DESIGNING AND CONSTRUCTING DIRECT-COUPLED A. F. AMPLIFIERS

PART II

This article is the second, and final, of the series giving complete theoretical and constructional details of direct-coupled amplifiers.

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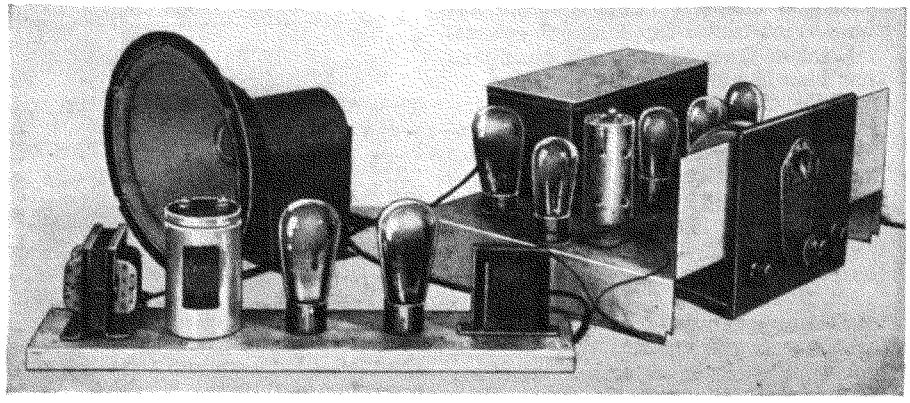
IN last month's issue of RADIO-CRAFT we touched briefly upon the construction of a two stage amplifier and gave enough details of the calculations to enable anyone to design his own particular amplifier. It was remarked, at that time, that the two stage amplifier had too small a voltage gain to have extensive uses, and that the plain, three or more stage circuit had drawbacks which limited its applications with ordinary materials. Therefore, this article will touch upon more elaborate types which give high gain and output without demanding other than standard components in universal use today.

In order to derive the benefits of multi-stages without resorting to special apparatus in the voltage supply—which would mean high cost and possibly trouble—a double powered amplifier was developed, as shown in Fig. 4. By using this method, the number of stages may be extended indefinitely without relying upon excessively high potentials; in addition, it does away with some of the bias bypass condensers, which naturally results in an additional advantage—better tone quality.

The layout of Fig. 4 is the one preferred for all receivers, including television. Outside of the power units, there is only one audio bypass condenser employed. This gives the lower frequencies a chance to show themselves, and their strength and clarity are amazing. Yet, there is absolutely no trace of the hollow barrel effect usually associated with receivers that produce the lower notes by artificial tone control methods.

For Service Men or others who desire to remodel old receivers whose tuning units are satisfactory, the layout of Fig. 4 is especially convenient. It permits the use of practically all the parts in the receiver, and only requires the addition of a power transformer, a filter choke, and two filter condensers. Because the power stage requires but 250 volts, the 50-volt bias being obtained from the first power unit, and because the current drain is small, the power transformer may be of any of the now obsolete types. They all have a 2½-volt filament winding which is suitable for the 45.

The second audio stage (a 27 or 56) requires a separate filament winding since the filament is at a much higher potential than ground. If the filament of the first-audio socket in the receiver is not individually wired, the power tube winding is usually adaptable, provided that a 45 tube is used. In case 5-volt filaments are used, the voltage may be dropped to 2½ volts by suitable resistors or, if the winding is center tapped, one-half of it may be used.



Typical converted receiver using the circuit of Fig. 4 constructed by the author.

As a general rule, any audio transformers in the receiver may be used as audio chokes in the revamped set. The primaries and secondaries should be wired in series to obtain the best results. It is preferable, however, to use good audio chokes if the added expense is not objectionable.

The removal of the heavy drain of the power tubes from the tuner power pack will necessitate readjustments of the voltages. In some cases, particularly those where the power section and speaker are separate from the tuner, it may be advisable to use the new power supply for the tuning section and to retain the power section of the set as it stands. A few changes are necessary to adapt such a unit for its new purpose.

