domestic receivers, however, have adequate gain to enable full boost to be used.

The question arises of how to boost "top" on EMI 78 rpm records, which are recorded without top boost. Clearly, here, we can *not* utilise the record characteristic to provide "Top." In this case, too, the question of top loss arises. If a long screened lead is used to connect the pick-up to the receiver or amplifier, the capacity of the cable may be easily enough to cause an appreciable *drop* in the treble register! If a little more output can be sacrificed, the circuit of Fig. 3 will enable a mild degree of top boost to be obtained even on records with a flat treble characteristic.

Finally, the question of "sharp cut" scratch filters arises. Whilst LP records are uncannily noiseless with velvety silent surfaces (at any rate when new!) and whilst modern 78 rpm British records have a very low noise level, old records and records from various sources may have bad surfaces. Again, some Continental pressings made by British firms appear to be very noisy. In addition the record enthusiast has many old favourites in his collection which show considerable wear and which give considerable "needle hiss" if reproduced with equipment having a good top reponse.

The use of a "top cut" type of tone control to reduce the distracting hiss background is a compromise solution. In cutting the top on a gradual slope as in Fig. 4, the top register treble is sadly attenuated if hiss is to be appreciably reduced. To overcome this, "sharp cut" filters are used. These cut very steeply beyond a given frequency, so that hiss is attenuated with as little as possible of the top register. These units are commercially available, but are *not* easy to construct. In some commercial filters the slope is some 50 decibels per octave, and both slope and cut-off frequency are variable.

As explained in earlier articles, the usual RC stage of tone correction has a slope of 6 decibels per octave. However, if two RC stages both designed for the same cut-off frequency are cascaded, the slope becomes 12 db per octave. Three identical cascaded stages provide 18 db per octave, and so on. Moreover, as more stages are cascaded, the onset of attenuation becomes sharper. As readers have requested details of some form of "sharp cut" filter for use as a record scratch attenuator, the solution suggested is to cascade identical "top cut" circuits designed for the same frequency. This again is a "compromise" solution, but is one that can be tried by the home constructor without involving critical circuits such as are employed in the more elaborate types of "steep cut" filter. Naturally the steep cut filters of elaborate design can give better results, but in general they require close tolerance components, and some care in setting up.

For those reluctant to tackle the more complex types of "sharp cut" filter, the arrangement of Fig. 5 gives a suggested set-up. This is intended as an intervalve coupling, and gives a choice of cut-off frequencies, so that as much scratch may be eliminated as possible without unduly destroying treble as well. It should be noted that this is not a tone control; and a normal tone control unit used in conjunction with a steep cut filter enables reasonable reproduction from even worn records. Fig. 5 is a compromise arrangement that is worth trying for its obvious simplicity and non-critical component values. [END

THE JUBILEE OF THE INVENTION OF THE THERMIONIC VALVE

In connection with the celebration of the Jubilee of the invention of the thermionic valve by Sir Ambrose Fleming on November 16th, 1904, a Conversazione will be held in the Electrical Engineering Department of University College London. A plaque commemorating the occasion will be unveiled by the Lord President of the Council.

In addition to exhibits and documents relating to Sir Ambrose Fleming's work while Professor of Electrical Engineering at the College, examples of recent researches will be on view. Admission to the Conversazione, which will extend over the three days November 16th, 17th and 18th, will be by invitation ticket only. A limited number of tickets for the 17th is available on application, and Senior Engineers or members of the Radio Industry who would like to visit the Exhibition at the College, which will be open from 3 p.m. to 10 p.m., should apply to the Assistant Secretary, University College, Gower Street, London W.C.1.

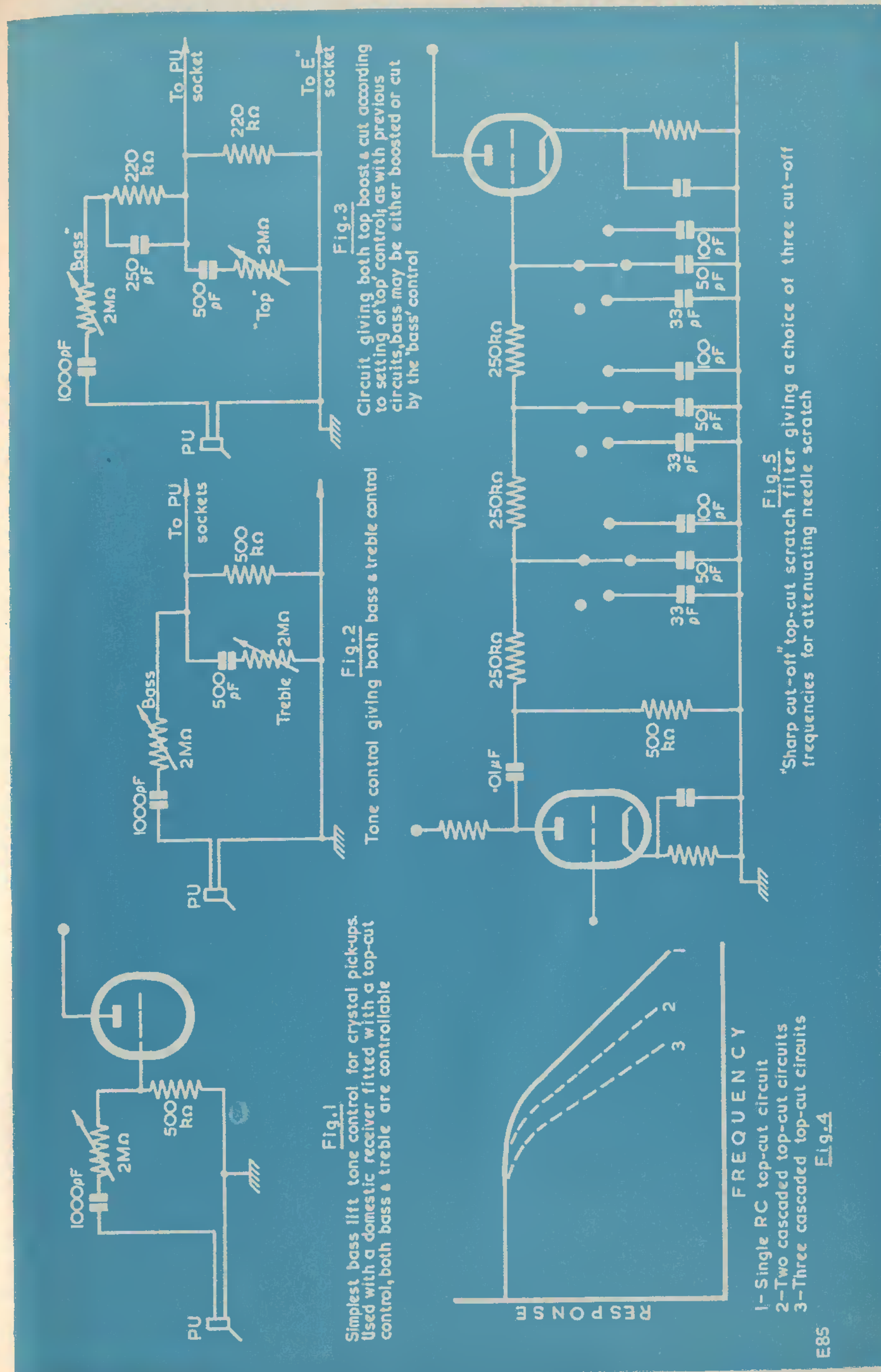


Fig. 1 Simplest bass lift tone control for crystal pick-ups. Used with a domestic receiver fitted with a top-cut control, both bass & treble are controllable

Fig. 2 Tone control giving both bass & treble control

Fig. 3 Circuit giving both top boost & cut according to setting of 'top' control, as with previous circuits, bass may be either boosted or cut by the 'bass' control

Fig. 4 1–Single RC top-cut circuit 2–Two cascaded top-cut circuits 3–Three cascaded top-cut circuits

Fig. 5 "Sharp cut-off" top-cut scratch filter giving a choice of three cut-off frequencies for attenuating needle scratch

Simple and Efficient AERIAL MATCHING UNIT

By **L. F. WEST**

Much has been written in the past about the problem of matching the aerial to the receiver, and many highly commendable circuits have been published. However, the complication of receiver operation, brought about by the need to keep the tuning of the matching unit in step with that of the receiver, not to mention the fact that as the tuning is varied the matching invariably has also to be corrected, scares many people away from tackling this problem.

The unit described here is an attempt to overcome the trouble for those enthusiasts who are unfortunate enough to live in flats or in houses with little space for complicated aerial systems. Whist it is possible to install a short aerial or vertical rod to present a low impedance on the higher frequency bands, it becomes increasingly difficult to do so as the frequency is decreased. To make matters worse, it is on the lower frequencies, such as the 160 metres and MF broadcast bands, that a vertical aerial will give better results, whilst, at the same time, presenting a much higher impedance to the receiver than the usual recommended 400Ω.

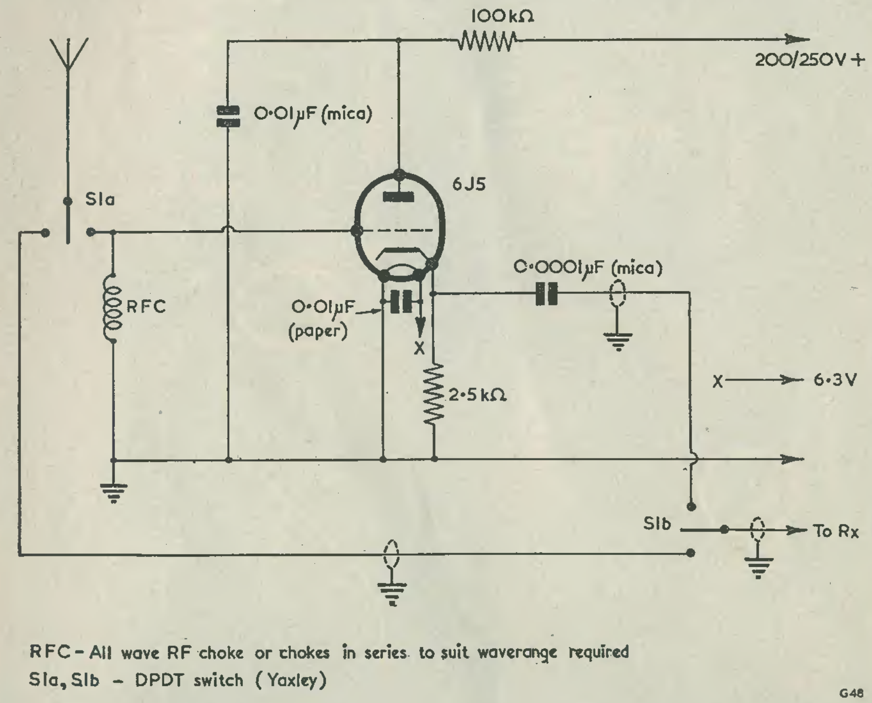
The cathode follower circuit has the advantage of providing a low impedance output whilst presenting a high impedance input, causing extremely light loading of the preceding circuit or signal source – coupled to the welcome fact that input and output impedances are not critical. This is due to the very high (100%) degree of negative feedback. The valve used in this circuit is the 6J5, which has a reasonably high g_m of 2.5mA/V, giving a cathode output impedance of 400Ω ($1 \div g_m$ in amps/volt).

The RF choke shown in the grid circuit provides a DC return path for the 6J5 grid, and it should be chosen to be effective over the operating range of the unit. If a suitable RF choke cannot be obtained, two chokes may be connected in series, e.g., a medium wave choke in series with an Eddystone 1010 type to cover 550-1,500 kc/s and 2-60 Mc/s. The short wave choke should be connected on the grid side of the chain.

Switch S1 is incorporated to allow the aerial to be switched direct to the receiver, when required, and is not necessary to the operation of the unit. It is, however, an asset when one aerial cut to one band is used on all bands.

It is recommended that the output to the receiver is run in co-ax cable and that the screening is earthed only at one end, a separate direct earth connection being made between unit and receiver. This is necessary if direct pick-up by the receiver input is to be avoided.

