A New Method of Amplifier Coupling

Author Develops New Type of A. F. Amplification Which Should Prove of Great Interest to Those Concerned with Quality Reproduction

By H. P. DONLE

IN the early days of radio broadcasting the transformer system of coupling audio amplifiers was almost universal, because the efficiency of this system is very high and it does not require many tubes. Furthermore, the standards of quality at that time were much lower than those of today. Transformer coupling is remarkably efficient on weak signals; but its performance differs considerably from that of other systems of coupling, in the fact that this high efficiency decreases very rapidly as the signal intensity is increased. This is a transformer characteristic which is not often considered but which, without doubt, gives rise to considerable distortion on account of the fact that the weak signals are amplified more than the stronger ones. It is, furthermore, difficult to use more than two stages of transformer coupling because there is a marked tendency for audio-frequency regeneration to take place, which not only increases distortion but produces

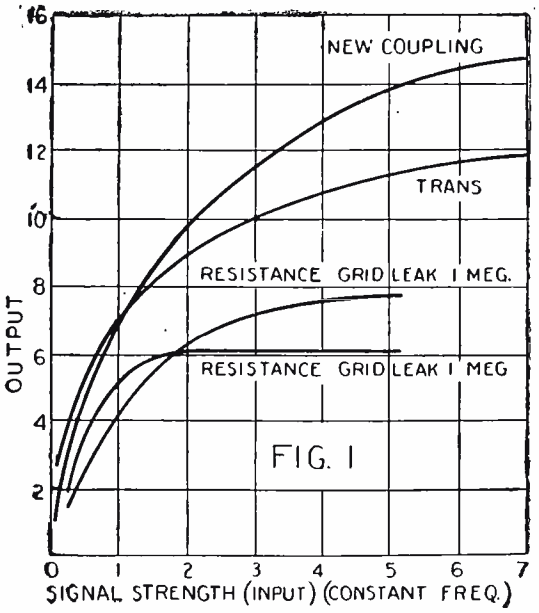

Fig. 1. Curves illustrating capability of various types of coupling devices to respond to signals of varying strength.

a howl or squeal in the loud speaker. And while this howl may be lessened, and more stages introduced by various methods of stopping regeneration, these methods themselves always introduce losses into the circuit; and thus decreases the volume of reproduction and neutralize to a large extent the expected gain from addition stages.

Resistance Coupling

Resistance coupling consists essentially of connecting the plate of an audio amplifier tube to the grid of another by means of a small condenser; supplying the plate current to the first tube through a resistance which is usually of the order of one-tenth of a megohm; and connecting the grid of

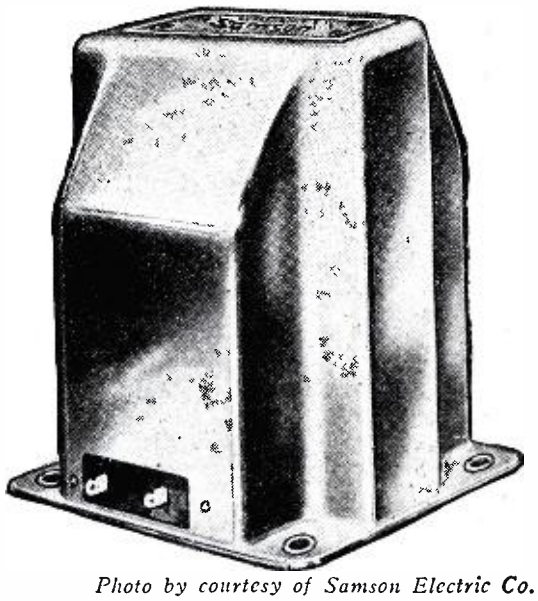

Photo by courtesy of Samson Electric Co.

Fig. 3. One of the coupling devices now on the market utilizing Mr. Donle's principle.

the second tube to the negative filament terminal through a resistance of from one-tenth to one megohm. This system, although very inefficient, has one advantage; it is capable of giving excellent quality of reproduction, only so long as the signal intensity is not too great. And since there is no tendency for regeneration to take place between stages, it is possible to use several stages, which allows a sufficient amount of amplification to be secured even though the individual stages are inefficient. Aside from the inefficiency of this system, it has the considerable disadvantage of inability to handle large signals, because the grids of the amplifier tubes accumulate charges too rapidly to be properly taken care of by the grid leaks. Furthermore, this effect is noticeable on signals of medium intensity, as manifested in a certain amount of blurring and distortion which increases as the signal intensity increases.

The so-called impedance system of amplifier coupling differs from resistance coupling only in that the resistance, through which the plate circuit of the amplifier tube is supplied, is with this system replaced by a choke coil. The rest of the circuit is the same. This system, while it has an efficiency per stage somewhat higher than resistance coupling, has the disadvantages of resistance coupling in the tendency for the grids of the amplifier tubes to load up and introduce distortion as the volume of signal increases. Unless a grid leak of very low resistance is employed, which reduces the efficiency of the system, this arrangement is not capable of giving much volume.