Whatever voltage supply is used for the tuner, it must be capable of giving a fairly high potential, since V1 and V2 derive their operating voltages, in addition to the bias for V3. 300 volts is usually sufficient for this purpose. As 50 volts are required for V3, this leaves 250 volts to be divided between V1 and V2. Inasmuch as the triode half of the 55 is diode biased, 90 volts on its plate will tend to accommodate the inequalities of bias and give better results than if the maximum potential were used. This will leave some 160 volts for V2 of which about ten will be required for its bias.

For those desiring a straight amplifier of the type in Fig. 4, for P. A. systems, phonographs, and the like, the only changes are in the first stage where the proper tube is substituted for the 55 and means for its bias taken care of as explained previously. If four stages are wanted, the second power section can be designed to accommodate another tube between V2 and V3. The effect is, in general, that of two, two stage amplifiers placed in series.

It must always be remembered that the second power unit is at a very high potential above ground and its parts must be insulated from the tuner chassis, or first section. For this reason, it is always preferable to build it as an individual unit in conjunction with the power tube and speaker.

The fact that a bleeder current flows through the series of resistances in Fig. 4 does not complicate the calculations to any extent. The only requirement is to add the desired bleeder current to the normal tube currents in each case. In Fig. 4, a bleeder current of 10 ma. was used in the calculations. The 5 ma. of V2 and the 10 ma. bleeder current thus flow through R1, while only 10 ma. passes through R2. V3, of course, has no bearing on any of the current flows, being an entirely separate unit.

Choke 2 of Fig. 4 may be mounted on either unit, depending entirely on mechanical convenience. However, three lead wires are necessary when it is mounted on the power tube unit, the leads running from the points marked

DIRECT-COUPLED AMPLIFIERS

Look through your files of diagrams of commercial radio receivers and notice how many of them use transformer coupling in the audio stages—practically none. Resistance coupling is at the wheel, and it certainly is doing its stuff. Direct coupling is an improved form of resistance coupling; it has all of its advantages and few of its disadvantages. In fact, it's the only "perfect" coupling to use.

with an x. R1 should preferably be placed in the second unit with choke.

One for the Experimenter

For those of an experimental turn of mind, the circuit in Fig. 5 may provide an interesting and instructing amplifier. The cost of construction is practically the same as that of a two stage system, yet it has the added advantages of much greater gain and output.

Unfortunately, the auxiliary power tube is not directly coupled to the source of its signal input, but must make use of the usual stopping condenser. However, this condenser is preferably of a large size and the usual bypass condenser from the power tube filaments to ground is eliminated, so any impairment of tone is more than counteracted.

The use of such an amplifier with power tubes of high gain is somewhat doubtful, although it has been operated with great success with standard low mu tubes, such as the 45. When used with a radio tuner, such an amplifier is sometimes obstructed in its operation by residual R.F. currents which go into a regenerative cycle in the power stages. Such an action is easily overcome by the use of a small bypass condenser from the plate of the first power tube to ground.

While only a few circuits have been presented in these articles the system of direct-coupling must not be construed to be limited to them. This coupling method can be adapted to practically any situation where superb tone is the chief factor. While the author has not actually constructed push-pull arrangements, there is little reason to doubt the success of complete systems. The absence of bias condensers and the removal of other restricting elements of the straight systems should result in beautiful reproduction with tremendous power. The cost, too, is very little more, since the same number of resistors would be used and only additional chokes and sockets needed. In a push-pull circuit based on Fig. 4, the full-wave rectification of the signals would be achieved by the use of twin 55 tubes, each feeding one side of the amplifier, or one 2B7 tube could be used with each diode plate operating into one half of the audio section.

In closing, it is appropriate to stress the fact that any amplifier based on this system should be considered more in the light of a delicate and precise musical instrument than as a soulless bit of apparatus. It is not exacting in its requirements and will perform miraculously over a wide range of values, but every additional care taken in its construction is reflected in increased beauty and mellowness of tone. It will make any speaker sound like a new thing; yet that vital part should be chosen with the greatest of care, and one should be sought which is capable of performing over the extended range of frequencies. The input transformer should be carefully examined. Usually they are small and totally unfit to step down the lower frequencies. If necessary, it may be wise to purchase a separate transformer of the best quality and of generous size. Further, the cone should be so mounted that it has a wide range of unrestricted movement and is not stiff. Finally, a baffle-board of generous size should be used, one that will properly bring out the lowest notes.