No originality is claimed for this circuit; the cathode follower as an impedance matching device is now well established and widely used. The increase in signal-to-noise ratio and apparent signal gain more than compensates for the slight cost of the few components required. In most cases, the complete unit could be squeezed into the receiver itself. There is no reason why one of the current miniature based valves should not be used in place of the 6J5, and the RF choke could be substituted, with little loss of efficiency, by a 470kΩ resistor.



TRADE REVIEW

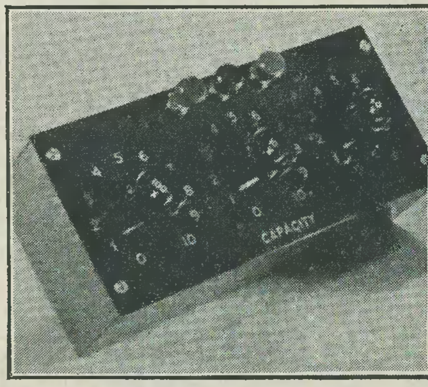
A NEW LOW-PRICE DECADE CAPACITOR BOX

Faced with the problem of considerable expenditure on decade capacitor boxes for a large research and development programme, two development engineers at Winston Electronics, Ltd., Hampton Hill, Middlesex, investigated the design of these instruments, starting from fundamentals.

By designing a new type of eleven-position switch—now patented—a great saving in bulk and manufacturing costs was made. An instrument which can be sold at a lower price than the cost of constructing home-made apparatus in either the factory or laboratory resulted, and is now being marketed at £10 15s. retail.

Technical specification:

- **Range:** 0.001 µF to 1.11 µF in 0.001 µF steps.
- **Stray Capacitance:** Less than 13 pF per decade.
- **Working Potentials:** 500 volts DC, except the 0.1 µF range, where it is 350 volts DC.
- **Switching:** Positive and firm. No play.
- **Controls:** Firm, finger-ready.
- **Finish:** Facia Panel, Photo-etched. Box, Steel, grey hammer-tone enamel.
- **Dimensions:** 8″ × 3¾″ × 3″ (20.3 cm. × 8.4 cm. × 7.6 cm.).
- **Weight:** 32 ozs. (0.9 kilos).



PLESSEY VHF AERIAL MULTICOUPLER

In VHF receiving stations, it is often desired to operate several receivers from one aerial. Direct attachment is seldom satisfactory as it results in considerable cross-coupling between the receivers and serious matching difficulties.

To overcome these problems, Plessey have developed a VHF aerial multicoupler, operating in the band 116–134 Mc/s, which enables up to six receivers to be worked from one aerial without loss of performance. An insertion gain of 17db., is achieved with a noise factor of 8 db., so that the use of this coupler often gives a substantial improvement in the signal-to-noise ratio. The coupling between any two output sockets is better than 40 db. down relative to the insertion gain, and the linearity is such that cross-modulation effects are negligible over the normal range of signal strengths. The input and output circuits are arranged for use with 75 ohms co-axial cable.

The input stage consists of two triodes connected in cascode which allows wide band operation with minimum noise. This amplifier is fed to the six separate grounded grid output stages, the output being taken at low impedance from a tap on the anode coil. Each output stage is provided with an adjustable trimmer which may be set against a calibrated scale to give maximum gain at the frequency being received. If this gain is not required, it may be reduced without deterioration in noise factor of the multicoupler, by deliberate mistuning. No other adjustments are required.

A built-in AC power supply is provided and the unit is designed for mounting in standard international 19″ racks, occupying a height of 5¼″. All components are tropically rated.

AN ELECTRONIC ENLARGER & EXPOSURE TIMER

By **A. R. TUNGATE** G3ELB

THE ALLIANCE OF RADIO AND PHOTOGRAPHY is, to the writer, like chalk is to cheese, but nevertheless, the alliance exists. Your contributor has found that a large proportion of those versed in the art of radio and electronics and employing same as a hobby, have at some time or other delved into the field of photography as a secondary hobby. The following article allows one so afflicted to follow both hobbies simultaneously.

Requirements

The unit, when used as the title expresses, is so constructed as to give automatic exposures from one second to one-hundred and-nine seconds in one-second steps.

Before construction was attempted, the requirements and necessary features were considered and tabulated as follows:

(a) The unit was to be simple to operate (sometimes in total darkness).

(b) Should be reliable and consistent.

(c) Have a fair degree of accuracy.

(d) Finally, the ever-important consideration —cost—was to be kept as low as possible.

The finalised unit complied with all the points tabulated, and the degree of accuracy was better than expected by the constructor when first putting the unit through a series of counts. The accuracy was found to be better than 5 per cent over the entire range, and consequent juggling with the resistors in the time forming circuit brought the accuracy to better than 2 per cent over the full range.

Circuit

Perusal of the circuit shows that a fairly orthodox arrangement is employed, and the principle of operation is commonplace. A condenser of fixed capacity is charged and allowed to discharge through a pre-selected resistance, the value of resistance governing the time taken to discharge the condenser.

Operation

When the mains supply (AC) is applied to the transformer, valves V1 and V2 acquire their heater supply and at the same time the bank of condensers C1, C2 and C3 is charged by the two valves in series, each valve acting

COMPONENT LIST

V1	6J5, 6C5 or L63	S1	DPDT Toggle switch Bulgin
V2	6L6 (or 6V6 with R4 shorted)	S2–S3	SPST Toggle switch Bulgin
R1	20kΩ ¼W ± 20 per cent Erie type 8	S4–S5	SP 11-way wafer switch, continuous rotation
R2	2.2MΩ ¼W ± 20 per cent Erie type 8	S6	Push button switch Bulgin or Siemens
R3	12kΩ ¼W ± 20 per cent Erie type 8	RLA	500Ω type 3000 GPO relay 4 change-over (or similar)
R4	68Ω ½W ± 20 per cent Erie type 9	T1	6.3V 0.3A, 6.3V 1.5A heater transformer
R5 to R14	1MΩ ⅛W ± 5 per cent Erie type 16	PL1, PL2	6.5V 0.3A MES Bulbs with suitable holders
R15 to R23	100kΩ ⅛W ± 5 per cent Erie type 16	F1	2A cartridge fuse Belling Lee
C1	0.5μF 500V wkg (or two 0.25 TCC 545 in parallel)	VR1	5kΩ wire wound potentiometer
C2	0.1μF 500V wkg TCC Metalpack		
C3	2μF 500V wkg TCC 82		
C4	0.01μF 350V wkg TCC Metalmite		
C5	16μF 350V wkg TCC Micropack (insulated case)		

Miscellaneous: 3-pin 5A mains plug, 3-pin 5A output socket, 2-pin 2A output socket, 9-in. x 6½-in. x 2-in. chassis (or similar), Panel to suit chassis, 2 white dials (or Panel Signs), nuts, bolts, grommets, pointer knobs (2).

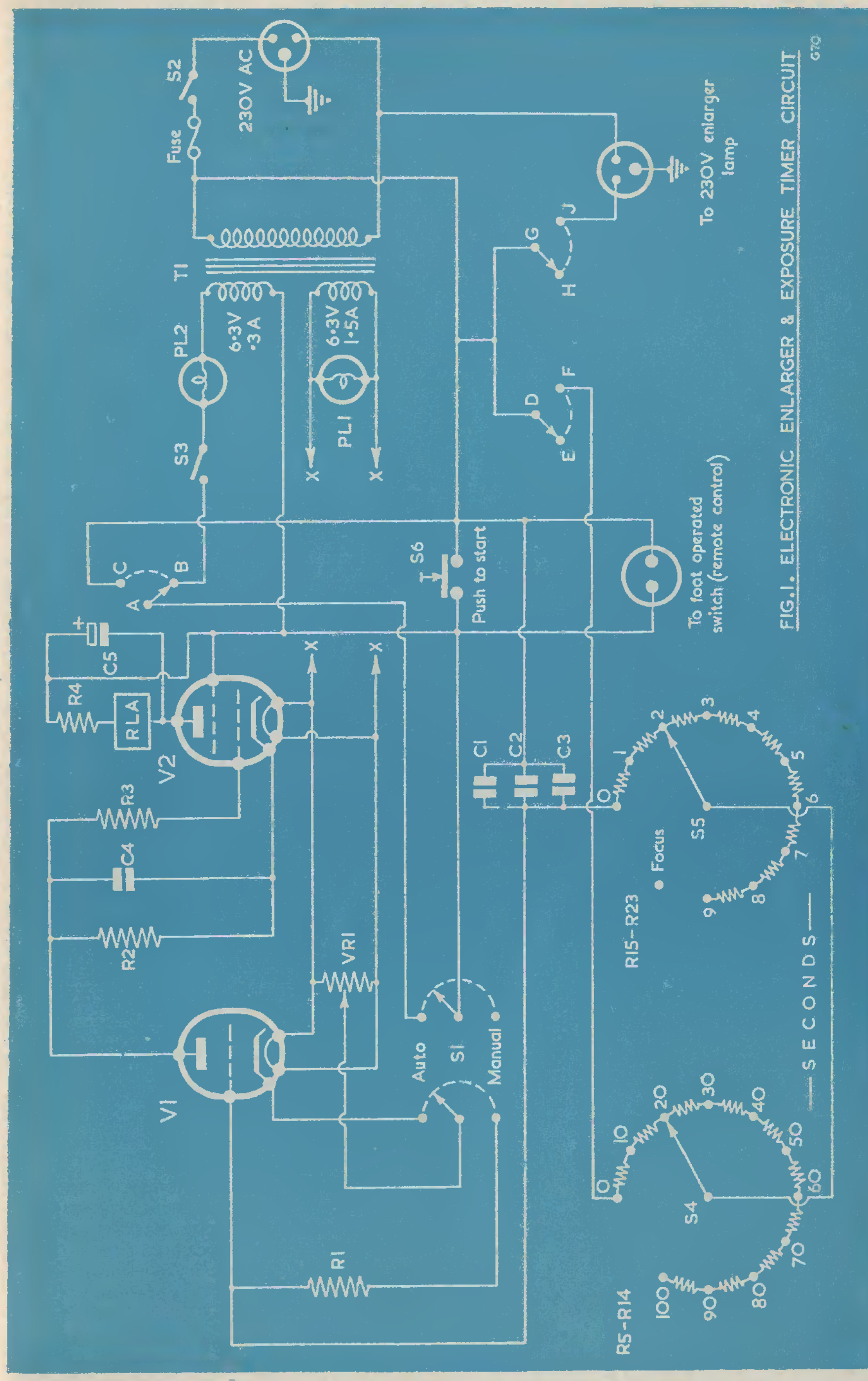


FIG. 1. ELECTRONIC ENLARGER & EXPOSURE TIMER CIRCUIT

as a half-wave rectifier. The charge developed across the condensers is in the region of 310 volts.

Depressing the "push-to-start" switch causes V2 to conduct because of the potential then applied across the valve. The anode current of V2 brings the relay RLA into operation, and the contacts A and C form a circuit which "holds" the relay RLA even after pressure on the "push-to-start" switch has been released.

Contacts D/F and G/J are so wired on the relay that they all make together and the mains supply is connected across an output socket which feeds, in turn, the lamp in the photographic enlarger, and secondly the anode current falls, causing the energising coil of the relay to become inoperative. The contacts open—the enlarging lamp is disconnected—and the condenser bank receives a further charge for the next count.

