A HOME-MADE

HI-FI OUTPUT TRANSFORMER

BY W. GROOME

E USE OF A TERTIARY FEEDBACK NDING ARRANGEMENT SIMPLIFIES E CONSTRUCTION OF THIS TRANS- RMER AND REDUCES THE COST.

(Continued from page 400 of the September issue)

ı last month's article the author began an ıation of his home-made transformer which led descriptions of some interesting circuits ; use. In Fig. 4, for example, a triode "see- phase-splitter amplifier stage feeds the out- entodes. The tertiary winding, earthed one upplies feedback to V1 via R2 and provides ı for the cathode current.

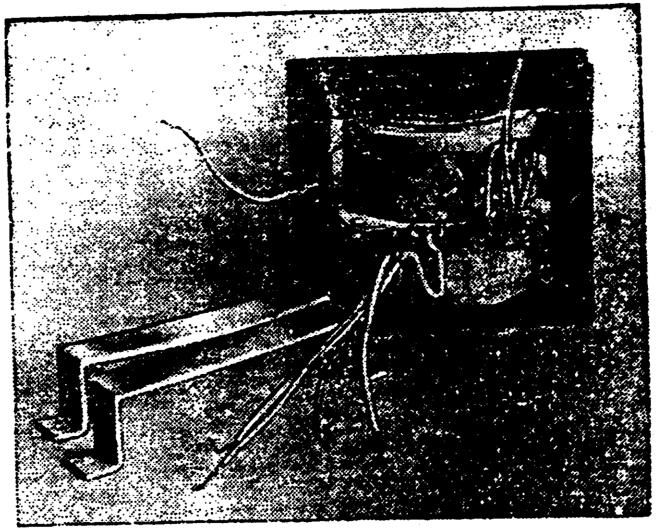
pentodes were used for the phase- r stage the sensitivity, held by the feed- ratio, would remain the same. The feedback and with it the amplifier ivity, can be made variable ıunting the tertiary winding a 100Ω potentiometer and ; the feedback voltage from ıp, as shown in Fig. 5 (last ı). This refinement may be of st to some experimenters, but riode circuit will be found ıle for most domestic pur- . The ECL82 valve, compris- ın amplifier triode and an ıt pentode enables a two- push-pull amplifier to be around only two valves— tereo using only four valves nes a practical proposition.

ıde Follower Output

e improvement achieved by se of feed-back over the out- stage (apart from easing the cation of overall feedback) is tural sound' that is not likely ıow up on instrument tests. real enough, however, and the popular cathode-follower cir- with its virtually complete ıllation of its own distortion ımmunity from the errors that can arise in a ılex loop, gives a realism that is still hard to r. Its limitation to triode efficiency and the grid voltage swing needed for full loading caused it to decline in popularity and designs suitable for pentodes have become more lar.

ıese are the "distributed load" circuits, of h the quaintly named ultra-linear version is known. As the author's transformer has both ıdary sections split into two well-insulated sections with free leads, it can be connected in the ultra-linear mode as shown in Fig. 7. It is true that the tap at 50% is higher than is customary but this closer approach to triode conditions has not been found to be the slightest drawback.

Ultra-linear connections are not the only, or even the first, form of distributed load circuit, for a more elegant circuit was developed in this country several years before the 'ultra-linear' circuit appeared. However, the version shown in (Fig. 7) embodies cathode loading which, as stated



One of the author's prototype experimental output transformers.

in an earlier paragraph, is a highly desirable method of obtaining output stage feedback. Despite the strangeness, on paper, of a load distributed between anode and cathode, the relationship to the ultra-linear arrangement can be appreciated when the screen is considered, this being tapped into the transformer load in both cases. This is obvious in the ultra-linear circuit; in Fig. 7, it is still loaded by the transformer because its current and signal are compelled to flow in the cathode winding.