(Unquestionably, direct-coupled A.F. amplifiers will become *la mode* in a short time. The technician is referred to the following articles in past issues of RADIO-CRAFT, for interesting data on amplifiers of this type. "Bureau of Standards Audio Amplifiers," by S. R. Winters, September, 1929, pg. 112. "Constructing the Loftin-White Amplifier," by M. W. Sterns, September, 1930, pg. 156. "A Direct-Coupled Pentode Amplifier," August, 1930, pg. 100. "Servicing Direct-Coupled Amplifiers," by Sidney Fishberg, January, 1932, pg. 403. "How to Build a Direct-Coupled Type 45 Amplifier," by S. H. Burns, December, 1930, pg. 354.

Additional information concerning direct-coupled amplifiers, has appeared in the Information Bureau of past issues. *Technical Editor.)*

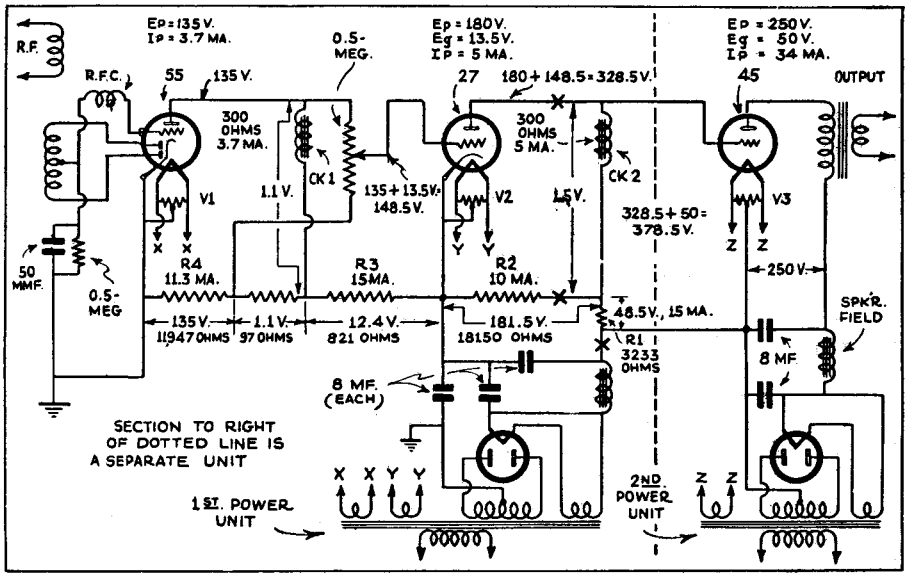


Fig. 4
A double-powered amplifier circuit. See the photograph.

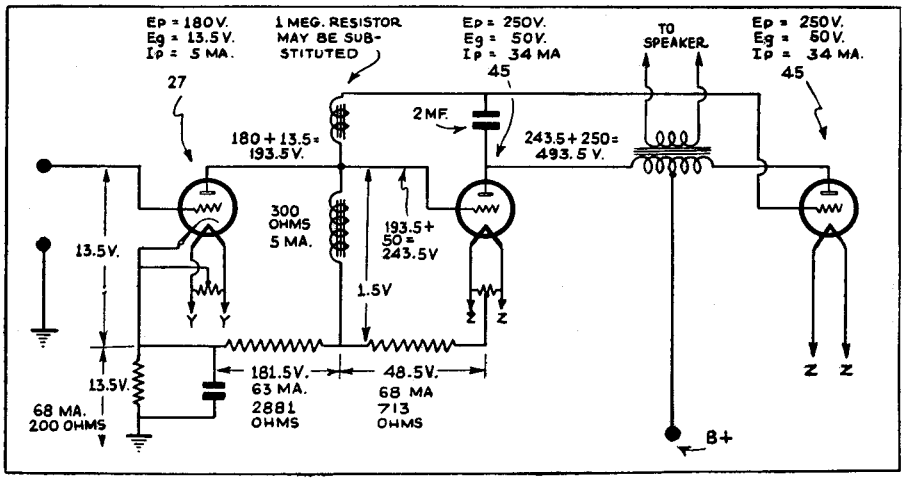


Fig. 5
Here is a good circuit for the experimenter, as suggested by the author.