General

In order to obtain best results with the timer, a little care is necessary in selecting the components in the timing network, i.e. the rotary switches, the condenser bank and the resistors. The writer finalised with Erie Type 16 resistors with a tolerance rating of 5 per cent and a 2 μF T.C.C. Type 82 condenser paralleled with a 0.5 μF tubular and

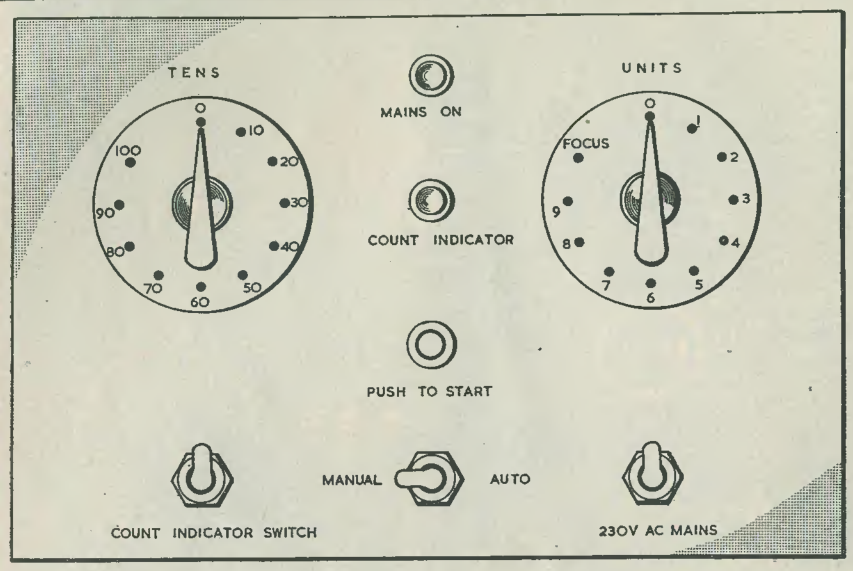


FIG. 2. FRONT PANEL CONTROLS

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selected resistor is placed across the condensers. The initial high voltage on the condenser bank appears on the grid of V1 as a high cut-off bias and consequently the valve will not conduct.

When the condenser bank has discharged to a sufficiently low value through the switched resistor brought into circuit at the beginning of the count, V1 will begin to pass current and a voltage will therefore appear across the anode load R2. This voltage biases V2 to cut-off point with the result that V2 0.1 μF Metalpack T.C.C. condenser, making a total capacity of 2.6 μF. New Yaxley switches were employed (single-pole 11-way).

The function of the remaining components needs little explanation, except maybe for the potential divider across the filament supply in the form of a wire-wound potentiometer. This control permits a small AC voltage to be applied to the cathode of V1, thus determining the point at which V1 will conduct when the charge on the condenser bank has leaked away. In other words, it forms a fine adjust-

ment control and, once set, need never be altered.

A lamp (PL2) indicates whether the unit is counting (lamp off) or if ready to commence a count (lamp on). A pair of contacts on the relay (A and B) bring this circuit into being when the relay is inoperative, i.e. V2 not conducting. The lamp could be substituted by a 6-volt solenoid capable of ringing a bell. This would indicate that the unit had completed its count and that exposure had finished. A switch S3 is incorporated to take PL2 out of circuit and this could be used to work in conjunction with the bell, if added.

With the rotary switch in the position marked "Focus," the condenser-resistor network is open circuited, thus presenting an infinite impedance to the condensers, and consequently the Enlarger lamp will stay illuminated until such time as the rotary switch is thrown to the zero position to discharge the condensers. (The customary "crack" occurs, but to date no adverse effect has been noticed to either the rotary switch contacts or the capacitors themselves).

Other attachments to the unit include a socket in parallel with the "push-to-start" button, into which a foot-operated switch can be inserted for remote control.

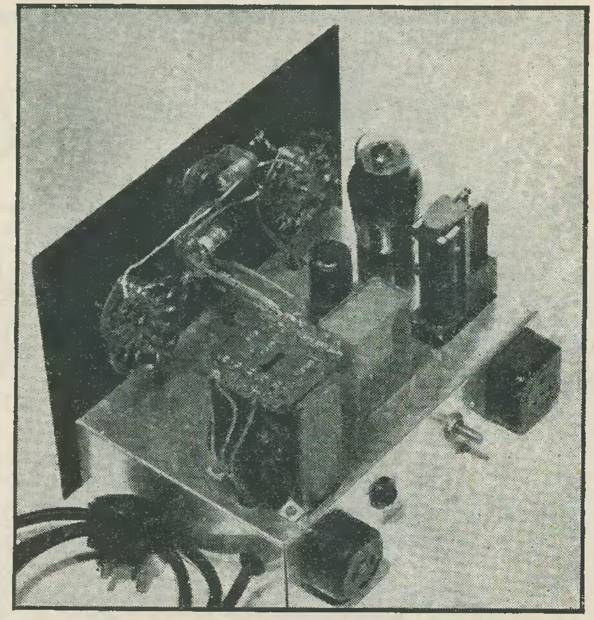
The "auto-manual" switch is included to enable manual timing to be used if desired. V1 is made inoperative by R1 when the switch is thrown to "Manual" and the holding circuit of the Relay RLA is disconnected, causing the Enlarger Lamp to stay in only when the "push-to-start" button or the foot switch is depressed. A wiring point to note is that no part of the circuitry is earthed, except the Earth lead on the lamp and the mains input earth lead. Therefore, a wooden baseboard could be employed; the writer, however, recommends a metal chassis (earthed) as this not only enhances the finished product but aids in the ease of construction.

The electrolytic in the anode circuit of V2 prevents relay chatter; Fig. 1 shows the theoretical circuit and reference to the photographs shows the layout and the front panel arrangement adopted by the writer.

Fig. 2 identifies the controls on the front panel. A chassis $6\frac{1}{2}'' \times 9''$ with a panel $10'' \times 6\frac{1}{2}''$ was employed; ample space is afforded for under-chassis wiring.

A 6V6 can be used in the place of the 6L6, but the limiting resistor R4 will probably have to be reduced in value, or even omitted entirely.

On putting the unit into operation and checking the timing against a reliable timepiece, it may be found inaccurate at one point



Rear view of Electronic Timer

(starting from the one second count). It is an easy matter to locate the defaulting resistor causing the error for it will be that one preceding the contact on which the switch is operating. Removal of the resistor and substitution for one nearer its nominal value will effect a cure.

Regarding wiring, no interaction will be found due to the low frequency operation (AC mains) and the rectified AC, so one need not bother about short and direct leads.

Conclusions

Those radio enthusiasts with a trend towards photography can satisfy both desires by constructing this Electronic Timer and then by using it in the pursuance of the second hobby, or constructing it for that cousin who is always in the dark room mixing his concoctions and potions of hypo and developer, and who will undoubtedly appreciate the gift!

Query Corner

A *Radio Constructor* Service for Readers

Ultra-Linear Operation

I have always been interested in the quality reproduction of Sound, and have successfully built several amplifiers during the past few years. However, I have recently noticed a new term which is creeping into what might be termed the "hi-fi" jargon. This term is "Ultra-Linear," which I believe refers to some new method of operating the output valves. Would you enlighten me on the advantages of this arrangement, and is it, in your opinion, to be recommended? D. Neath, Acton.

The ultra-linear or distributed load method of operating a push-pull output stage in an audio amplifier has been known for some years now, and was first employed in a commercially produced amplifier just after the war. It consists of distributing the load impedance between the screen grid and anode of each output valve in order to achieve a reduction in the harmonic distortion which the output stage introduces. In its basic form the circuit appears as in Fig. 1a.

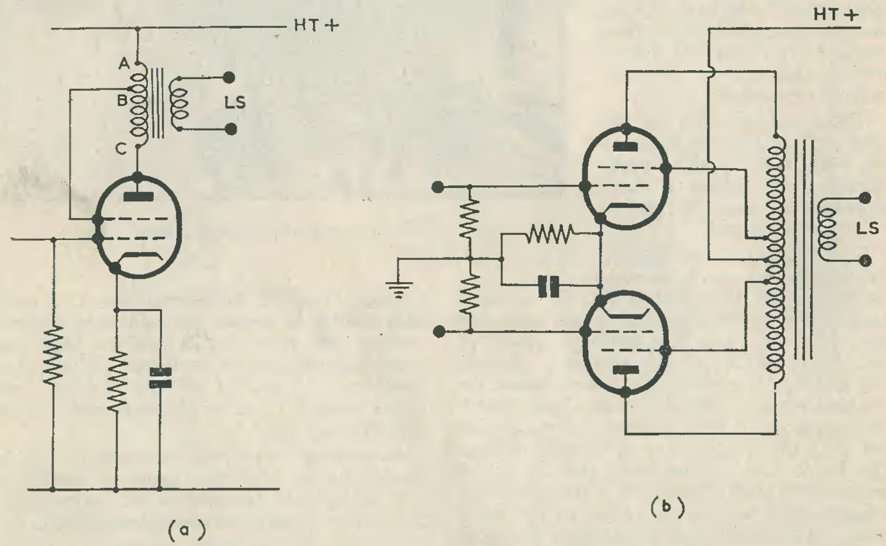


FIG. 1. The ultra linear arrangement applied to both a single-ended and a push-pull stage

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The arrangement differs from that normally used only in that the screen grid is tapped into the primary of the output transformer; this makes a part of the load common to both the screen and anode circuits. If the tapping point is moved to "C" the valve behaves as a triode, whilst if it is at "A" the performance is that of a normal tetrode. Thus as the tapping point is moved progressively from "C" to "A," the characteristic changes from triode to tetrode. The effect which this has on the anode-current/anode-voltage characteristic of the valve is shown in Fig. 2. This set of curves indicates the way in which the curve shape changes as the tapping point is adjusted.

It will be apparent from the circuit diagram that the arrangement is virtually a tetrode output stage operating with negative feedback applied to the screen grid. As the feedback is increased, so the permissible anode swing is decreased because of anode current cut-off on the negative half-cycle. This reduces the maximum output. The optimum tapping point on the output transformer will depend on the type of output valves employed, but it is usually in the region of 20 per cent from the top. This only reduces the available output power by about 10 per cent, but the distortion can be reduced by as much as 50 per cent in a push-pull stage.

The screen grid characteristic of the valve introduces a non-linear element into the feedback circuit, and this can result in an increase in even harmonic distortion in a single-ended output stage. However, when using push-pull the even order harmonics tend to cancel out in the load circuit. It is under these conditions that the ultra-linear circuit offers its main advantages—a reduction in distortion at the expense of only a small decrease in power efficiency, coupled with an appreciable reduction in output resistance resulting from the negative feedback.

It is generally preferable to apply feedback to an audio amplifier in a series of separate loops, each embracing a minimum number of stages. By so doing, the phase shift in each loop is kept small and the stability and response of the amplifier preserved. The ultra-linear circuit covers only the output stage, and leaves the designer free to choose the remainder of the circuit constants without the added difficulties associated with the more conventional wide loop feedback. When considering the bias circuit of an ultra-linear output stage, it is important when a common cathode resistor is used to shunt it with a large value capacitor (at least 100μF).

Finally, a note about the output transformer. It is reasonable to state that any amplifier is only as good as the output transformer, it being false economy to purchase a cheap component. The various windings and sections of windings on a transformer are coupled by a complex system of leakage reactances which may produce a large phase shift at the higher frequencies. This can, in turn, result in peaks forming in the frequency response, and may, in severe cases, result in instability. Troubles of this nature can only be avoided by using tightly coupled windings and by keeping the shunt capacitances to a minimum; in other words, by using a well-designed and well-made transformer.

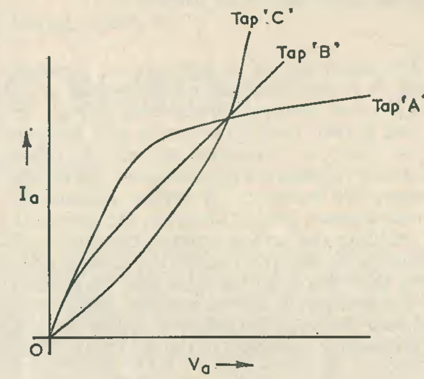

FIG. 2. I_a/V_a characteristic showing the change in shape as the output transformer tap is changed

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Query Corner

RULES

(1) A nominal fee of 2/6 will be made for each query.
(2) Queries on any subject relating to technical radio matters will be accepted, though it will not be possible to provide complete circuit diagrams for the more complex receivers, transmitters and the like. Queries relating to ex-W.D. surplus or commercial equipment cannot be accepted.
(3) Complete circuits of equipment may be submitted to us before construction is commenced. This will ensure that component values are correct and that the circuit is theoretically sound.
(4) All queries will receive critical scrutiny and replies will be as comprehensive as possible.
(5) Correspondence to be addressed to "Query Corner," Radio Constructor, 57 Maida Vale, Paddington, London, W.9.
(6) A selection of those queries with a more general interest will be reproduced in these pages each month.

