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ELECTRICAL APPARATUS FOR LOUD SPEAKER SYSTEMS

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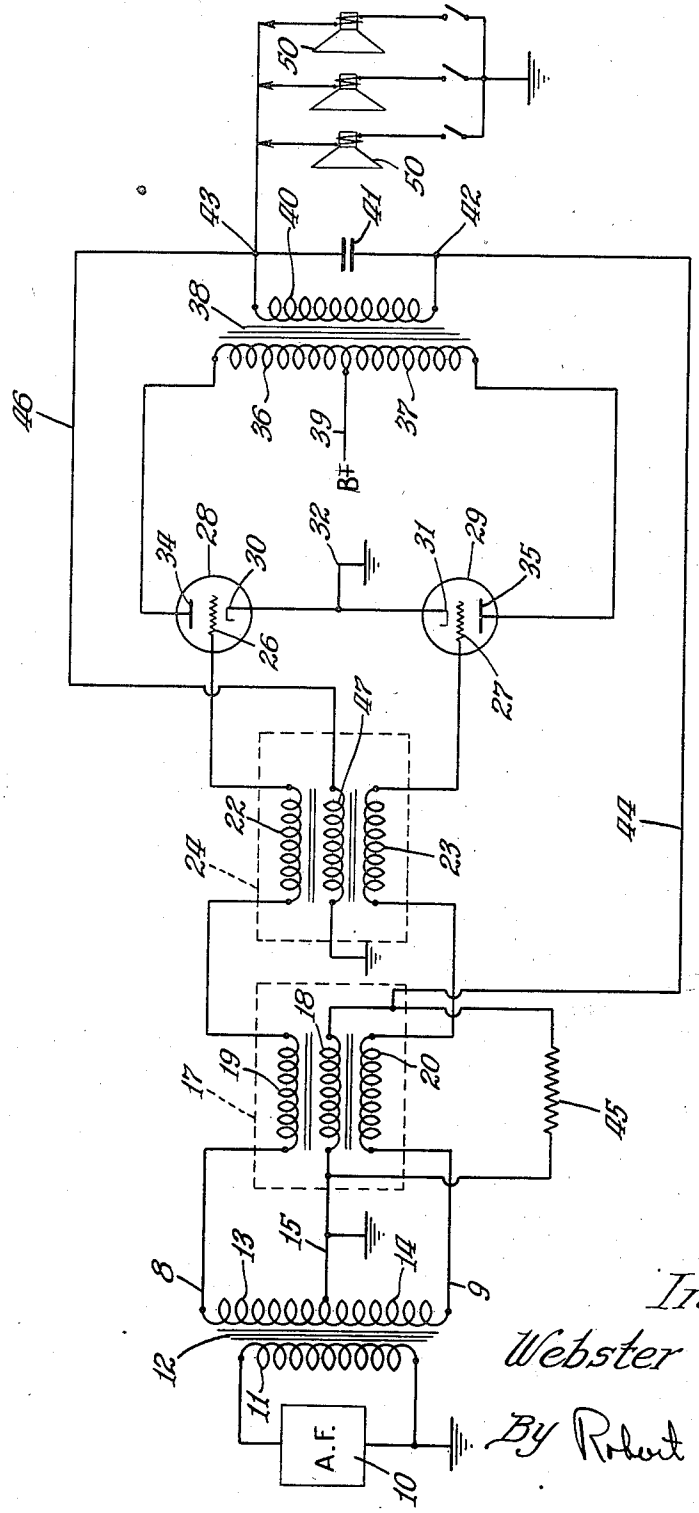

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ELECTRICAL APPARATUS FOR LOUD-SPEAKER SYSTEMS

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This invention relates to an electrical apparatus and particularly to a speaker system. In public address systems, announcing systems or alarm systems, it is desirable to operate a number of speakers and to vary the number of such speakers in accordance with load requirements. If a speaker system is to be operated efficiently, it becomes important that proper matching between the output transformer of the system and the speakers be maintained. While a certain amount of mis-match may be tolerated, the efficiency of the system is greatly reduced if the magnitude of the speaker load varies through substantial limits. Unless means are provided for introducing some degree of regulation, the audio frequency potential available across speakers may rise sharply with the removal of a substantial number of speakers from the load. The converse is also true.

