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PUSH-PULL AMPLIFIER

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Fig. 1

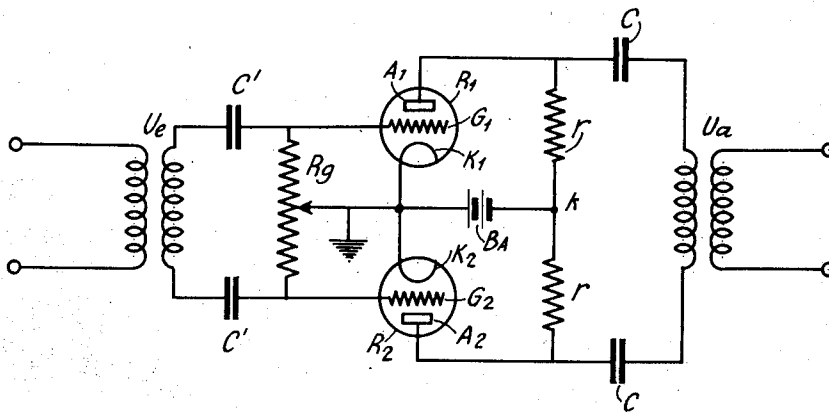
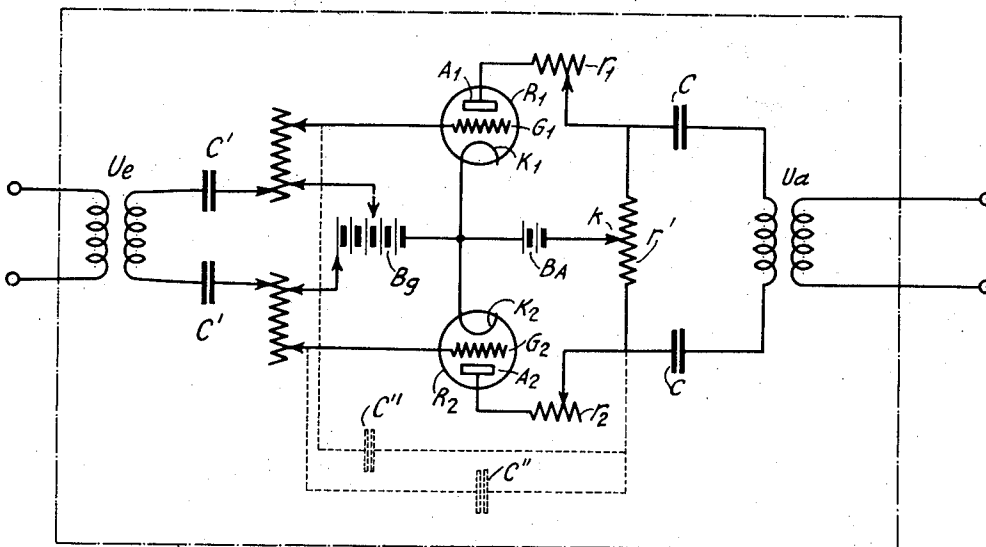


Fig. 2



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PUSH-PULL AMPLIFIER

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1 Claim. (Cl. 179—171)

The object of the invention is a push-pull amplifier circuit scheme which, as regards symmetry of output currents, compared with the arrangements known in the earlier art, is adapted to secure particularly high accuracy.

The arrangement here disclosed insures such great symmetry that instead of the customary output transformer or instead of a potential divider comprising inductance coils, there is provided an arrangement of ohmic resistances to which the output transformer is associated capacitively.

The arrangement here disclosed offers particularly great advantages in connection with the idea well known in the prior art of shunting the input transformer by means of two series connected similar ohmic resistances, the filaments being associated with the midpoint of this series arrangement, whereas the secondary end of the input transformer is capacitively connected with the resistance, by virtue of such symmetric disposition both at the input and the output ends of the amplifier the danger of the arising of back-feeds is extensively precluded, contradistinct from what is true to a marked degree where symmetric conditions are secured only at the input end. Quite apart from the reduction of the chances of back-feeds being set up, an arrangement of the kind here disclosed offers advantages also in other respects. In the presence of inequality of the amplifier curves both as regards amplitude and phase, the two tubes fail to cooperate in an accurate manner also as amplifiers, most particularly at the upper frequency limit. In other words, the amplifier is then adapted only for the lower frequency ranges. The use of resistances secures a convenient equalization also in this regard, while this is quite difficult where coils are employed.

In the drawing two embodiments of the basic idea of the invention are illustrated by way of example, these schemes incorporating likewise the idea of rendering the input end symmetric, indeed, the fundamental idea of this invention deserves special importance in this combination. Fig. 1 is a basic principle embodiment of such an arrangement, while in Fig. 2 several particularly advantageous embodiments or constructional features are shown in a detailed key diagram.

As indicated in Fig. 1, the plates A1 and A2 of the two tubes R1 and R2 are inter-connected by way of two similar ohmic resistances r . The plate potential source B_A is associated to a tap k disposed at the midpoint of this series arrange-

ment, whereas the output transformer U_a at its primary end is united through condensers C with the terminal points of the resistances and thus with the plates A. In this manner the potential of the electrical midpoint of the primary winding of the transformer is fixed, the accuracy of symmetry is governed by the accuracy of the agreement of the two resistances r . When push-pull transformers are used, symmetry is governed by the accuracy of agreement of the properties of the two separate windings (inductances, leakages, self-capacitance, etc.) and the same is therefore substantially less close.

Furthermore the secondary end of the input transformer U_e is connected with a resistance R_g by way of a condenser C' , the two grids G1 and G2 being connected to the two terminals of said resistance R_g . Cathodes K1 and K2 are united with a point inside the resistance R_g , and this way also symmetry of the input is insured to an extensive extent.