Inner-Mu

I have found references in valve makers' literature to the term "Inner-Mu," which applies to a characteristic of a tetrode or pentode valve. Could you define this term and give me some idea of its purpose?

E. Evans, Bristol

The inner-mu of a pentode or tetrode valve is a characteristic of the screen grid, and is often denoted by the term μgl-g2. It is well known that if the screen grid voltage of a valve is increased whilst all other electrode voltages are held constant, the anode current will increase. A similar increase in anode current could, however, be obtained by holding the screen voltage constant and reducing the negative bias on the control grid. Now the inner-mu of a valve may be defined as the change in screen voltage which will produce the same deviation in anode current as a change of one volt in the grid bias. This characteristic is usually measured about the normal class A working point of the valve.

Take, as an example, a pentode which has an inner-mu of 20 and a slope or mutual conductance of 10mA/V. A change of one volt in grid bias will alter the anode current by 10mA, but if the bias is held constant a similar difference in current can be produced by changing the screen voltage by 20V. Thus, with a knowledge of the inner-mu we can calculate the anode current which a valve will pass at screen voltages other than those published in the maker's data; or, conversely, if a different screen voltage has to be employed it is a simple matter to determine the bias voltage required to bring the anode current back to its working value.

In conclusion, it is useful to remember that if a pentode valve is being used as a current stabiliser, for example to control the focus coil current in a TV set, a valve with the lowest inner-mu will be least susceptible to differences in HT supply voltage.

Let's Get Started

17: PHASE SHIFT

By **A. BLACKBURN**

MY ORIGINAL INTENTION THIS MONTH was to go into the complexities of negative feedback, but the deeper I went into the subject, the more it appeared necessary to talk about phase shift instead. Which only goes to show how easily one can be sidetracked!

However, there was obviously no point in attempting to explain negative feedback when a vital and integral part of the subject was not clear. In tackling this question of phase shift, several limitations of amplifiers will come to light.

Capacity

The problem boils down to two basic questions. Firstly, why does a capacitor pass AC and not DC? and secondly, what is phase shift anyway? The reason for a capacitor's failure to pass DC is, of course, that the plates are separated by an insulating material.

The presence of this insulating material, however, affects the application of AC very differently. Fig. 1 shows a circuit in which a capacitor C is charged through a resistor by a battery. When the switch is closed, electrons leave one plate, flow around the circuit and arrive at the other plate. If a meter were inserted in series with, say, the resistor, a current would be indicated, due to the flow of electrons. When the capacitor were fully charged, i.e., it had the same voltage between its plates as the battery, the current would cease.

Switching to position B would cause a current to flow in the opposite direction as the capacitor discharged. On completion of the discharge, the current would once again cease. The meter, then, will have indicated current flowing just as though a resistor were in circuit, instead of a capacitor. Unlike a purely resistive circuit, however, the current only lasts for a short period and then ceases altogether.

An interesting digression here is to note how a capacitor charges and discharges. If a voltmeter were connected across the capacitor during the charging period, and the voltage read at regular intervals, we could produce a graph like that shown in Fig. 2a. Leaving the voltmeter connected and putting the switch to position B would produce a graph as in Fig. 2b. The water levels in a lock, as it fills and empties, plotted against time would produce exactly the same graph. The vertical and horizontal scales in Figs. 2a and 2b have been marked in terms of these quantities also.

The lock is a very good comparison. When the underwater sluices are opened, a surge of water rushes into the lock. This flow represents the current (dotted in Fig. 2a). The head of water (represented by voltage in 2a) begins to rise quickly. However, as time passes, the head in the lock begins to oppose the flow of water entering it, and the rate of flow of the water will decrease, as will the rate of rise of the head of water be correspondingly slowed. When the head in the lock is almost at the level of the river outside the gates, the current will be very slow indeed—in fact, the lock *never* completely fills. It will always be in the state of filling, however slowly, long after you have got tired of waiting and moved on.

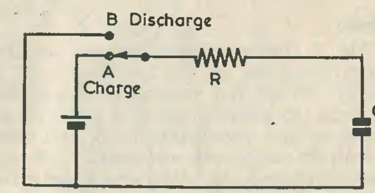

Fig.1

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The charging capacitor is exactly the same—it never completely charges. The same condition applies for emptying the lock, and of course, discharging the capacitor. There will always be a residual charge, which grows less as time goes on.

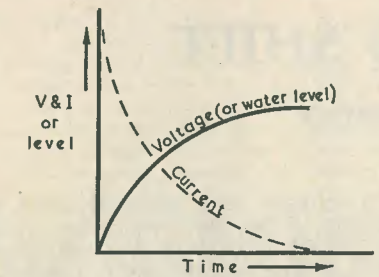

Fig. 2a
Capacitor charging

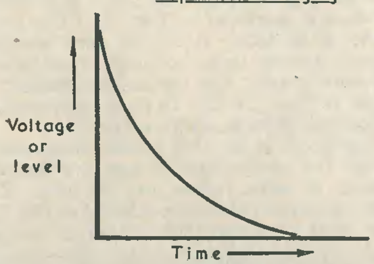

Fig. 2b
Capacitor discharging

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Phase

Fig. 3 shows a capacitor and resistor in series being fed by the customary AC generator. When the generator voltage begins to increase towards its first positive peak, electrons flow round the circuit and develop a voltage across R. However, when the peak is reached, the voltage begins to increase towards the negative peak. The electrons reverse their direction and move round the circuit, thus developing a voltage of opposite polarity across the resistor. In other words, the voltage waveform appearing across the resistor will be a replica of that produced by the generator.

We get the impression, therefore, that the capacitor is acting rather like a resistor in our circuit of Fig. 3. But if we could observe, on an oscilloscope for example, the waveform at the generator, simultaneously displayed with the waveform across R, we would notice that they were not in step, as shown in Fig. 4. These voltages are said to be 'out of phase'.

Fig. 2a gives a clue to the reason for this 'phase shift' as it is called. The current in the capacitor is a maximum when the voltage is a minimum, and vice-versa. When the generator voltage (Fig. 3) reaches a maximum, therefore, the current round the circuit will be a minimum, and the resultant voltage developed across the resistor will also be a minimum. Conversely, when the generator voltage reaches a minimum, the current around the circuit will be a maximum and the voltage developed across the resistor will be a maximum.

The amount by which the phase is shifted depends upon the frequency of the applied voltage, and the values of resistance and capacity. The phase shift θ in degrees is given by:

$$\text{Tan}\ \theta = \frac{1}{\omega CR}$$

where $\omega = 2\pi$ frequency, C=capacity in Farads, R=resistance in Ohms; but one needn't really worry about the mathematics of the thing.

The maximum phase shift possible with a single resistor and capacitor is 90°. The reason for denoting the amount of phase shift by degrees is connected with the vector generating the signal. One rotation of the vector representing one cycle is 360°. The phase shift between current and voltage is measured, therefore, by their relative *angular* positions, i.e., in degrees of rotation.

Because it reaches its maximum value before the voltage, the current is said to lead the voltage.

Attenuation

We have seen that the capacitor acts in an AC circuit rather in the manner of a resistor, except that it produces a shift in phase between input and output voltages. The question which follows naturally is whether a capacitor produces a voltage drop in the same way as a resistor. And the answer, with reservations, is yes. The reservations are important.

If the capacitor in Fig. 3 were replaced by a resistor, the total load seen by the battery would be the sum of the two resistors. Now the apparent resistance, or reactance as it is called, of a capacitor is:

$$\text{Reactance}\ X_c = \frac{10^6}{2\pi fc} \qquad (1)$$

Where f is in cycles/sec., and C is in μF, and X_c is in ohms.

It would seem logical, therefore, to suppose that the total impedance of a resistor in series with a capacitor would be $R+X_c$.

(Note that a resistor on its own has the property of *resistance*, a capacitor on its own is said to have a *reactance*, and a combination of resistor and capacitor (or inductor) is said to constitute an *impedance*).

It is disappointing, however, to learn that whereas $R+X_c$ would seem a reasonable conclusion to draw, it is nothing so simple as that. The phase difference between current and voltage complicates the issue.

The resultant impedance of the series R and C in Fig. 3 can be expressed as:

$$\text{Impedance}\ Z = \sqrt{R^2+X_c^2} \qquad (2)$$

We have now sufficient information to calculate how many volts are lost in any particular network of this type. The current will be:

$$I = \frac{E}{Z}$$

The R for resistance in a DC circuit is simply replaced by Z in Ohms Law, when it is an AC circuit. The output voltage is expressed as:

$$V = IR,$$

but we know the value of I, so if we insert this value into this expression, we get:

$$V = \frac{ER}{Z}$$

A practical example is shown in Fig. 4, where RC coupling between two amplifier stages, in which two volts are developed across the anode load of the first stage, is illustrated. We want to find what voltage appears at the grid of the second stage at 5 kc/s and 50 c/s.

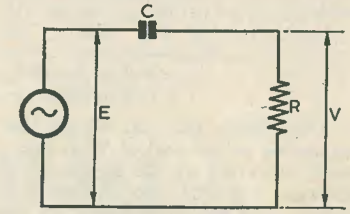

Fig. 3

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We have the values R=100kΩ, C=0.01μF, and E=2V. The simplest way, and the best, to go about this is to work out X_c first, using the equation (1) above.

$$X_c = \frac{10^6}{2\pi \times 5 \times 10^3 \times .01} = 3.2\text{k}\Omega.$$

Substitute X_c in expression (3) for its value of 3.2kΩ and we get:

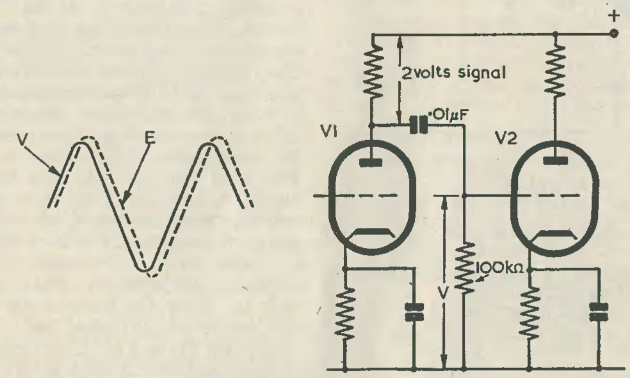

Fig. 4
Phase of voltages in fig. 3 & application to valve circuit

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However, we have already worked out that $Z=R^2+X_c^2$, so the output voltage must be:

$$V = \frac{R}{\sqrt{R^2+X_c^2}}\,E \qquad (3)$$

$$V = \frac{10^5}{\sqrt{10^{10}+3.2^2\times 10^6}} \times 2\ \text{volts}$$

$$=2\ \text{volts.}$$

At a frequency of 5 kc/s, then, the signal voltage at the grid of V_2 is equal to the signal voltage at the anode of V_1. At 50 c/s, however,

$$X_c = \frac{10^6}{2\pi \times 50 \times .01} = 320k\Omega.$$

and

$$V = \frac{10^5}{10^{10} + 3.2 \times 10^{10}} \times 2V = 1 \text{ volt approx.}$$

This shows that at 50 c/s the voltage appearing at the grid of V_2 is only one half that appearing at the anode of V_1. This voltage is called the attenuation of the circuit, and will immediately be familiar to the 'quality' man as a falling off of bass response.

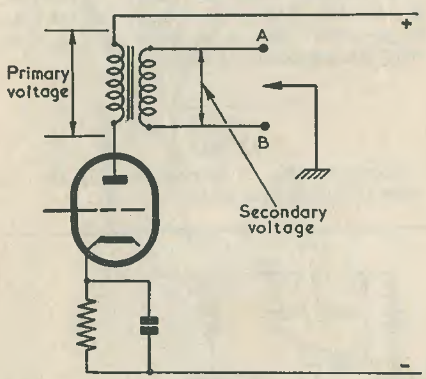

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Fig.5

It is interesting to try the same calculations for a 0.1μF coupling condenser.

