Dec. 19, 1939. G. M. WRIGHT 2,183,731

ELECTRON DISCHARGE DEVICE AMPLIFIER

Filed June 6, 1936

Fig. 1

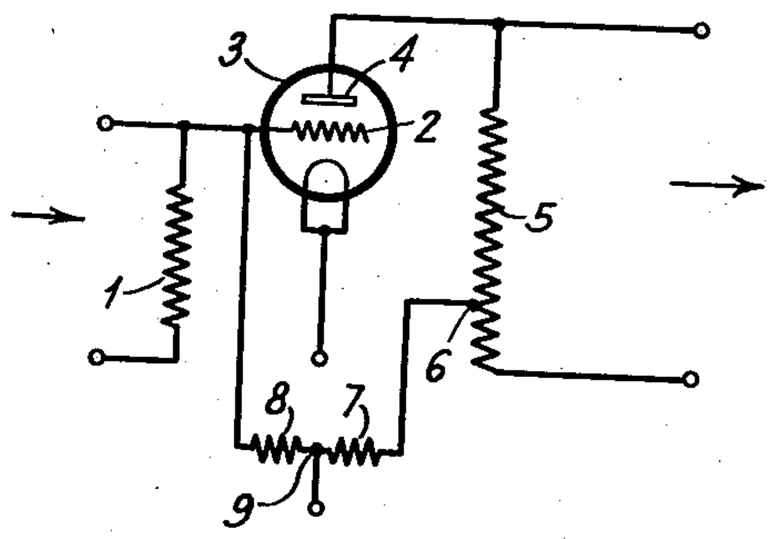
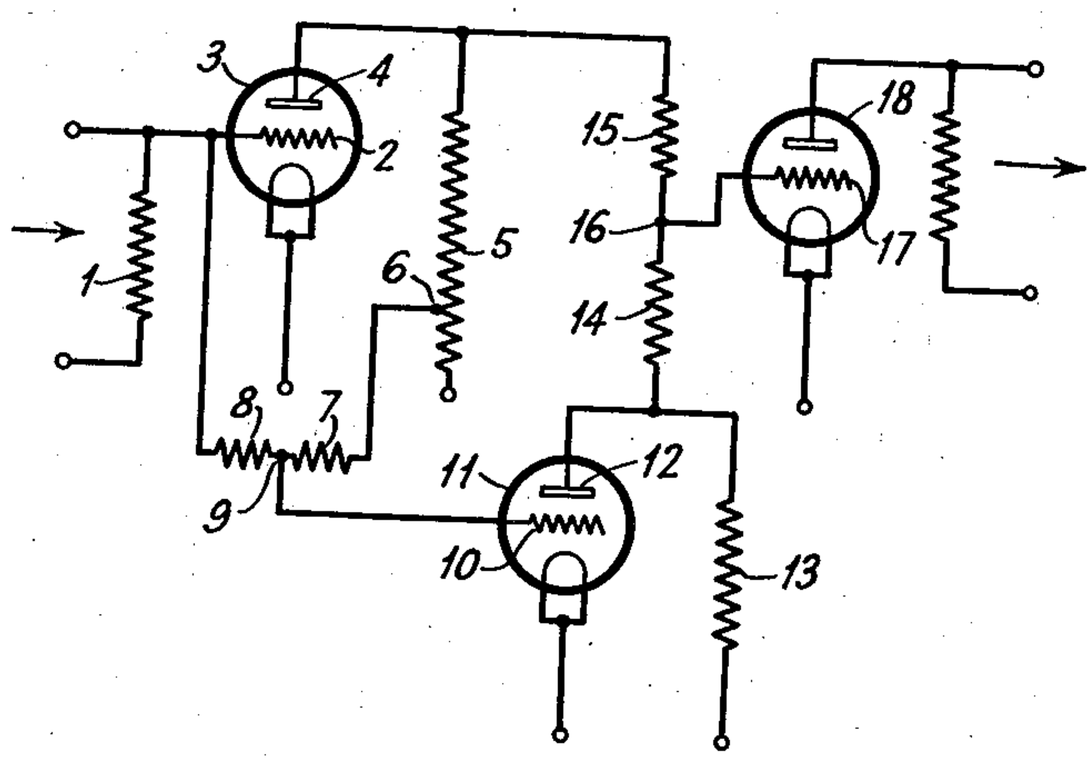