The New Donle Coupling

A system of audio-frequency amplifier coupling has been developed by the writer, which overcomes most of the disadvantages of previously known systems. It permits a quality of reproduction which is equal to the very best which can be secured with resistance coupling under the most favorable conditions of weak signals. It is a much more efficient method of coupling tubes than resistance or impedance and thus affords a considerably greater amount of amplification per stage. It does not share the disagreeable characteristic of transformer coupling, amplifying weak signals to an excessive degree. It may be readily used in three stages without

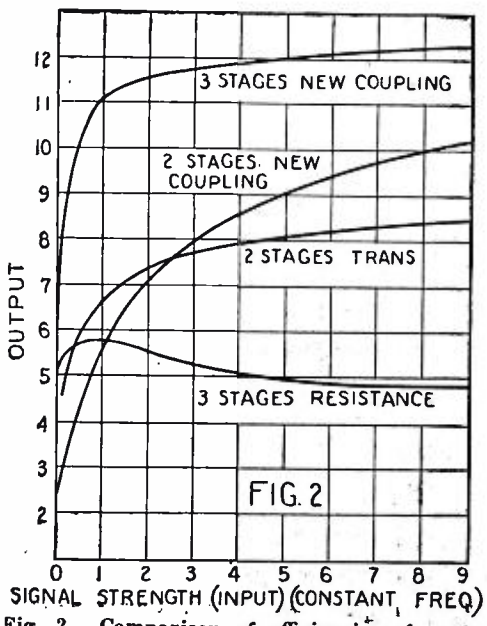

Fig. 2. Comparison of efficiencies, of various types of amplifiers taken under the same conditions as the curves of Fig. 1, excepting that the latter curves are for one stage only.

the slightest tendency towards audio-frequency regeneration or howling; and when so used, will give a signal intensity for any input far greater than can be secured with any other known system of coupling an equal number of stages.

The system used is diagramed in Fig. 4, by which it will be seen that an impedance leak is used instead of a resistance leak. By this method high impedance is presented to the alternating

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signal, but the resistance to the grid charge is unusually low. How well this system performs is shown by the accompanying curves (Figs. 1 and 2) in comparison to two well-recognized systems, that is, transformer and resistance coupling.

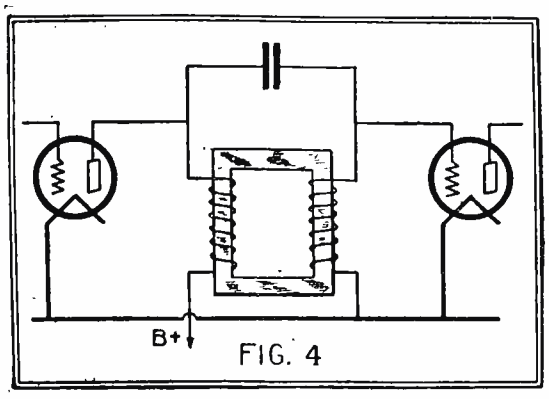

FIG. 4

Fig. 4 (above). Circuit diagram of the Donle coupling system. The two windings are on a single core; the grid charges leak off through the winding on the right.

Fig. 1 shows the operation of the Donle system, in comparison with the others. On this curve the input and output are given in arbitrary units; it shows very clearly most of the characteristics mentioned above. For example, with transformer coupling the efficiency falls off very rapidly as the input increases. The curve for the Donle system crosses the transformer curve at a relatively low input and rises to a considerably higher value.

The curve of resistance coupling, with the grid leak of one megohm, shows in a very interesting manner the low efficiency of the system on weak signals and the attainment of saturation at a very low input. With resistance coupling, if a large output is desired it is necessary to use a grid leak of low resistance. The effect of this is shown in the same figure on the curve for a grid leak of 0.1 megohm—a lower efficiency on weak signals but saturation at a higher value.

From the curves of Fig. 1 it is obvious that the transformer is an efficient coupling device for weak signals but incapable of handling signals of great volume. Resistance coupling is inefficient and will handle still less volume than transformer coupling. And that, furthermore the new system of coupling is more efficient for signals of all intensities than resistances and yet is capable of handling a greater volume than the transformer.

Comparison of Several Stages

In Fig. 2 curves are shown, taken under similar conditions to those of Fig. 1 and the results given in arbitrary units, for the performance of two and three stages of this new system of amplifier coupling compared with two stages of transformer coupling and

three stages of resistance coupling. The results indicated are too obvious to require a lengthy description. There are a few points, however, which should be mentioned. In the first place the two stages of the new system show considerably less efficiency than two stages of transformer coupling for signals of weak intensity; but as the intensity increases the new system equals transformer coupling and finally exceeds it, because the two stages of transformer coupling have become nearly saturated at a relatively low intensity.

The three stages of the new system show a very high efficiency for all signal intensities compared to two stages of transformer coupling. The curve for three stages of resistance coupling shows the usual characteristic of this system; that is, the attainment of saturation at relatively low input and even a falling off of the output as the input increases beyond the saturation point. It might be stated here that, on these curves for resistance coupling, above the point where saturation takes place the quality of reproduction is ruined, and the signal quality almost is totally destroyed when the input increases that point.

Quality with Efficiency

The advantages of the new system may be summarized as follows: A very high quality of reproduction on signals of all intensities, with an efficiency per stage equalled only by a transformer on signals of low intensity, and equalled by no other system on signals of greater intensity. On account of the lack of regeneration between stages with the new system it may be used, and will in fact give the best performance, with three stages; under this condition it will exceed in efficiency the operation of two stages of transformer on signals of all intensities and will handle a signal volume considerably in excess of any other system. Furthermore, it may be arranged in a compact manner, is not readily affected by stray fields and may be connected into an ordinary circuit without the slightest difficulty.

The Improved "Diamond of the Air"

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circuit coil. The space between it and the first receptacle is used for four binding posts arranged in a little square, with the second battery switch, S2, in the center, and for the audio transformer, which is mounted on the under side of the bakelite strip. The purpose of the switch and posts will be explained shortly.

The other three sockets are distributed evenly along the remaining