The phase changes from the anode of V_1 to the grid of V_2 are as follows, and were calculated from $\tan\theta = \frac{1}{\omega CR}$

At 5 kc/s, Phase change approx. 2°.
At 50 c/s, Phase change approx. 72½°.

In a straightforward amplifier without feedback, this phase shift is not particularly important. However, the point to notice and remember is that the phase shift increases as the attenuation increases.

To retain the low frequency response, therefore, the coupling capacitor and grid leak should be of the highest value possible.

Inductance

It is seldom nowadays that the various forms of inductance, chokes and transformers are found in amplifiers, except in the output circuit. It won't do any harm, however, and will complete the picture, if we have a brief look at the properties of inductors.

An inductance in a circuit produces a shift in phase in the same way as a capacitor. In this case, however, the voltage leads the current, and the phase shift is given by:

$$\tan\theta = \frac{\omega L}{R}$$

If the capacitor is replaced by an inductance in Fig. 3, the impedance of the series inductance and resistance becomes:

$$Z = \sqrt{R^2 + X_L^2}$$

and the voltage output becomes:

$$V = \frac{R}{\sqrt{R^2 + X_L^2}} E$$

The Transformer

The effect of a transformer on the phase of input and output voltages cannot be stated so definitely as in the case of C and L.

Fig. 5 shows a transformer in the anode of a valve. It may be either an intervalve coupling component, or an output transformer. For a start, we will assume that the transformer is perfect. By perfect, I mean that no energy is lost in the resistance of the windings or in magnetising the core. What is more, to be perfect, every magnetic line of force produced by the primary must cut the secondary, i.e., there is no leakage. The final condition is that there must be negligible capacity in the windings.

If all these conditions are met, the voltage across the secondary will be either precisely in phase with the voltage applied to the primary, or precisely 180° out of phase with it. How the transformer is connected will decide which it shall be.

If point B, in Fig. 5, is earthed, then the voltage between A and B, we will assume, is in phase with the primary voltage. If, however, point A is earthed, the voltage between B and A will be 180° out of phase with the primary voltage.

This all sounds delightfully simple, but of course in practice no transformer—or anything else for that matter—is perfect. All the conditions set out above are modified to some extent, depending upon the design. The output voltage is, therefore, never exactly in phase with the input, and never exactly 180° out of phase.

To further complicate matters, the phase shift varies with frequency as in the case of inductance and capacity.

These effects, however, may be kept to a minimum by proper design of the transformer. In high quality amplifiers the output transformer is often the most expensive component in the circuit.

Summing Up

The salient points about capacity and inductance can be collected and correlated. A capacitor will transfer AC energy from one part of the circuit to another, but not DC. In doing so it attenuates the applied voltage and produces a phase shift, the extent of both effects depending on the values of capacity and resistance in the circuit. The phase shift and attenuation depend upon frequency. Current leads voltage in a capacitor and *vice versa* in an inductor. A transformer may reverse the phase or not, according to its connection.

This last remark will be immediately clear to anyone who has connected oscillator coils the wrong way round—and we all have at some time!

Can Anyone Help?

DEAR SIR,—I have recently obtained an ex-Government 194 IF strip and wish to use it as a vision receiver for London area. Unfortunately it has been partly modified for some purpose unknown, and as I wish to carry out the conversion as described in *Inexpensive Television*, I shall need to know what the original components were, or, at least, the values of all components to be used. The conversion in Data Book No. 4 only gives the values of added components. Can anyone help in this matter, or if not, can you through your columns contact anyone who may have the details?—*P. J. Peuleve*, 64 *Cambria Road, Ruskin Park, London, S.E.5.*

DEAR SIR,—I have tried without success to obtain a design for an Electric Guitar which I hope to make. I have tried several places for this design but no one appears to stock them and I would very much appreciate help from fellow readers of *The Radio Constructor* – *W. Bell*, 26 *Glenbryn Drive, Belfast, N. Ireland.*

DEAR SIR,–I wonder if any of your readers would either lend or sell me the circuit of the Army transmitter No. 18 Mark III. – *A. R. Williams*, 24 *Marlborough Road, Ipswich.*

DEAR SIR, – I would be very much obliged if any reader could lend or sell me the Handbook of the Army "12 Sender" or the circuit of same. I would also like to hear from any reader who has modified the "12 Sender." I will willingly pay for any expense involved. – *R. W. Stewart G3ELS* 21 *Kilwick Street, West Hartlepool, Durham.*

DEAR SIR, – I have just purchased an ex-Government Type 10(A) Power Unit, 24 volts input. This unit is fitted with a 10-prong socket and I would like information on the connections to this—a circuit would be most useful. – *N. S. York*, 52 *Pathfinder-Tedburn-St. Mary, Exeter.*

DEAR SIR, – Can any of your readers supply me with any data on the RAF Transmitter Type 53, Ref. No. 10D/1310. Conversion data would be most gratefully received and all literature will be returned if required. *A. E. Harvey*, 593 *Field End Road, South Ruislip, Middx.*

DEAR SIR, – I wonder if any of your readers can help me with modification data on the R1132A. – *R. W. Hilton*, 8 *Hogshill Lane, Cobham, Surrey.*

DEAR SIR, – Can any reader please supply on loan or sale a circuit diagram covering a Hallicrafters Receiver-Transmitter type RT73-UPN2, including service number of microphone/headset and waveband used. – *A. W. Marsh*, 16 *Lugley Street, Newport, I.O.W.*

DEAR SIR, – I would like to contact a reader who has a Mullard Master Test Board type 7629 and who would be willing to give information on the setting up cards and adaptors issued for the above instrument. – *K. Williams*, 126 *Admaston Road, S.E.*18.

DEAR SIR, – I wonder if any fellow reader of *The Radio Constructor* could possibly help me by supplying information or by lending or selling a circuit diagram of an Emmerson personal superhet. As the set is in a battered condition, the only information I can give as to type etc., is the valve line-up as follows: 12A8GT, 12K7GT, 12SQ7GT, 50L6GT and 35Z5GT. – *C. A. Whiffiing*, "*Killarney*," *Station Road, Cliffe, Rochester, Kent.*

DEAR SIR, – Can anyone please supply me with the circuit diagram of the American Transceiver BC800A, AM No. SCR729F, or the frequency on which it operated. – *James Jollie*, 31 *Hawthorn Street, Methel, Fife, Scotland.*

Radio Miscellany

A LETTER FROM MR. CHARLES BREWER OF Blackpool, accompanying a small panel of transfers, revived some half-forgotten memories of bygone days. We claimed nothing new, of course, for *The Radio Constructor* Panel-Sign transfers (except possibly their application to control panels and dials), although they are rather more brilliant and complete than any yet marketed. The transfer sheet sent along by Mr. Brewer measures 3½ by 4½ inches, and was presented free with copies of *Wireless* dated 25th September, 1926.

In those good old days it was the custom to present free gifts when a new magazine made its bow, or wanted to boost its circulation. I can well recall little flat "wireless" spanners, ohms law charts, blue-prints, data sheets and valve guides, etc., coming along this way. In fact, I still have a combined world clock and voltage dropping calculator given free by *Popular Wireless*. It is made of three-piece card which revolves on a hollow rivet, but unfortunately bears no date. It is, however, cheerfully "priced" at One Shilling—just to prevent any ungrateful reader from valuing it cheaply. As *Popular Wireless* cost only 3d. weekly, no one could have much to grumble at anyway.

Happy Days

Popular Wireless was early in the field, being born about the same time as daily broadcasting started. I cannot be sure from memory whether they beat *Amateur Wireless* by a few days, or vice versa. It was almost near enough to be a dead-heat. I can, however, clearly recall the latter coming out with a first issue minus a cover. Title and text started off on page one.

These threepenny weeklies did not have the field to themselves for long. Of course, *Wireless World*, now in its forty-fourth year, was already well established. Incidentally, during its long career it has been priced at 3d., 4d. and 6d. weekly, and its contents during the boom years were of rather more popular appeal than has been the case since the thirties.

The other two were soon followed by *Modern Wireless* and *Wireless Magazine*, both shilling monthlies, and *Wireless Constructor*, sixpence fortnightly, and others. In the mid-twenties the population was "wireless" mad. We had wireless cigarette cards, and one series at least was devoted to components. The boom lasted over quite a few years but with the more complicated receiver and the mass produced set, it trailed away miserably in the early thirties.

Young Readers, Ask Your Dad

Mr. Brewer's transfers are quite a museum piece in their way, and I wonder how many more of them are still in existence. The old hands will instantly conjure up visions of ebonite panels and lacquered brass terminals when they hear of some of the names that appear on it. *Neutrodyne Receiver*, *Reinartz Tuned Anode Receiver*, and *Filament*, to say nothing of 2*LO*, 2*ZY*, 5*IT*, etc. It would be almost sacrilege to cut off any of these just to see how they work!

The subject of transfers reminds me that when I called at our Editorial Office a short while back, I found the place full of sizzling gas-burners, boiling water and steam. Through the haze I could discern the Editor peering in a dark, bubbling liquid, apparently muttering mysterious incantations while he stirred it with a stick. My first impression was that an Evil Fairy had transformed the place into a Witch's Kitchen, or that the Staff were doing their first lesson from a correspondence course on Modern Sorcery.

It turned out to be nothing as exciting as that. They were merely torturing some metal sheets on which R.C. Panel-Signs had been affixed (as supplied, without fixing varnish), to see just what the transfers would stand in the way of misuse before peeling. Having no intention of taking a Turkish bath fully dressed, even in the interests of Scientific Investigation, I hurriedly left before the temperature became unbearable. However, I did go back to examine the results after the panels had been thoroughly heated and then dropped into cold water. All the transfers suffered was a loss of gloss!

That Vice Again

Another interesting letter, from John Gilbert of TV's Inventors' Club, gives further details of the contour accommodating vice upon which I commented a couple of months back. He says "—each jaw of the vice houses six hydraulically operated cylinders similar to those used in hydraulically operated braking systems. The object to be gripped is placed between the jaws and an external hydraulic pump, lever operated, caused to expand the hydraulic cylinders. On each cylinder an identical pressure is exerted as all are in parallel. Thus any odd-shaped object can be held rigidly with even pressure at all twelve points."

every praise for covering so much of the basic ideas by skilful "potting." One day when the BBC higher-ups are made to realise we want a lot more virility in our TV, we may be lucky enough to get a bit more of Inventors' Club and similar programmes.

Incidentally, I am delighted to hear from Mr. Gilbert that this particular inventor has sold his idea at a handsome profit. It is certainly a well-deserved success, and there will surely be a wide interest if a home-workshop model of it is produced.

CENTRE TAP *talks about* MEMORIES — INVENTORS' CLUB — THE BBC — TOOLS

Both Mr. Gilbert and Geoffrey Boumphrey are only too conscious of the drastic compression which they are compelled to apply to much of the material in their programme. Only a "Planner" obsessed with his time-tables could fail to see the absurdity of making those responsible for presenting such a programme squash it into short and infrequent sessions.

This programme could well be classified as "educational." This reason alone ought to commend it to the BBC, particularly as we are primarily an industrial nation. Its wide appeal to the non-mechanically minded is undeniable. The man-in-the-street loves gadgets, even if he has no use for them. While the more serious ideas and tools may have a specialised appeal, most people *do* take an intelligent interest in them. It makes one wonder if the strange types who have the final allotment of programme times consider that anything which isn't arty-crafty can really be "educational."

On several occasions this column has concerned itself with items from Inventors' Club. Apart from the pleasure this programme gives to so many, it has also been responsible for bringing some excellent ideas into broad daylight. Those concerned with presenting it must find it disheartening to have to cut good material down to a minimum in order to beat the clock. Yet, with the rarest exceptions, they have deserved

Workmanship

The contour-accommodating vice may not be cheap, as the demand may not be sufficient to warrant mass production. But good tools never are cheap, and although many amateurs gaily tackle quite ambitious work with little more than a penknife and a screwdriver, equally as many lean in the opposite direction. Like me, they find great pleasure and pride in the possession and use of good tools.