Fig. 2



INVENTOR
GEORGE MAURICE WRIGHT
BY
ATTORNEY

Patented Dec. 19, 1939 2,183,731

UNITED STATES PATENT OFFICE

2,183,731

ELECTRON DISCHARGE DEVICE AMPLIFIER

George Maurice Wright, Woodham Ferrers, England, assignor to Radio Corporation of America, a corporation of Delaware

Application June 6, 1936, Serial No. 83,872
In Great Britain June 21, 1935

6 Claims. (Cl. 179—171)

This invention relates to electron discharge device amplifiers and has for its object to provide improved and simple thermionic valve amplifiers wherein non-rectilinear distortion due to curvature of the characteristic of an amplifier valve or valves employed is substantially completely compensated for, while at the same time high magnification is obtained.

It is, of course, normally required from a thermionic valve amplifier that it shall reproduce in its output circuit variations of voltage current or power (as the case may be) which accurately correspond to but which are on a magnified scale with relation to variations applied to the input circuit. It is, however, well known that the characteristic curves of thermionic valves as at present available are not absolutely rectilinear, but are more or less curved, and this curvature if left uncorrected for, results in what may be termed non-rectilinear distortion. In the case of speech current and similar low frequency amplifiers the distortion gives rise to the production of spurious and unwanted frequencies higher than the input frequencies, while in the case of high frequency amplifiers, such as carrier frequency amplifiers for radio signalling, the distortion leads to the introduction of undesired harmonics. In both cases intermodulation effects occur between different frequencies present simultaneously.

The difficulties above referred to are well known and various expedients have been resorted to with the object of correcting for the valve characteristic curvature which is the cause of the difficulties in question. So far as the present applicant is aware, however, known proposals with this object in view, have either been undesirably complex or have involved serious loss of amplification (as compared to the amplification which would be obtained were there no correction) or have not provided substantially complete correction. For example, it is known in thermionic valve amplifiers to derive from the output circuit of the amplifier energy proportional to departures from rectilinearity occasioned by said amplifier and to employ the distortion energy components thus obtained to supplement the input energy proper in such manner as to tend to correct for the distortion. As will be appreciated, however, this expedient cannot theoretically produce complete correction (and in practice unless elaborate precautions be taken the correction provided is generally considerably short of that necessary) for it will be realized that with this expedient no correction is applied to the input circuit unless distortion is already present in the output circuit.

According to this invention energy corresponding to departures from rectilinearity by a valve amplifier is separated out from the output circuit of said amplifier and is applied at a point subsequent to the input circuit thereof in such manner and to such a degree as substantially to compensate for the distortion introduced. In this way the actual output is in effect itself supplemented in the required sense and to the required degree to cause the total output to be a substantially accurate replica on a magnified scale of the input. The invention is thus distinct from the known correcting arrangements wherein correction is applied as a supplement to the input energy of a valve stage introducing the distortion, for in carrying out the present invention it is not this input energy which is supplemented but the output energy.

In the drawing, Figure 1 illustrates schematically a circuit diagram used in explaining the invention; and,

Figure 2 is a diagrammatic representation of a preferred embodiment of the invention shown in Figure 1.

In order that the method of operation of a preferred embodiment to be described later herein may be the better understood consider first the case shown diagrammatically in the accompanying Figure 1 of a simple triode amplifier in which the input and output impedances are ohmic resistances. In the case to be considered input energy is applied across an input resistance 1 one end of which is connected to the grid 2 of the valve 3. The anode 4 of the valve is connected to one end of an output resistance 5 from the terminals of which output energy is taken. A tapping 6 upon this last resistance is connected through two equal resistances 7, 8, in series to the grid of the triode. For the sake of simplicity only the essential impedances of the circuit are shown and bias and other necessary circuits have been omitted.