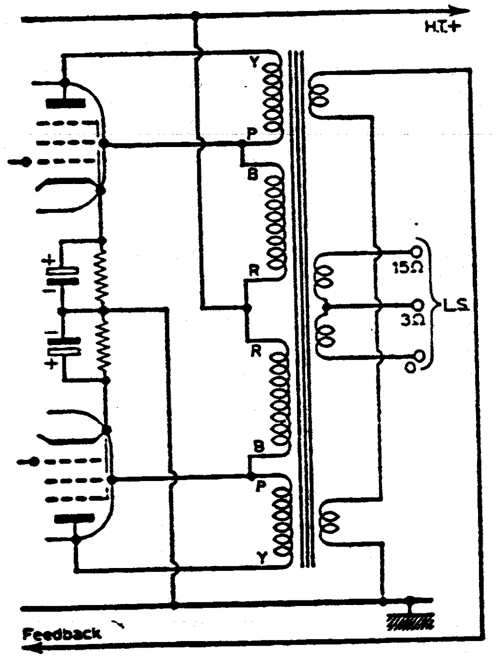
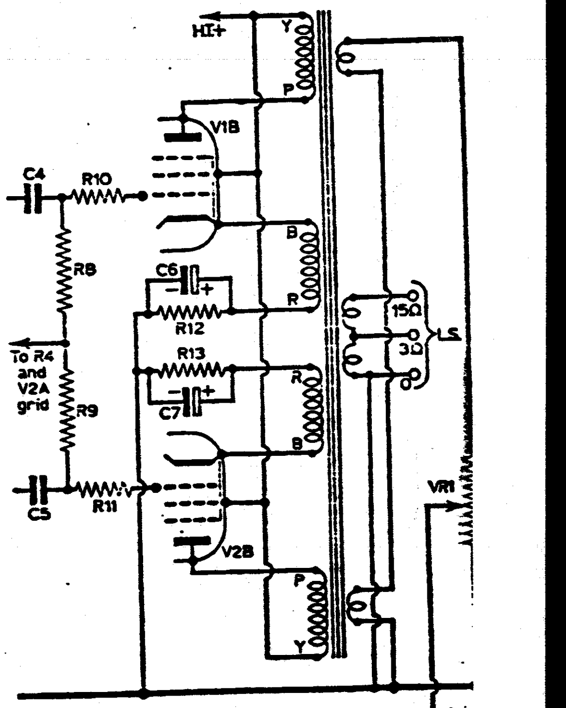


Fig. 6 (left)—Connections for ultra-linear loading.

Fig. 8 (below)—Rearrangement of a two-stage amplifier for anode/cathode loading.



50 : 50 Distribution

This form of loading can be tried by connecting the transformer as indicated in Fig. 8. Bear in mind, however, that the output circuit is patented. The transformer and its associated circuits must not be compared with a well-known make of amplifiers to which this form of loading is exclusive. As 50:50 load distribution must be used, the output stage feed-back is already nearly enough to give the required reduction in distortion and output impedance and the amount needed in the overall loop is therefore small. For this reason, a potentiometer is shown across the feedback winding in Fig. 8, which shows the ECL82 circuit modified for this form of loading.

As the grid resistors are returned to earth (via the grid resistor of V2A) the D.C. resistance of the cathode loads contributes towards the bias voltage of the output valves. The resistance of these portions of the windings should therefore be checked and the value of the bias resistors reduced correspondingly. A variation of this form of distributed loading has the grid resistors connected to the cathode ends of the load and no adjustment of the bias resistors is needed. It is not really suitable for use with a see-saw phase splitter, but can be driven by a "concertina" circuit either in the straight form or in the high gain versions, one of which employs the high resistance of the phase-splitter to load an amplifier pentode, and another using the pentode in starvation anode conditions. This phase-splitter can also be used in a positive feedback circuit, but high gain but it is preferred to keep the signal "clean" at every stage rather than have to clean up an accumulation of distortions with the main feedback loop.