In every shopping centre of any size one is sure to find a tool-shop, and invariably one sees a group of men studying the windows with the same lively interest that women find in a gown-shop. Amateurs generally spend quite a lot of money on tools, often a disproportionate amount to the work they can put them to. In my own workshop I have a number of tools which have never earned their keep, although I have never regretted the money spent on them. The pleasure of owning them is almost its own reward, and the day when they become vital for doing a job I shall feel that I have had more than my money's-worth.

It used to be the custom in many trades for the apprentices to have to make their own tools, and perhaps there is no better way to learn not only to appreciate tools, but to use them correctly. For the hobbyist it is good policy to invest in quality tools. One is then not so likely to mis-use them oneself, but perhaps more important—to keep them out of the reach of botchers!

PHASE SHIFTING FOR PUSH-PULL

By **A. G. EDWARDS**

THE ADVANTAGES OF PUSH-PULL OUTPUT are fairly widely appreciated, but methods of obtaining the input to such a stage are not so. The object of this article is, then, to present in non-mathematical language various methods of obtaining two similar voltages in anti-phase with which to feed a push-pull stage.

One of the most common and widely used methods of obtaining this input is by the use of a centre-tapped transformer. This method will be dealt with, therefore, very briefly, and a skeleton circuit is shown in Fig. 1.

Audio-frequency current changes produce across the secondary of the transformer variations of voltage at audio frequency. If the electrical centre of the secondary winding is taken to chassis at point B, then clearly A must be at opposite potential with respect to point B than the voltage at C. As B is the centre-tap, then we have produced two voltages, equal and in anti-phase.

The latter phrase, then, "equal and in antiphase," is the aim of the various forms of phase splitters or phase inverters.

I propose to introduce the reader to three types, the first of which employs two phase-splitting valves. The circuit is given in Fig. 2, where input signals are developed across R_1 from the preceding stage by the usual coupling methods.

Valves V1 and V2 are identical in type, two 6J5's being suggested, and they are provided with the same bias voltage, developed across R_2 and R_5 respectively. R_3 and R_6, the respective load resistors, should be equal, and it will be noted that R_3 has a variable tapping point.

We will now assume the signal across R_1 is causing the grid of V_1 to move less negative. Anode current in V_1 increases, causing the lower end of R_3 to move less positive, or looking at it from a signal point of view, i.e. the voltage change across R_3, it is moving negative. Hence the grid of V_3, which is connected to the lower end of R_3 via C_3, will be moving negative with respect to chassis by an amount determined by $Vg \times \mu R/R+Ra$, where Vg is the input signal, μ the amplification factor of the valve, R the *effective* anode load and Ra the Plate resistance of the valve.

Now the input to the second valve Vg_2 is taken from a tap on R_3 which is moving less positive with respect to point A (which is virtually at chassis potential). Now if Vg_2 is made equal to Vg_1, then the input to V_1 and V_2 will be of the same amplitude but in opposite phase. When the signal causes V_1 grid to go less negative, therefore, the grid of V_2 is going more negative by the same amount. V_2 is operating under exactly the same conditions as V_1, hence if input voltage to each is the same then the voltage developed across each load resistor will be equal, but in anti-phase. The grid of V_4, therefore, being connected to the lower end of R_6 via C_5 will be moving positive with respect to chassis. Our aim, then, has been achieved by using two phase splitting valves — which also provide a measure of stage gain.

The second circuit to be discussed employs a single valve to achieve this result. The circuit is shown at Fig. 3.

Use is made of the fact that when an unbypassed resistor is placed in the cathode lead, voltages are developed across it which are in antiphase to those developed across the anode load. Clearly as the current through these resistors is the same, i.e., anode current, then if R_2 equals R_3 the voltage developed across R_2 will equal that across R_3. Hence phase splitting will be achieved.

However, voltages developed across R_2 at signal frequencies are in antiphase to those present across R_1 and cathode follower principles must be applied. Because of this it is found that the voltage across R_2 will be slightly less than that across R_1. Hence the voltage passed to each of the push-pull pair will be slightly less than the input to V_1, but we shall have achieved phase splitting employing only one valve.

The final circuit to be outlined in this article is a method of phase splitting employing no extra valve, the antiphase output for the second push-pull valve being taken from the output of the first. The circuit is shown in Fig. 4.

In studying this, it is well to bear in mind that, due to the low impedance path between HT+ and chassis, the former can be treated as chassis potential.

Let us suppose that the signal developed across R_1 is causing the grid of V_1 to move positive (as no standing bias is shown); then V1 anode current is rising. Now R_2 is placed in parallel with the half of the transformer primary associated with V1, hence with respect to HT+ (chassis) the anode end of R_2 is moving less positive. Hence the grid of V2, being connected to point A via C_1, must be moving negative with respect to chassis. It only remains now to adjust the tapping point on R_2 to enable the signal voltage developed between A and HT+ (i.e. Vg_2) to equal Vg_1. Again equal and antiphase voltages have been produced, this time without the use of an extra valve.

It is hoped that this short article has proved of interest. If a more advanced approach is required, then the reader is advised to consult one of the well known publications on the subject.

BOOK REVIEWS

MULLARD 5-VALVE 10-WATT HIGH QUALITY AMPLIFIER CIRCUIT. *Prepared by The Technical Service Department, Mullard Ltd., Century House, Shaftesbury Avenue, London, W.C.2.* 86 pages. Price 2s. 6d.

The circuit of this neatly-laid-out amplifier for home construction has aroused considerable interest recently. This booklet describes the design and construction in full detail, not the least of the interesting features being the publication of all the information required to make the output transformer at home.

Designed for an audio output of 10W with 26db negative feedback, the amplifier consists of an EF86 low-hum, low-microphony voltage amplifying pentode stage, ECC83 double triode phase inverter, and two EL84 output pentodes in push-pull. The full-wave rectifier can be a GZ30 to supply up to 125mA in order to provide current for feeder units, or an EZ80 where the HT current drain is not in excess of 90mA. A tone control circuit precedes the EF86 voltage amplifying stage.

The output stage can be operated under "normal loading" or "low loading" conditions. With the latter arrangement, there is less distortion with speech and music inputs, and there is a considerable saving of HT current drawn by the output stage. The "normal loading" condition will not normally be used, since it is intended for correct operation for sine and square wave testing.

Several graphs are included which show the effect of the bass and treble tone controls, distortion, and power out response against frequency. About half of the book is given over to very full data and curves for the valves used in the amplifier. Some brief notes are given on associated equipment such as pick-ups and turntables. Recording characteristics, equalizing networks, and the choice of a suitable speaker are also discussed in this section.

Working drawings are provided for the benefit of those who can fabricate their own chassis and speaker cabinet. These items, however, are available as commercially-made components, and at least three manufacturers are in a position to supply complete kits of parts for the amplifier. Visitors to the National Radio Exhibition will doubtless have seen specimens of these, and taken the opportunity to appraise the quality of the reproduction the 912 amplifier can give.

The circuit of the amplifier reveals a break-away from the traditional arrangement in two respects; ultra-linear operation of the push-pull output stage provides the relatively high gain of the pentode but preserves the lower distortion and output damping factor of the triode, while an unusual selective feed-back arrangement enables "presence" in the reproduction to be under control of the listener.

It is to be expected that this well-produced booklet should make a profound appeal to the ever-widening circle of high-fidelity enthusiasts, and in doing so will bring within this orbit many who would not otherwise have attempted to build such equipment for themselves. Provided that only the specified components are used, success at the first attempt should follow naturally. It should, of course, be appreciated that the full capabilities of the amplifier depend upon using the G.E.C. metal cone speaker unit, around which it was designed.

OSRAM 912 HIGH QUALITY GRAMOPHONE AMPLIFIER. *Published by The General Electric Co. Ltd., Magnet House, Kingsway, London, W.C.2.* Price 3s. 6d.

This 44-page handbook describes in full detail the design and construction of a high-quality amplifier having a maximum peak power output of 12 watts, and a frequency response that extends over 9 octaves.

The requirements for high-fidelity reproduction are clearly expounded, and it is shown how the 912 amplifier design complies with them. The greater part of the book is devoted to stage-by-stage instructions on building the amplifier, the unusual superimposed wiring diagrams making this part of the work particularly easy to follow.

A GUIDE TO AMATEUR RADIO. 6th Edition. *Edited by John Clarricoats, G6CL. Published by the Radio Society of Great Britain, New Ruskin House, Little Russell Street, London, W.C.1.* Price 2s. 6d. (2s. 9d. by post).

Previous editions of this present valuable contribution to the field of Amateur Radio have sold in many thousands, and the handbook now available maintains the same high standard.

Compiled by a team of acknowledged experts in the field, this latest Guide packs into its 40 pages everything that is needed to introduce the newcomer to the interests available to him. Factual information in concise terms is the keynote of the book's composition.

A chapter of "questions and answers," and two others on simple equipment, provide a good insight into how one can get started. There follow advice on learning the Morse Code and operating procedure, while further chapters deal adequately with obtaining a transmitting licence and the Radio Amateur's Examination. The QSL Bureau conducted by the R.S.G.B. is fully described.

Other useful data is found in the references to the Q-code, International Prefixes, Amateur Abbreviations, etc. With this handbook at his side, the new licensee should fall naturally into the class of "good operator"; without it he could all too easily degenerate into a "lid" or "clot."

W. E. THOMPSON

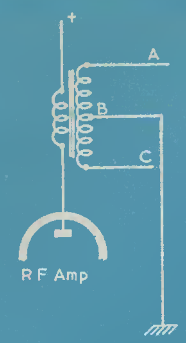


Fig.1

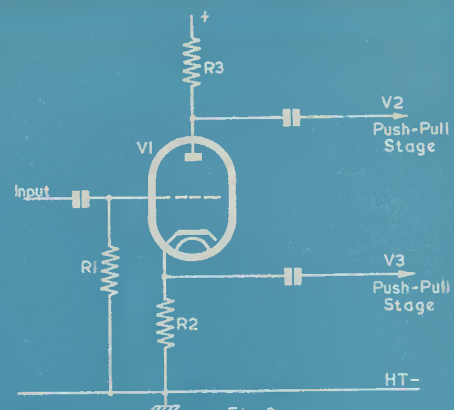


Fig.3

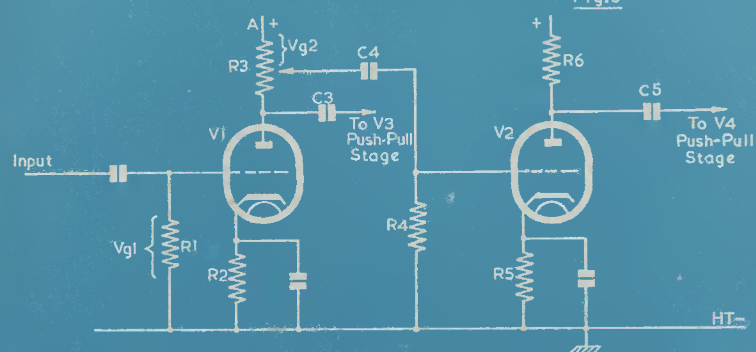


Fig.2

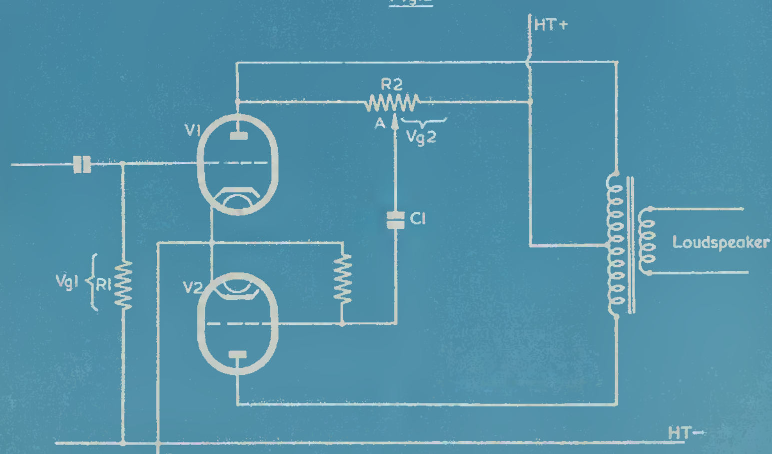


Fig.4

E5

THE DESIGN, CONSTRUCTION CALIBRATION and USE of SIGNAL GENERATORS

Part 3 *By* **R. J. STEPHENSON**

THERE IS ONE POINT WHICH MAY BE helpful. Suppose a signal is tuned in on the receiver at 500 metres (600 kc/s), how are we to know the frequency at which the generator is oscillating? We may be receiving a fundamental of 600 kc/s, or a second harmonic of 300 kc/s, or a third harmonic of 200 kc/s, or even a tenth harmonic of 60 kc/s, etc. Leaving the signal generator set, tune in the next harmonic on the receiver and note the two frequencies. For example, suppose we are receiving a signal on 500 metres (600 kc/s), and we notice on tuning the receiver that the next response is on 430 metres (700 kc/s). If we subtract the two frequencies (700–600 kc/s), it will give us the fundamental, in this case 100 kc/s. This method is, unfortunately, not accurate enough for calibration purposes, but it is accurate enough to positively identify a particular harmonic. However, when all the lower frequency ranges have been calibrated, graphs can be drawn for each range.

