

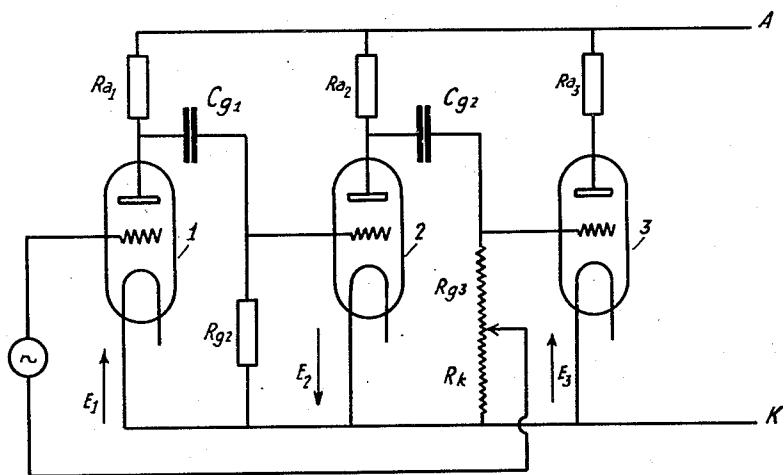
April 16, 1929.

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AMPLIFIER

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AMPLIFIER.

Application filed March 29, 1927, Serial No. 179,282, and in Germany March 27, 1926.

An application for this invention has been filed in Germany, March 27, 1926, No. 73,965.

In order to raise the efficiency of multi-stage resistance coupled amplifiers, resistance coupled amplifiers with back-coupling have been previously disclosed. In most of these schemes, the plate of a given tube is coupled with the grid of a preceding tube by way of a condenser or a resistance. However, arrangements of this kind involve a number of drawbacks. When using condensers for back-coupling, the degree of regenerative coupling and consequently the amplification factor of the arrangement depend markedly upon the frequency of the currents to be transferred so that the amplifier loses its property as a distortionless coupling means.

When using a resistance for regenerative coupling, there arises the difficulty that this resistance, for zero back-coupling, must be of infinitely large size, indeed, that it must be of very large size also for such other reaction coefficients as may be needed in practice (of an order of magnitude of 10^7 ohms). In the presence of resistances of such value, accurate adjustment of the latter is entirely out of the question. Another demerit in the case of a kind of regeneration as hereinbefore referred to is that the tube in question whose plate is in back-coupling relation with the grid of a preceding tube, is connected in parallel to the input resistance of the grid of the first tube, in other words, to the secondary winding of the input transformer at which the controlling electro-motive force is acting, with the result that, on applying the controlling electro-motive forces, currents are set up in the back-coupling circuit so that, upon variation of a resistance, say, the input resistance of the amplifier, even if the controlling electro-motive force is kept at a constant value, undesirable fluctuations of the back-coupling factor are brought about.

Now, the present invention obviates the said drawbacks. This is accomplished by that the back-coupling is not established between plate and grid, but rather between grid and grid, in such a manner that the electro-motive force impressed upon the grid of the first tube is connected in series with the regenerative-coupling element. Branched off from a back-coupling resistance of a tube in series with the ordinary grid leak, direct connection is established in this scheme with the grid of a tube

2, 4, 6 . . . stages below. This latter idea, namely, the omission of the intermediate tube, is resorted to on the ground that the potentials acting at the grid of two adjacent or neighboring tubes presents a phase difference (phase angle) of 180 degrees so that the same is unsuited for back-coupling.

Since in this novel regeneration scheme as hereinbefore outlined no inductive or capacitive reactances whatever are caused to arise (for the back-coupling resistance is free from capacity and inductance actions just like the other plate and grid resistances), this arrangement offers reliable conditions for perfect freedom from frequency dependency and perfect freedom from distortion.

The accompanying drawing by way of example shows an embodiment of this design of regenerative coupling. R_a are the plate resistances of tubes 1 to 3, C_g the coupling condenser, R_g the grid leaks of an ordinary regenerative grid circuit of tube 3, in series with the grid resistance R_{g3} , there is the back-coupling resistance R_k . The point connecting these two resistances by way of the alternating current potential source E whose voltage is to be amplified, is united with the grid of the tube 1.