It has hitherto been the practice to provide resistor as dummy loads for speakers. In addition to wasting power, the resistors frequently burn out.

To overcome the disadvantage incident to dummy resistor loads, the art has relied upon so-called parallel feedback transformers for endowing a speaker system with satisfactory regulation. This parallel feedback transformer comprises a three-winding transformer having one winding which may be arbitrarily considered as a primary and the remaining two windings which may be considered as secondaries. The primary winding in this system is connected in shunt to the speaker load. The secondary windings are connected in the input circuits of a push-pull amplifier. The phasing between primary and secondaries is such as to provide degeneration. Thus, as the potential across the speaker load increases above a predetermined normal value, degeneration will increase and there will be an increasing tendency to cut down the signal strength at the input of the amplifiers. Conversely, if the potential across the speaker load tends to decrease toward a predetermined normal value, the degeneration becomes weaker. It is understood that the potentials referred to are audio frequency potentials. Thus, when the system is operating under what might be termed an arbitrary normal load condition, a predetermined amount of degeneration occurs in the feedback transformer. The regulation depends upon the variation in this degenerative action.

In the system described above, it has been found that the regulation permits substantial variation in the potential applied to the speakers

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resulting in variation in the power output from individual speakers as the load changed. As a rule, it has been found that a power variation of not less than three db. at each speaker would result from a change of speaker load in spite of the regulation. Thus, the regulating action of the parallel feedback transformer inherently requires a substantial potential variation across the speaker load for operation.

Since a three db. power variation represents a substantial change, as far as a human ear is concerned, it is desirable to improve the regulation. The invention herein provides a system wherein the potential across the speaker loads is maintained substantially constant over wide variations of speaker load. The invention provides, in one respect, a three-winding feedback transformer wherein the primary is connected in series with the entire speaker load rather than in shunt thereto. By virtue of such a connection, the variation of current through the load is relied upon for regulation. This three-winding transformer, which may be considered as a series feedback transformer, has the primary and secondaries so phased that the action is regenerative.

To control regeneration, minimize instability and control frequency non-discrimination, the primary may be by-passed with a suitable resistor. In order to reduce distortion introduced by a regenerative feedback transformer, the invention additionally provides for the inclusion in the system of a parallel feedback transformer connected as in the prior art. Thus, the parallel feedback transformer secondaries are connected in series with the secondaries of the series feedback transformer. By virtue of the degenerative action of the parallel feedback transformer, the amount of regeneration in the series feedback transformer may be increased above what might be considered desirable if a parallel feedback transformer is omitted. The combination of the two feedback transformers provides a compound feedback action which is particularly effective as far as regulation is concerned and provides a minimum of distortion.

Referring, therefore, to the drawing, the single figure shows a circuit diagram of a multi-speaker system embodying the present invention. 10 represents any suitable source of audio frequency as a microphone, phonograph pick-up or other sound reproducing system, or that portion of a radio receiver which provides audio frequencies. Source 10, which in itself may include as many stages of amplification as desired, is connected to primary 11 of driver transformer 12. Trans-

former 12 has secondary windings 13 and 14 providing a common grounded connection 15 and outer terminals 8 and 9.

Transformer 12 feeds its output to series feedback transformer 17 consisting of primary 18 and secondaries 19 and 20. Transformer 17 is a conventional iron core audio frequency transformer with the various windings closely coupled to each other. The phasing of the windings are regenerative as will be indicated later.

Outer terminals 8 and 9 of driver transformer 12 are connected respectively to secondary windings 19 and 20. Secondaries 19 and 20 are connected to secondaries 22 and 23 respectively of transformer 24 similar to transformer 17. Windings 22 and 23 extend the circuit to control grids 26 and 27 of push-pull amplifiers 28 and 29 respectively. These amplifiers are power amplifiers and, for simplicity, are shown as three electrode tubes. It is understood, however, that other amplifiers, such as beam power tubes, may be used.