We can now turn our attention to the SW bands covered by the receiver. Set the signal generator (modulated output) to the highest frequency which has been calibrated, say 1.5 Mc/s, and connect the output to the aerial socket of the receiver. Switch the receiver to the SW band. Let us assume that the receiver tunes from 20 Mc/s to 6 Mc/s (15–50 metres). Tune around 7.5 Mc/s until the fifth harmonic of 1.5 Mc/s is received. Make sure that it is not the second channel which is being tuned. This will be 7.5 Mc/s minus twice 465 kc/s (assuming the IF is 465 kc/s), which is 6.57 Mc/s, and whilst the receiver dial may not be accurate, it should be possible to identify which is the true and which the spurious response. This problem may not happen if the receiver has an RF stage, or is a TRF design. If in any doubt, remember that of the two responses close together it is the one which tunes to the higher receiver dial reading in terms of frequency (lower in terms of wavelength). Having positively identified the fifth harmonic, carefully note the receiver dial reading.

In the same way, identify the sixth harmonic (9 Mc/s), note the receiver dial reading, and so on with the seventh (10.5 Mc/s), the eighth (12 Mc/s), the ninth (13.5 Mc/s), the tenth (15 Mc/s), the eleventh (16.5 Mc/s), the twelfth (18 Mc/s), the thirteenth (19.5 Mc/s) and fourteenth (21 Mc/s) harmonics. Make a careful note of the dial reading and the frequency for each harmonic. Now re-set the receiver to the dial reading for 7.5 Mc/s, switch to the appropriate band on the signal generator and adjust the tuning (of the generator) to receive the fundamental of 7.5 Mc/s. Make a note of the generator dial reading and frequency, and repeat for 9.0 Mc/s, 10.5 Mc/s, etc. In this way some ten points on the generator dial can be calibrated between, say, 20 and 6 Mc/s.

Now we can start all over again, but this time using an initial frequency of slightly lower value, say 1.4 Mc/s, and ten more points on the dial can be calibrated. This can be carried on until enough points have been calibrated to enable the graph to be plotted.

We now come to the frequencies between the low end of the SW band and the high frequency end of the MW band, which the signal generator covers, but probably not the receiver. It has already been shown that by using the MW band of the receiver, lower frequency bands on the generator may be calibrated. In exactly the same way, once the SW band (20–6 Mc/s) has been calibrated, the 6–1.5 Mc/s range can be calibrated using the same technique. The only difference is in the frequencies employed.

It is not possible to calibrate to a higher frequency than the highest frequency to which the receiver will tune, but for these higher frequencies harmonics of the signal generator can be used. For instance, if a signal on 30 Mc/s is required, set the generator to 15 Mc/s and use the second harmonic, or to 10 Mc/s and use the third harmonic. If needed, the dial can be directly calibrated to save referring each time to a calibration chart, but, unless great care is taken, loss of accuracy will occur. The usual practice with commercial generators is to calibrate the dial directly, but calibration charts are provided when greater accuracy is required.

Much could be written about the uses of a signal generator, and much more about the technique of using it, but there is space only for a few brief notes here. Neither are we concerned with a detailed analysis of probable faults and the effects they produce, but rather with the use of the signal generator in tracing faults, showing weakness in design and servicing.

Let us take as an example a conventional receiver consisting of frequency changer, IF stage, detector and 1st AF, output stage and rectifier. The method will, of course, vary in detail with different receivers, but it will be the same in broad outline for all types of receiver. The usual precautions should be taken with AC/DC types to guard against electric shock.

If a receiver has suddenly failed, it saves a great deal of time if the faulty stage can be quickly traced. If the fault is in the power supplies it can be quickly checked with a few measurements using a voltmeter and milliammeter. To find which of the amplifying stages is at fault, feed an AF signal from the generator into the grid of the output valve. If this stage is working properly a 400 c/s note will be heard in the speaker; if no note is heard, the output stage is obviously at fault. If the output stage is working, reduce the signal input until it is just audible and transfer the generator output lead to the grid of the penultimate stage (usually a DDT). The volume control of the receiver should be turned to maximum since (although the signal is fed into the receiver *after* the volume control) it shorts out the signal to a greater or lesser degree, if used as the grid leak, and will still act as a gain control.

If this particular stage is working also, a signal will again be heard from the speaker, but it should be much louder than before. If there is no speaker response, then this stage is obviously at fault.

If the receiver is working so far, the output of the signal generator should be set to "modulated RF" at 465 kc/s (or whatever the IF of the receiver happens to be) and should be connected to the control grid of the IF amplifier stage (the last one, if there are more than one such stages). If this stage is in order, a signal will again be heard from the speaker. If no signal is heard, then the fault lies in the IF stage or in the detector. Similarly with any other IF stages.

If the faulty stage has not yet been revealed, set the signal generator to some frequency covered by the tuning range of the receiver (still with modulated RF output), and set the receiver tuning to the same frequency. Connect the generator output to the signal grid of the frequency changer valve. If this stage is working, again a response will be heard from the speaker. A little searching may be necessary on the receiver tuning, since the alignment may have drifted. If a signal is heard, the fault must be in front of the frequency changer; in the aerial circuit, or an RF stage if this is fitted.

It will be seen that with a signal generator the faulty stage can be isolated, with a little practice, within quite a short time. Once the faulty stage has been found, it can be checked in detail with a multi-range testmeter.

This particular technique is usually known as "working backwards," since a start is made at the output end of the receiver. Another method is to feed a signal into the aerial end of the receiver and to trace it through to the speaker with a signal tracer. This latter system seems to be more popular in America than in this country.

It sometimes happens that it is necessary to check that the AVC of a receiver is functioning correctly. If the AVC is not working, it may show as distortion on strong signals due to overloading of the detector, or perhaps as fading on distant stations becoming more noticeable.

To check that the AVC is working, a milliammeter should be connected in each of the anodes of the controlled valves, or a voltmeter across each of the cathode resistors (an increase of anode current will show as an increase of cathode voltage). Also, an output meter should be connected to the output stage. The output of the signal generator should be connected via the dummy aerial to the aerial socket of the receiver. The receiver tuning can be set to any frequency in the Medium or Long wavebands, and a modulated signal of the same frequency from the generator fed in. It is not advisable to use a short waveband since in some receivers the AVC is wholly or partially cut out on such bands.

The attenuator of the signal generator should be turned to minimum and then gradually increased. The receiver volume control should be turned low enough to avoid any overloading of the output stage, but high enough to give, say, half a watt output at maximum. If the AVC is working correctly, the following will be noticed. As the signal generator output is increased, the output of the receiver increases proportionately (in terms of voltage, or the output will increase as the square of the input voltage in terms of output power). At the same time, the milliammeter (or voltmeter) in the controlled stages will remain steady. As the signal generator output is further increased, there will be a point where further increasing gives only a very small increase in receiver output. At the same time, the milliammeter (or voltmeter) in the controlled stages will show a proportional decrease. This is the point where the input to the receiver is sufficient to overcome the delay voltage of the AVC.

If the AVC is not working as it should, it will show at once with this test.

It is almost impossible to align a modern receiver without the use of a signal generator. True, some manufacturers supply components which are pre-aligned, but this does not help to align a receiver which has drifted through age, replacement of valve, or some other cause such as some handyman "spring-cleaning" the set and tightening all loose screws—including the trimmers! It is found that the following procedure is one which enables the receiver to be quickly aligned.

(*To be continued*)

CLUB NEWS

Romford and District Amateur Radio Society. Hon. Sec., N. Miller, 18 Mascalls Gardens, Brentwood, Essex.

The Society's winter programme includes film shows, lectures, discussions, "on the air" evenings with G4KF and the monthly "junk sales."

The Society meets every Tuesday evening at 8.15 p.m. at RAFA House, 18 Carlton Road, Romford, and all visitors and new members will be warmly welcomed.

Further information can be obtained from the Hon. Secretary, N. Miller, 18 Mascalls Gardens, Brentwood, Essex.

Clifton Amateur Radio Society. The Annual General Meeting of the Society was held on Friday, 10th September and the following were re-elected for a further term of office:

Chairman	J. Lambert, G3FNZ
Hon. Treasurer	N. Moore
Hon. Secretary	C. Bullivant, G3DIC
Committee members ..	E Smith, D. Veasey

On Friday, 24th September Mr. G. P. Thwaites of Standard Telephones and Cables Ltd. gave a very interesting talk on "Radio Receiving Valves and Their manufacture," whilst on the 3rd and 17th Constructional Evenings were held.

The final D.F. Contest for 1954 was held at Green Street Green, Kent on Sunday 5th September and was won by E. Strong, assisted by D. Reed. However, the D.F. Shield for 1954 was won by C. Hatfull, G3HZI, who put up the best performance in the three contests.

The Club Championship Cup for 1953–54 has been won by N. Moore.

Programme for November:

5th	Quiz.
12th	Constructional Evening.
19th	"Metropolitan Police Radio System" by W. H. Andrews, G2YG.
26th	Constructional Evening.

Meetings are held at the clubrooms 225 New Cross Road, London, S.E.14 every Friday at 7.30 p.m. Details of membership can be obtained upon application to the Secretary.

Secretary, C. H. Bullivant, G3DIC, 25 St. Fillans Road, Catford, London, S.E.6.

Portsmouth and District Radio Society. The club has been fortunate in securing new premises at the British Legion Club, Queen's Crescent, Southsea. Meetings are held regularly each Tuesday at 19.30 hours, the last Tuesday in each month being devoted to a business meeting. The club rooms are available to members *every* night until 22.00 hours or later. A morse class is held every Friday under the direction of G3JLO, and any new students would be welcomed. A junk sale is held monthly.

New members are cordially invited to attend any Tuesday at 19.30, or to communicate with the Hon Secretary.

November meetings: 9th, TV Lecture; 16th, Junk Sale; 23rd, Discussion on TVI.

Hon. Secretary, L. B. Brooms, G8BU, 51 Locksway Road, Milton, Portsmouth.

The Slade Radio Society. Headquarters: The Church House, High Street, Erdington, Birmingham 23.

FUTURE PROGRAMME

1954	
Nov. 12th	"Television Aerials" by Mr. A. P. Hale of Belling & Lee Ltd. This lecture will cover the general field of aerial theoretical considerations, differences between bands 1 and 3 feeder cable arrangements, positioning of aerials, and abnormal propagation effects.
Nov. 26th	**Annual General Meeting.**
Dec. 10th	"Television Transmission Systems" by B. V. Somes-Charlton of Pye Ltd. This will include a survey of camera photo electric tubes, and colour, underwater and industrial television cameras. A demonstration of the Pye miniature industrial TV camera will be given at the end of the talk.
Dec. 24th	**No meeting.**

Full particulars of the Society and its activities may be obtained from the Hon. Secretary, Mr. C. N. Smart, 110 Woolmore Road, Erdington, Birmingham 23. Visitors to the Society's meetings, which commence at 7.45 p.m. prompt, are cordially welcome.

The Society's clubroom at the Church House is now available, and is open every day of the week for the use of Members. Transmitting and receiving equipment is being installed, constructional facilities are available, and Morse and theory classes are being arranged.