Under the assumption that both tubes as well as the balance of circuit elements are perfectly similar, a circuit scheme of this kind would be completely symmetric and free from spurious back-feeds. However, in practice defects and regenerations are introduced owing to the fact that, particularly the tubes, are never absolutely alike.

According to this invention such dissimilarities may be obviated by suitable adjustment or fixing of the terminal contacts upon the input resistance R_g and on the output resistance $r' = 2r$. A circuit scheme in which these features have been adopted and incorporated is illustrated in Fig. 2.

In the first place attention shall be drawn to the advantages obtained by making the terminal k of the plate potential source B_A shiftable upon the resistance r' . The plate currents, in the two branch circuits between k and the two plates A1 and A2 result in drops of potential so that the residual plate potentials are dependent upon the position of the contact or terminal k . Now, if the circuit elements, especially the tubes, present some dissymmetry or another which, if the contact k were set to the exact midpoint of the resistance would result in dissymmetric output currents, then, by suitable selection of the plate potential relation, in other words, by convenient adjustment of the slidable contact k it is possible to eliminate the said effect, seeing that the output alternating current is a function of the plate potential. Arrangement could also be made in such a way that potentials of differ-

ent value for the two tubes are taken from the plate potential source.

Another mode of insuring regulation consists in balancing out such discrepancies as may obtain in the internal resistances of the two tubes by supplementary resistances r_1 and r_2 . In this case the resistance shunting the plates comprises three parts, to the middle one of which the primary of the output transformer U_a is united by way of the two condensers C and which has a constant value. The two outer sections r_1 and r_2 , on the contrary, may be set to any desired value, in fact, they serve for equalizing such discrepancies as may exist in the internal resistances of the tubes.

A similar idea could be used with reference to the input end. In the example illustrated in the Figure, two resistances having different taps are used, in fact, the contacts or connections for the grids G_1 and G_2 , those for the filaments K_1 and K_2 and finally also those for the secondary winding of the input transformer U_e are adjustable ad libitum. This embodiment further shows that the grid biasing potential for both tubes is separately regulable. This disposition makes it possible to neutralize particularly irregularities in the value of $1:\mu$ of the two tubes (cross-grid actions of the plates) and the effects thereof. If in the presence of a perfectly symmetric setting of the ohmic input resistances both tubes are fed with the same alternating current potential, then the inequality of $1:\mu$ has this effect that the ensuing electromotive forces in the plate circuits are unequal. This discrepancy, however, could also be obviated by that the potentials supplied to the grids are altered in this sense that the differences thus caused will compensate the differences in the values of $1:\mu$. The provision of different grid potentials (bias), if desired also of different plate potentials insures also the adjustment of suitable operating points in working characteristics. As can be seen from the key diagram, this combination is readily realizable by suitable adjustment of the contacts. Generally speaking, it is advisable to provide this compensation for both the input as well as the output ends from the outset, and to fix the contacts in such favorable position as may have been ascertained. However, in some instances it may be more advantageous to make some or all of the connections shiftable and to effect compensation from case to case especially when this necessity arises owing to the substitution of a tube or tubes.

It will be obvious that some such schemes of securing symmetry could be adopted also only for the input end, while this may be dispensed with at the output end, this condition being particularly present where no ohmic resistances are used at the output end. The same thing, of course, might arise also for the output end.

Another source of trouble resides in capacitive dissymmetries. In order that these may be obviated as far as feasible it is necessary that the circuit elements comprised in the two paralleled amplifier branches should be made symmetric

not only in electrical but also in spatial (geometric) respect, that is to say, to dispose them symmetrically not only in reference to each other, but also in reference to the neighboring conductors. However, inasmuch as this is practically feasible only to a certain extent, inevitable capacitive dissymmetries can be rendered harmless by capacitive equalization, as shown, for instance, in Fig. 2 by the aid of condensers C'' . The chance of insuring such capacitive equalization is a special advantage of the arrangement of this invention. For when a push-pull amplifier involves inherent irregularities of an electrical nature, in other words, when due to dissimilarities in the resonance curves the push-pull transformer and because of dissimilarities of the tubes the amplifier curves are different both as to amount and phase, such a capacity neutralization or compensation is not practicable.

If it were feasible to secure the conditions hereinbefore described in an absolute sense, then a perfectly non-regenerative push-pull amplifier scheme would be obtained. Although, as will be understood the conditions stipulated can be fulfilled only to an approximate sense, it will be easily understood that a neutralization of ohmic resistances can be secured with a far higher degree of accuracy or closeness than an equalization of transformers or inductance coils, and that as a result the quality of the amplifier here disclosed is far higher than that of arrangements known in the prior art.

What is claimed is:

In an amplification system, in combination, two electron tubes each having cathode, grid and plate electrodes, a source of power connected to said cathode electrodes, a pair of aperiodic input resistors, an aperiodic output resistor, said input resistors being provided with a multiplicity of variable tap connections, two additional output resistors, a source of plate potential, a plurality of condensers, a balanced network including certain of said tap connections wherein said cathode electrodes are connected together and to said input resistors, said cathode electrodes being connected through said source of plate potential to a variable central tap on said output resistor, said grid electrodes being connected to certain of said taps on said input resistors on opposite sides of said cathode taps, each of said plate electrodes being connected through one of said additional output resistors to said output resistor, said two plates being connected to opposite sides of said output resistor through variable taps, input connections including a transformer for said amplifying system connected to certain of said variable input taps on said input resistors through two of said condensers, output connections including a transformer for said amplifying system connected to said output resistor on opposite sides of said central tap thereof through two other of said condensers, whereby the energy supplied to said input connections is amplified and delivered to said output connections substantially without distortion.

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