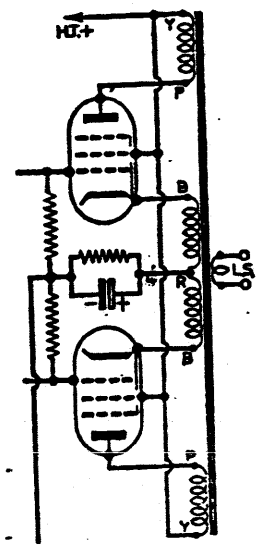


Fig. 7 (right)—Here the load is distributed be-

Input Signal

Now that crystal pick-ups have reached hi fidelity standard, with outputs so much grea than the magnetic types that were once essent for the discriminating listener, and radio tun also deliver large signals, there is no longer urgent need for great sensitivity in the domes amplifier. Indeed, amplifiers requiring as mu

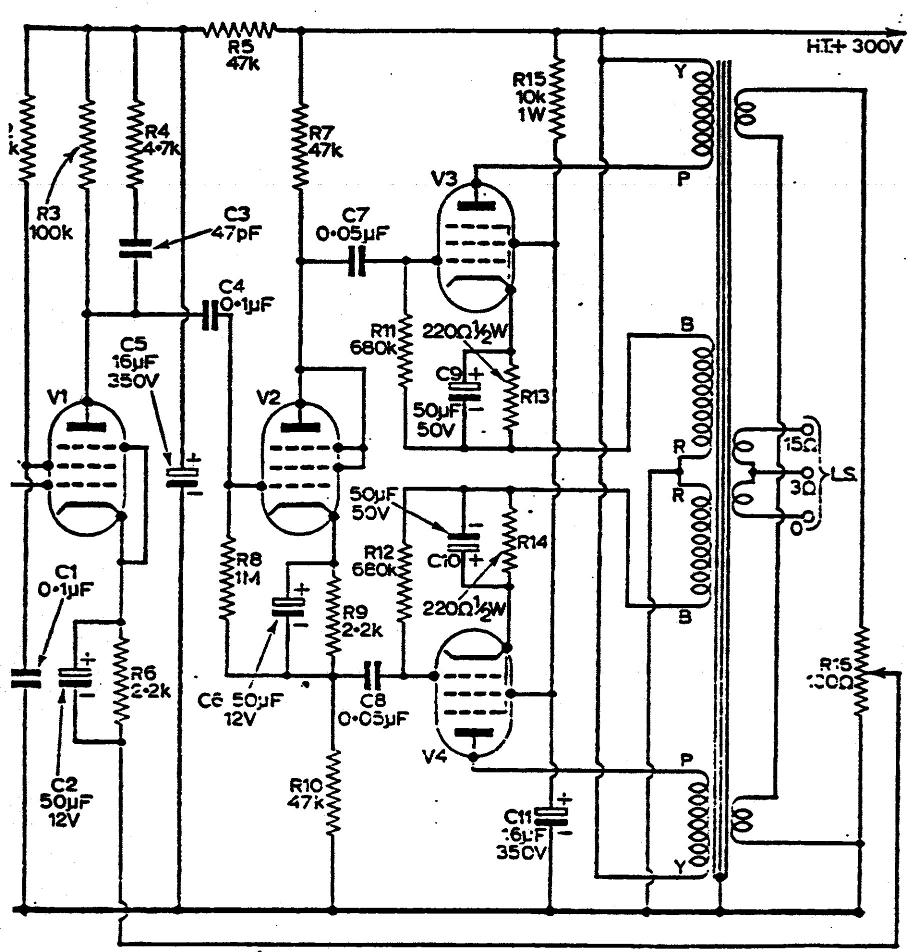


Fig. 9—A three-stage amplifier with another version of anode/cathode loading.

always passed through a pre-amplifier t first, and a highly sensitive amplifier opelessly overloaded. ight pentode and concertina circuit Fig. 9 will give all the gain likely to be he grid resistors of the output valves ted to the cathode ends of the cathode front end can be altered if it is wished e of the high-gain versions, without ration of the remainder. The use of ouplings is not likely to cause instability y feedback, but direct coupling between /2 can be used by the constructor in the experiment. V1 and V2 could i.e., a double triode. sformer, of which constructional details en in the next issue, has been used in of circuits, not all of which were con- irable when matters of cost and ease nt were taken into account. All, how- d to prove the inherent stability of the dback system.