Torbay Amateur Radio Society. At the meeting held on Saturday, 18th September, 1954, G3AVF gave a very interesting talk on "Transistors," and brought along his TTX for demonstration. In conjunction with this talk G3GDW brought along a portable receiver, so that the Transistor could be heard working.

A proposal has been made to hold a Dinner Party—at a date near Christmas—for Members and their ladies.

Meetings are held on the 3rd Saturday each month, at 7.30 p.m. at the Y.M.C.A., Torquay. Visitors are always welcome.

Norwood and District R.S.G.B. Group. During September members visited Tatsfield B.B.C. Receiving Station, and visits to other places of interest are to be arranged during the winter months.

The next meeting of the Group will be held on 20th November at which there will be a lecture given by G6HD. The meeting will commence as usual at 7.30 p.m. at Windermere House, Westow Street, Crystal Palace, and all local members and interested persons are invited to attend.

South Manchester Radio Club. Further additions to our programme of lectures are as follows:

Nov. 19th	"Communication Receivers" by D. Atter, G3GRO.
Dec. 3rd	"Receivers"—this is a tape-recorded lecture by Hammans G2IG and is from the Recorded Lecture Library of the R.S.G.B.

Hon. Secretary, M. Barnsley, G3HZM, 17 Cross Street, Bradford, Manchester 11.

PEAK MODULATION LIMITER

By **E. A. RULE** G3FEW

VARIOUS FORMS OF SPEECH LEVEL OR volume compression circuits have appeared in radio publications, but most have the complication of additional valves and/or circuits in either the modulator or the transmitter PA stage. Most of these systems add up to the same thing, namely that of providing a constant modulation level, usually to a hundred percent during normal speaking. The intensity level of a person speaking varies with the complex forms, sounds of words and accentuation, so that, with a speech amplifier system having anything like a reasonably level response, an exact and constant modulation level of one hundred percent is unobtainable. The average may be a hundred percent, but peaks may approach 150% or more, resulting in sideband splutter and other forms of interference. The following describes a system which has proved very effective, and which requires but little modification to any conventional type of speech amplifier and modulator.

Simplicity

Fig. 1 shows the extremely simple basic arrangement, which requires only a potentiometer in the anode circuit of an intermediate amplifier stage preceding the final speech amplifier or the modulator valves proper.

Control over the *peaks* of the speech is maintained by the variable resistor (R1), which limits the anode voltage fluctuations irrespective of the amplitude of the signal at the grid. The diagram of Fig. 2 may explain this better.

The sine wave 'A' represents the *minimum* amplitude required for a hundred percent modulation, and 'B' represents a higher level which would produce say just over a hundred percent, whereas 'C' would result in, say, 150% or more. The effect of the control (R1) is to limit 'B' and 'C' to the same amplitude as 'A', due to the limiting action of the valve at a predetermined HT potential.

As in any limiter circuit, the action of limiting will cause distortion, and thus an increase in the harmonic content of the audio signal; this in itself may cause wide sidebands, and/or splatter. To avoid this, it is desirable to remove the harmonics with a filter, which should have a sharp cut-off above 2.5 kc/s. Such a filter is shown in Fig. 4, and should be placed in the grid circuit of the stage following the limiter.

As already mentioned, control may be effected in an amplifier stage preceding the final speech amplifier, or modulator valve or valves proper. The stage containing the normal gain control may be before or after the limiter, preferably before. At least sufficient gain must be available after the limiter to drive the modulator stage for a hundred per cent modulation.

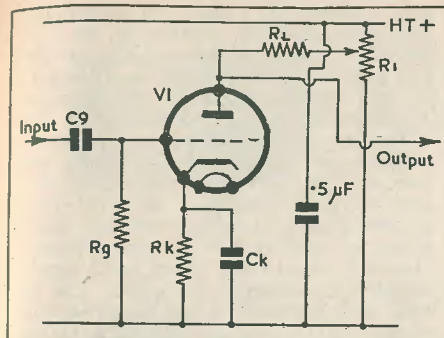
It is realised, however, that individual choice of speech amplifier circuits is varied, and the block diagrams of Fig. 3 are representative of typical arrangements and may be of use in deciding where the limiter shall be placed. With an arrangement as in Fig. 3A, the control should take place in the triode stage, but here it may be necessary, if the amplifier is providing only just sufficient gain for full modulation, to include an additional amplifier stage.

Another example of the position of the control is as the block diagram Fig. 3B, where the limiter may be placed at 'X', there being enough gain in the following amplifier to produce the desired effect of a hundred percent modulation irrespective of the speech level.

Results

The following is a resumé of tests carried out by the writer. The speech amplifier consisting of a EF37A pre-amplifier, a 6J7 intermediate amplifier, a 6SN7, one half of which is used as the limiter, and the other as the phase splitter. Following this a 6SN7 final speech amplifier driving a pair of 807's in push-pull.

Tests carried out with local stations proved that a decided increase in audio level at the receiving end was obtainable without any increase in sideband splutter.



Cg, Ck, Rg, Rk, RL are normal circuit values. V1 may be almost any medium impedance type. R1 may be any value from 500 kΩ to 50 kΩ. Values from 250 kΩ up to 500 kΩ may be carbon type, below this they should be wire wound

FIG. 1.

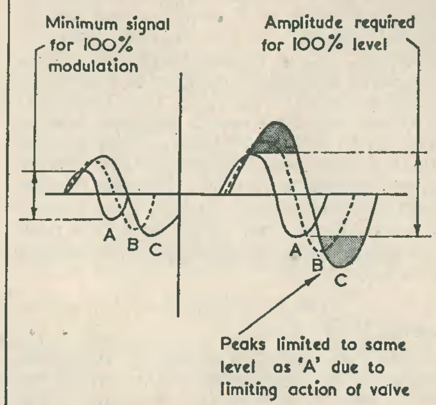


FIG. 2.

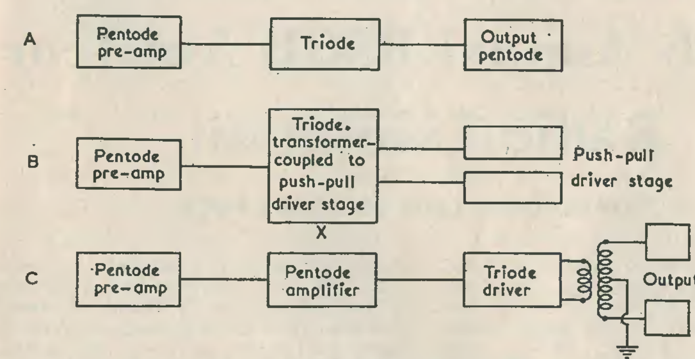


FIG. 3. Diagram C shows a system where the pentode amplifier may be changed to the triode limiter

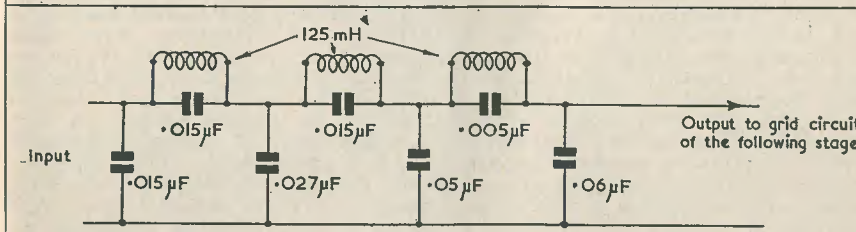


FIG. 4. A blocking condenser must be placed between input of filter and anode of limiter (0·01μF to 0·1μF) This filter gives approx 45 db cut at 2·5 k c/s
1 kc/s = 0 db

G35

Comparison with a more complex system of volume compression showed *no* time lag as is usual with AVC systems, and proved equally effective as far as audio gain is concerned. It is realised that the system introduces a small percentage of distortion, but since this is probably less than that introduced by most speech clipping systems, it is hardly worth considering, and for all practical purposes may be ignored. If the system is used merely as a preventative for slight over modulation (assuming an average of a little lower than 100%) then distortion is negligible, and the filter may be left out of circuit.

Setting Up

If an oscilloscope is available, setting the limiter is a fairly easy matter. With the limiter control at zero (full HT) adjust the gain control for slight over-modulation with average speech, bringing up the limiter until the modulation does not exceed 100%. The gain control may then be advanced to increase the *average depth* of modulation. Too much will result in distortion.

The system may be set up without an oscilloscope, but will require rather more care, and the help of a local station, or an over-modulation indicator. With the control at zero (full HT), adjust the gain until a report of indication of over-modulation is obtained. Adjust the limiter until signs of excessive modulation disappear. The gain may be increased consistent with good speech quality, checking with a local station for an increase in audio level. Slight further adjustments of the limiter may be necessary.

The writer makes no claim to originality in this circuit, and suggests that the reader may like to develop or improve it for himself.

Eighth Annual RSGB Amateur Radio Exhibition

November 24th to 27th, 1954

The Eight Annual Amateur Radio Exhibition organised by the Radio Society of Great Britain will be held as in former years at the Royal Hotel, Woburn Place, London, W.C.1, from Wednesday, November 24th to Saturday, November 27th, both dates inclusive. The Exhibition will be opened at 12 noon on the 24th by Mr. H. Faulkner, C.M.G., B.SC(ENG.)., M.I.E.E., F.I.R.E., Director of Telecommunication, Engineering and Manufacturing Association. Mr. Faulkner was, until recently, Deputy Engineer-in-Chief of the G.P.O.

As in past years the Exhibition will be supported by companies who specialise in the provision of valves, components, metalwork and publications for the radio amateur. In addition the Services will be represented.

Members of the R.S.G.B. will exhibit a wide range of home constructed equipment of modern design including miniaturised, portable, and mobile transmitter-receivers for use in connection with the Radio Amateur Emergency Network. Amateur Television will be represented by the actual equipment used by Messrs. W. R. and J. Royle, G2WJ, for their historic 70 cm tests. Single sideband equipment will be featured, as will v.h.f. and u.h.f. receivers and transmitters.

New editions of *A Guide to Amateur Radio* and the *R.S.G.B. Amateur Radio Call Book* will be on show on the R.S.G.B. stand together with examples of amateur built equipment which have been or are to be described in the Society's Journal.

The following have reserved space at the Exhibition:—Air Ministry; Amos (Electronics) Ltd.; Automatic Coil Winder and Electrical Equipment Co. Ltd.; Cosmocord Ltd.; English Electric Co. Ltd.; Enthoven Solders Ltd.; General Electric Co. Ltd.; Iliffe and Sons Ltd.; Labgear (Cambridge) Ltd.; Magnetic Devices Ltd.; Minimitter Co.; Philpotts (Metalworks) Ltd.; Radio Society of Great Britain; Short Wave Magazine Ltd.; Standard Telephones and Cables Ltd.; Taylor Electrical Instruments Ltd.; War Office; Grundig (Great Britain) Ltd.; Pye Ltd.

The Exhibition will open at 11 a.m. and close at 9 p.m. each day. Admission 1/–.

The Manager of the Exhibition is Mr. P. A. Thorogood, 35 Gibbs Green, Edgware, Middx.

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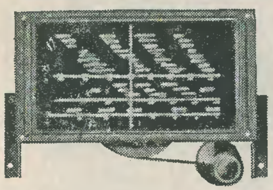

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12SK7	8/6
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[*continued on page 255*

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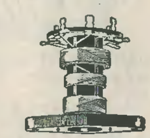

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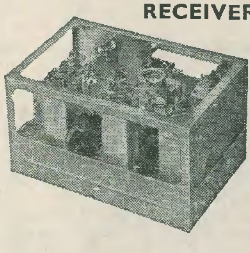

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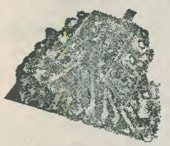

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continued from page 253]

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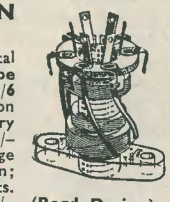

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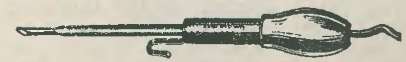

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