The following calculation will demonstrate the increase in amplification realizable by means of the foregoing circuit arrangement: Denoting the grid alternating current potentials of the different tubes of the amplifier by E_1, E_2, E_3 (the arrows in the drawing indicating the different directions of the currents at the same instant), and if W denotes the amplification factor of one tube of the regeneratively coupled amplifier, then:

$$E_2 = -W.E_1$$

and

$$E_3 = +W^2.E_1$$

Application of the grid back-coupling in the way as here shown then results in a growth in grid potential of the first tube to:

$$E'_1 = E_1 + E_3 \cdot \frac{R_k}{R_g + R_k}$$

The increase in resistance in the first grid circuit (E_1) by the value of the back-coupling resistance " R_k " may be disregarded in the calculation. Then, by adding the successive outputs of the amplifier due to the successive feed backs, for regenerative amplification the re-

sultant output is given by a convergent series whose sum may be shown to be equal to:

$$E_3 = E_1 \cdot \frac{W^2}{1 - \left(\frac{R_k}{R_g + R_k} \right) \cdot W^2}$$

As an example shall be cited the conditions for an amplifier tube resulting in an amplification factor=7, in the presence of a grid leak of $R_g=60000$ ohm. The first two tubes, in the absence of back-coupling ($R_k=0$), then result in a potential amplification of $7 \times 7=49$. Choosing a back-coupling resistance $R_k=1200$ ohm, then, in the light of Equation (3), the potential amplification of the first two tubes becomes:

$$\frac{49}{1 - \frac{1200}{61200} \times 49} = 1225$$

as contrasted with 49 without regeneration. For one stage, this means an amplification of

$$W = \sqrt{1225} = 35.$$

Hence, by means of regeneration it is possible to insure just as large an amplification as with transformer-coupled amplifiers, though the advantage is obtained over the transformer-coupling scheme that operation is largely free from distortion.

If the alternating current potential of a current source is to be amplified and if one of the poles of the source is grounded, then, since the latter is not united with any filament, a convenient plan is to insert a transformer between the potential source and the input circuit of the amplifier.

I claim as my invention:

1. A regenerative system comprising a plu-

rality of thermionic tubes, the feed back circuit of said system comprising a substantially pure resistance connection from the grid circuit of one tube to the input side of a preceding tube.

2. A regenerative system comprising a plurality of vacuum tubes, the input circuit of said system comprising in series, a portion of the grid leak resistance of one of the grid circuits of one of the tubes of the system.

3. A regenerative system comprising a plurality of vacuum tubes and a variable portion of the grid leak of one of the tubes in series with the input of a tube a multiple of two stages preceding the said one tube.

4. A regenerative system comprising a plurality of resistance coupled vacuum tubes, a pair of grids of separate tubes being conductively connected together for providing a regenerative feed back, the grids so connected together having controlling potentials of the same sign at any given instant.

5. A regenerative resistance coupled amplifier system comprising a first vacuum tube, a second vacuum tube and a third vacuum tube, the input to the first tube being fed through a variable portion of a resistance in series with the grid of the third tube.

6. A regenerative system comprising a plurality of vacuum tubes and a connection between two of the tubes of the system for feeding back energy from one to the other of said two tubes, said connection connecting the grids of the two tubes.

7. In a system for amplifying electrical impulses, a plurality of resistance coupled vacuum tubes, and conductive coupling means between two grids of two of the tubes for providing a regenerative feed back.

HANS MAYER.

Certificate of Correction

Patent No. 1,709,360.

Granted April 16, 1929, to

HANS MAYER

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 1, strike out lines 75 and 76 and insert instead the syllable and words *densers, R_g the grid leaks of an ordinary resistance-capacity amplifier arrangement.* In, and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 11th day of February, A. D. 1930.

[SEAL.]

M. J. MOORE,

Acting Commissioner of Patents.

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