Amplifiers 28 and 29 have cathodes 30 and 31 grounded at 32. These tubes have anodes 34 and 35 connected to primaries 36 and 37 respectively of push-pull output transformer 38. Primary windings 36 and 37 have center tap 39 for connection to the usual source of B plus supply. Output transformer 38 has secondary 40 across which condenser 41 is connected. Condenser 41 serves to stabilize against oscillation. Secondary 40 and condenser 41 together have terminals 42 and 43 respectively. Terminal 42 is connected by line 44 back to grounded primary 18 of transformer 17. Across primary 18, there is preferably disposed low resistance 45 for controlling regeneration and frequency non-discrimination. This resistance may be omitted if desired under certain conditions. Terminal 43 is connected by lead 46 back to grounded primary 47 of transformer 24.

Connected between terminal 43 and ground are speakers 50 of any desired construction. Thus, if these speakers are of the permanent magnet type, the speaker input will be connected between terminal 43 and ground. If these speakers are of electro-dynamic type, it will be understood that the voice coils are connected between terminal 43 and ground and that other means for supplying current to the field windings will have to be provided. Whether or not the field circuit in a dynamic speaker is cut-out together with the voice coil makes little difference with regard to the invention. Suitable switching means are diagrammatically indicated by switches in the speaker leads.

It will be noted that primary 18 and resistor 45 is in series with the entire speaker load. Transformer 17 may be considered as a series-connected feedback transformer.

Transformer primary 47 of transformer 24, on the other hand, is connected across terminal 43 and ground so that it is effectively in shunt to all the speaker loads. This transformer may, therefore, be considered as a parallel feedback transformer.

Referring now to transformer 17, primary 18 is so phased with reference to the two secondaries that the transformer action is regenerative for the entire system. Thus, any signal going through primary 18 will induce in both secondaries 19 and 20 potentials tending to increase the signal strength already in the secondaries by virtue of the output from driver transformer windings 13 and 14. By shunting primary 18 with a resistance, the amount of regeneration may be determined while keeping the over-all resistance of the output circuit for secondary 40 low.

Primary 47 on the other hand is phased with reference to secondaries 22 and 23 so that degenerative action occurs. Thus, a signal through primary 47 will induce potentials in secondaries 22 and 23 which tend to oppose the normal signal potentials in these secondaries by virtue of their connection in the output circuit of windings 13 and 14. The amount of degeneration in transformer 24 may be controlled by the transformer ratio or by disposing a resistance in series with primary winding 47. If transformer 24 is omitted, series feedback transformer 17 may provide good regulation but tends to introduce distortion. The distortion, as a rule, increases with the amount of regeneration. By decreasing regeneration in transformer 17, however, regulating action is undesirably affected.

By combining both transformer 17 and 24, as shown in the system, the distortion which may arise by virtue of regeneration is reduced greatly by the opposing degeneration introduced by transformer 24. In fact, by having both transformers, substantial regeneration in transformer 17 may be tolerated without rendering the entire system unstable and susceptible to oscillation.

The combination of transformer 17 and 24 is highly effective in providing a regulating characteristic which is effective for slight changes in output from secondary 40. As is well known, the essence of regulation resides in the utilization of slight variations in the quantity being regulated to maintain the quantity being regulated constant within limits. Thus, as speakers are added or subtracted from the load, little or no variation in potential across the speaker and large variation in load current suffice to introduce a regulating action in the amplifier circuit.

The impedance as seen by output winding 40 remains constant over a wide range of speaker loads. The impedances introduced into the output system by primary windings 18 and 27 are complex and variable and, in a properly designed system, tend to compensate for the variation of impedance due to adding or subtracting speakers. The regenerative action in transformer 17 results in the introduction of a negative resistance in the system. The reverse is true of transformer 24. Thus, as speakers are added or subtracted, the relative magnitudes of these resistances vary and maintain the efficiency of the entire system at a high level over large variations of load.