(To be continued)

P.W. SIGNAL GENERATOR

(Continued from page 482)

so on, at 200kc/s intervals, until the generator harmonics are too weak to hear.

The fifth harmonic of 200kc/s will be 1,000kc/s, or 1Mc/s, and the generator may be tuned to this. Harmonics of the generator will then be heard at 2Mc/s, 3Mc/s, 4Mc/s and so on, at 1Mc/s intervals, until too weak to be found. It is, of course, necessary to have a receiver with short-wave ranges, for this purpose. By proceeding as described, calibration marks can be obtained at 1Mc/s intervals.

In many parts of the country the National Physical Labaratory signal on 2·5Mc/s can be received. This will furnish a 2·5Mc/s calibration of great accuracy. By proceeding as above, harmonics of this will furnish calibration marks at 5Mc/s, 7·5Mc/s, 10Mc/s and so on, at 2·5Mc/s intervals. ■

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THE USE OF A TERTIARY FEEDBACK WINDING ARRANGEMENT SIMPLIFIES THE CONSTRUCTION OF THIS TRANS- FORMER AND REDUCES THE COST.

(Continued from page 502 of the Octo

THE section diagram of one of the author's tertiary-wound transformers is shown in Fig. 12, which may seem, at first glance, to be as complex as the conventional high quality product, but it is really quite a simple job for the enthusiastic home constructor. Sections 1 and 7 are only of 20 turns each spaced to form single layers and the secondary (4) is a simple winding of about a hundred turns. The primary is so arranged that sections 2 and 5, serving one valve,

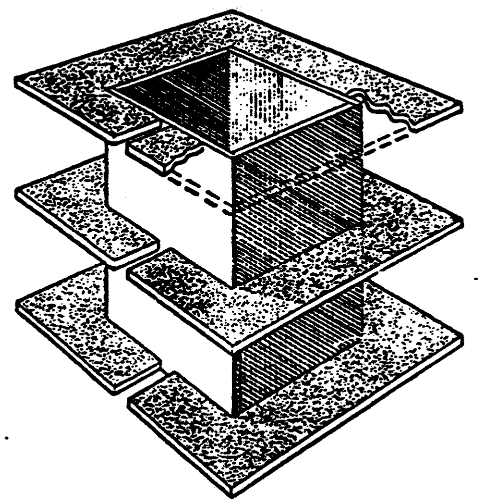

Fig. 10—The construction of the bobbin.

match 3 and 6 for the other much more accurately than the more usual arrangement in which only the number or turns—and nothing else—can be matched.

Laminations

The amateur's main difficulty is obtaining core material, for very few dealers carry laminations in stock and the delivery for small orders of one or two stacks seems somewhat lengthy. Fortunately, the tertiary-wound transformer is so stable, so free of trouble in the use of heavy negative feedback, that quite generous tolerance

any audibly detectable loss of quali Because of this, a departure has been the usual rigid specification that amateur's choice of material (and reduc because core material is far from cheap structional details will be given whi adapted to material that is available obtainable.

Stripping down an old component is obtaining laminations, and wire too. It a slight simplification in the job of because, as stripping proceeds, the turns and the number of layers can be coun the number of primary turns to put on handling at least equal to, and prob than, the original component can be It will be a useful guide, but not quite wire will go back on because two tertiary windings, some extra insulati possible loss of compactness owing winding, will use up some space. Th need not be too great, and the turns must be the same) can be maintained.

Former

The constructor who does not reso old components will have to make d wire gauge and number of turns. guidance will be given. The transfor a special cheeked and partitioned bobb of the simple former most often used shown in Fig. 10, can be made at l paxolin, Perspex or even cardboard. bobbins look rather the worse for wea pletion of the winding but can be ma the purpose.