The large variation in current drawn by the speaker load causes substantial action in transformer 17. Any slight variation in potential across the speaker load causes some action in transformer 24.

By proper design of the system, various regulating characteristics may be obtained. Thus, a constant potential across the speaker load may be obtained with wide changes in the load. It is also possible to obtain a rising potential characteristic across the speaker load with increase in speaker load. The reverse may also be obtained.

It is possible to use ordinary single tube amplifiers instead of push-pull. In such case, the extra secondary windings for feedback would be unnecessary.

What is claimed is:

1. A speaker system comprising a driver transformer having a primary adapted to be energized with audio frequency potentials and having a

secondary, a vacuum tube amplifier having input and output circuits, a feedback transformer having primary and secondary windings, means for connecting the secondary windings of said driver and feedback transformers in series in said amplifier input circuit, an output transformer having primary and secondary, said output primary being connected in said output amplifier circuit, a plurality of parallel connected speakers forming a load, means for connecting said load, feedback primary and output secondary in series, said feedback windings being so phased as to provide regenerative action whereby the potential across said speaker load is maintained substantially constant in spite of load variations.

2. The system of claim 1 wherein a by-pass resistor is connected across the feedback primary.

3. A speaker system comprising a driver transformer having a primary adapted to be energized with audio frequency potentials and having a secondary with a center tap and outer terminals for push-pull operation, a vacuum tube amplifier in push-pull having cathode, grid, and anode electrodes, a feedback transformer having one primary and two secondary windings, connections for disposing a secondary feedback winding between one control grid and the outer terminal of the driver secondary so that said two feedback secondaries are in the input circuits of said push-pull amplifier, said cathodes and center tap being connected, an output transformer having a primary connected to the anodes of said amplifiers, said output transformer having a secondary, a plurality of parallel connected speakers forming a load, connections for disposing said load and the primary of said feedback transformer in series across said output secondary, said feedback transformer having the primary and secondary windings so phased as to provide regeneration.

4. The system of claim 3 wherein a by-pass resistor is provided across said feedback primary to control said regeneration.

5. A speaker system comprising a driver transformer having a primary adapted to be fed by audio frequency potentials and having a secondary, an audio frequency amplifier having input and output circuits, a pair of feedback transformers having primary and secondary windings, means for connecting said driver secondary and the feedback secondaries in series in said amplifier input circuit, an output transformer having a primary in the amplifier output circuit, said output transformer having a secondary, a plurality of speakers in parallel forming a load, means for connecting one feedback primary in

series with said load across said output secondary and means for connecting the other feedback primary across said load, said one series-connected feedback transformer having the windings phased to provide regeneration and the other parallel feedback transformer having the windings phased to provide degeneration.

6. The system of claim 5 wherein a by-pass resistor is connected across said one feedback primary in said series feedback transformer.

7. A speaker system comprising a driver transformer having a primary adapted to be energized with audio frequency potentials and having a secondary with two outer and one center terminal, a pair of vacuum tube amplifiers, each having cathode, grid and anode electrodes, means for connecting said cathodes to said center terminal of said driver secondary, circuits connecting the outer driver secondary terminals to said control grids for push-pull operation, two feedback transformers each having a primary and two secondaries, said grid circuits each including one secondary of each transformer in series between a grid and outer terminal of the driver secondary, an output transformer having a push-pull primary connected to said amplifier anodes, said output transformer having a secondary, a plurality of parallel connected speakers as a load, means for connecting the primary of one feedback transformer in series with said load across said output secondary and means for connecting the primary of the other feedback transformer in shunt across said load, said one feedback transformer having its windings phased for regeneration and the other feedback transformer having its windings phased for degeneration.

8. The system of claim 7 wherein a by-pass resistor is connected across the primary of said one series feedback transformer.

9. The system of claim 7 wherein a by-pass resistor is connected across the primary of the one series feedback transformer and wherein a condenser is connected across the output secondary.

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