Set the dimensions by measurement of laminations. The end cheeks and partition are identical, and can be slotte the leads to be brought out if rigid used. Alternatively, with cardboard, t brought out through holes pierced wit as winding proceeds. A bobbin made of square section will wind more smo one made for a rectangular stack. A ge brace makes a useful winder when cla vice. Check the gear ratio by counting revolutions for one turn of the handl shows one simple way of fitting the bol chuck. It comprises a woodscrew dri piece of wood of the same size and sec e gadget must be made accurately, otherwise ll revolve with a wobble that will cause over- ng turns and snapped wires. Try cutting the l oversize and paring it to exact size after g the screw.

nost the only simple aspect of transformer n is the turns ratio, which is given by (Zp/Zs) e Zp and Zs are respectively the valve nt impedance and the nominal loudspeaker lance. All others are so complex that no : specification can be offered when the object l enable the constructor to use available rials. Nor would it be helpful to present a of formulae with an invitation to the con- tor to sort it out himself. Because of these ulties, and because the tertiary-wound trans- er is tolerant to a reasonable range of varia- a procedure that seems rough and ready is but which will prove satisfactory. A general iption of the method will be given first, wed by step-to-step winding instructions.

fer to Fig. 12, which gives a cross-section of vindings with the core on the left and the ion seen horizontally. The cheeks, which d be horizontal at top and bottom, have been ed to avoid confusing the leads in the am. All sections are balanced equally each of the secondary winding (section 4), and fore this section must be positioned accurately vay through the depth of the winding space. ving for four layers (at the most) of 20 or w.g. enamelled wire plus paper interleaving Empire cloth insulation, the secondary will ry 0·20in. of winding space, of which 0·10in. ie either side of the true mid-point.

rk these boundaries on the outsides of the s near the slots, or on the insides if they not slotted. The inner marks indicate the of sections 1, 2 and 3. There, with all ation layers, they must stop, regardless of the er of turns wound on because an equal space eded for sections 5, 6 and 7. As all four ary sections are equal, the number of turns ection 2 can be multiplied by 4 and the ict divided by the required turns ratio to give umber of turns that must be wound on for econdary (section 4).

ference to standard wire tables will give ice guidance as to the likely number of ary turns that can be accommodated. The between one cheek and the partition divided e wire diameter, gives the number of close- d turns per layer. The section depth less for insulation gives the actual winding . Add 0·003in. to the wire diameter for eaving paper and the layer thickness is ned. The total number of turns is then given

$$\frac{\text{Winding space} \times \text{turns-per-layer}}{\text{Layer thickness}}$$

om 3000 to 3500 turns is a fair total for a ary winding and the gauge can be chosen the range 32 to 38s.w.g. to suit the available . If the original gauge of wire is used with ld component, it will be found that the number of turns is less than the number removed.

Use laminations of reasonably good quality and aim for a core section of about ¾in. square for 5W and up to 1¼in. thickness for 10W. Make the bobbin to suit and mark the secondary boundaries on the cheeks. Wind section 1 (Fig. 12) straight on to the bobbin, 20 turns only, spaced to occupy the full width, passing the partition so that 10 turns lie each side of it. Gauge (25 to 30s.w.g.) is not very important because the feedback net- work draws virtually zero current and only a few milliamps of V1 cathode current passes through the winding.

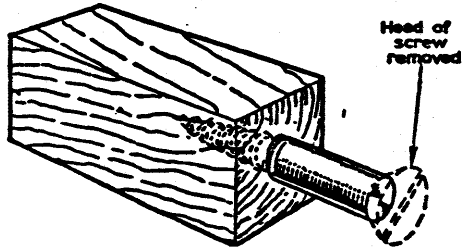

Fig. 11—A suitable bobbin holder for use with a geared brace for winding.

Insulation

Fasten the wire ends to the cheeks with adhesive tape to prevent them becoming tangled as winding proceeds. This section will operate near to earth potential, but the next will have a wide A.C. swing; therefore, three layers of 0·005in. Empire cloth should be wound on for insulation. It also provides an even surface on which to commence the next winding.

The first primary layer for section 2 should be close-wound to fill the width between one cheek and the partition. Note the number of turns, add a layer of 0·003in. paper and continue to add similar paper-interleaved layers until it is obvious that the addition of three layers of Empire cloth will fill the allotted space up to the boundary mark. Calcu- late the total number of turns.

Section 3 is identical to section 2 but, as it serves the other valve of a push-pull pair, it must be wound in the reverse direction. Simply take the bobbin off its temporary wood core and put it on the other way round; then, rotation of the winder need not be reversed. This section, complete with insulation, should end up level with section 2 on the other side of the partition.

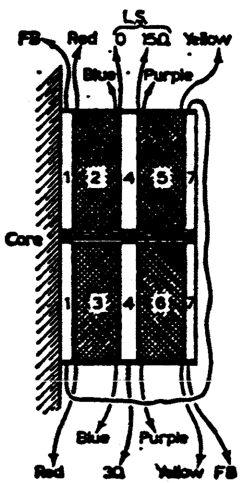

Fig. 12 (right)—The arrangement of the sections.

Calculation

Next is the secondary, section 4, and the number of turns has to be calculated. The number of turns in section 2, multiplied by 4, gives the total primary turns and this figure divided by the turns ratio, gives the number of secondary turns. For example, if section 2 has 750 turns and the ratio required is 30:1 the calculation is

$$\frac{750 \times 4}{30} = 100$$

The secondary must be wound evenly right across the bobbin, passing the partition as it extends from cheek to cheek. If the last layer has insufficient turns to fill its full width the turns must be spaced evenly to distribute them equally each side of the partition. A 3Ω tap can be made at 50% of a 15Ω secondary provided it can be arranged near a cheek. This is impossible with a three-layer secondary and easy with a two-layer one when the wire gauge is chosen to fill the width exactly. In a four-layer winding, the second and fourth can be spaced evenly so that the tap can be at a cheek and the balance maintained.

When the secondary has been insulated with three layers of Empire cloth, the remaining wind- ing space should equal that used for sections 1, 2 and 3. Wind section 5 exactly the same as section 2 and in the same direction. Section 6 must be wound in the same direction as section 3. These sections, with three-layer insulation, should leave just enough space for the outer tertiary winding which is identical with section 1 and wound in the same direction. Three more layers of Empire cloth complete the work of winding.

The end of section 1 and the beginning of

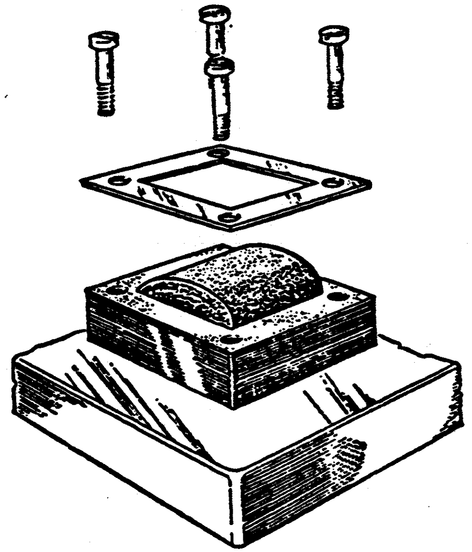

Fig. 13—A method of clamping the finished transformer to the amplifier chassis.

primary wires should be anchored and coded immediately, those from each che a separate one-valve set. Sleeve them, u colours indicated in Fig. 12, and then l sleeves firmly to the insulated windin adhesive tape, or tape coloured leads to th tion and solder the wires to these. If the is delayed until after assembly of the lam tag-strips can be fitted to the tra mounting.

Assembly

Insert the laminations with the E's ar alternate directions, and butted together gaps. Firm clamping is essential to avoid l chatter. Fig. 13 shows a transformer into a rectangular hole in the chassis and by a plate with a rectangular hole bolted the laminations.

In all circuits to which this versatile tra can be applied, sections 2 and 5 togeth the load for one valve of a push-pull for straight anode loading they are put by joining the blue and purple leads Yellow is then taken to the anode and rec Sections 3 and 6 are used in exactly the s with the other valve. Ultra-linear lo obtained by taking the screens to the jun the blue and purple leads.

end u partit *Calcu* Ne of tu turns prim ratio, exam requi Th acros exten

Fig.

has in must b each s at 50° be arr three w exactly fourth be at a Whe three l ing sp and 3 section must b These leave windin wound of Em The section leads