Now if in the circuit of Figure 1 the valve amplification is completely rectilinear in character the output variations set up across the output resistance 5 will be an exact copy on a magnified scale of the input variations applied across the input resistance 1 and will, of course, be in opposite phase. Let the ratio of these output variations to these input variations be m. It is therefore possible to select the tapping point 6 in such manner that a fall of potential at this said point will exactly equal a causative rise in

input potential at the grid of the valve and vice versa, and for this result the position of the tapping point 6 should be so selected that the ratio of the whole output resistance 5 to the portion between the said tapping point and the end of the said resistance remote from the anode is equal to m. Accordingly if the tapping point be so selected, since the said tapping point is connected to the grid through two equal resistances 7, 8, the mid-point 9 between these two equal resistances will remain at a steady potential irrespective of the input and output variations assuming, of course, that the said two equal resistances are of large value as compared to the input and output resistances 1 and 5. If, however, as in practice is the case, the valve characteristic is not completely rectilinear the point between the two equal resistances, which point may be termed the neutral point, will not remain at a steady potential, but will fluctuate to an extent which is a measure of the departure from rectilinearity of the valve characteristic. It is these fluctuations in potential of a neutral point which are utilized in the preferred method of carrying out the invention for adding to the output the necessary correction. It should be noted that since in the circuit just described by way of explanatory example, the neutral point 9 is between two equal resistances 7, 8, the distortion components appearing at the said neutral point will be in the ratio of

$$\frac{1}{2m}$$

to the distortion components appearing across the output resistance 5.

In the preferred embodiment of this invention illustrated in the accompanying Figure 2 the above described explanatory circuit is taken as the starting point and the neutral point 9 is connected to the grid of an auxiliary valve 11 arranged to have a magnification of $2m$. The anode 12 of this valve is connected to a suitable source of anode potential (not shown) through a resistance 13 the voltage fluctuations across which will accordingly be equal to the distortion variations set up across the resistance 5. The anode 12 is connected to the anode 4 of the valve 3 through two large equal resistances 14, 15, the junction joint 16 between which is connected to the grid 17 of a succeeding valve 18. It will be seen, therefore, that providing the resistance 14, 15, are large as compared with resistance 1, 5, the grid 17 will not vary in potential due to distortion components and the valve 18 will receive an accurate copy, magnified by

$$\frac{m}{2}$$

of the input variations applied across resistance 1.

For the sake of convenience only those portions of the circuits necessary for an understanding of the invention have been referred to in the preceding description and shown in the drawing. It will, however, be understood that in practice blocking or coupling condensers must be introduced at all points where static differences of potential (due to anode and grid bias sources) occur and grid leaks must be introduced where grids which would otherwise be insulated occur.

The illustrated arrangement of Figure 2 will be found to give ample correction for most practical purposes, since correction for non-rectilinearity of characteristic on the part of the valve 3 is obtained. There will, of course, still remain uncorrected second order non-rectilinearities due to curvature of characteristic on the part of the valve 11. Generally such second order non-rectilinearities will be too small to matter in practice but if in any case, further correction is required, the method of the invention may be applied to obtain correction for non-rectilinearity on the part of the valve 11 also.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:

1. In combination a thermionic valve having an effective magnification (ignoring departures from rectilinearity of characteristic) m; an impedance in the anode circuit of said valve; a tap on said impedance such that the ratio of said impedance to the portion thereof on the side of the tap remote from the anode is m; a high resistance between said tap and the input grid of said valve; an auxiliary valve arranged to have a magnification factor $2m$; a connection between the mid-point of said high resistance and the input grid of said auxiliary valve; a second high resistance between the anode of said auxiliary valve and the anode of the first mentioned valve; means for applying signals to be amplified to the input grid of said first mentioned valve; and means for taking off corrected amplified signals from the mid-point of said second high resistance.

2. In amplifying apparatus, an electronic tube having an input electrode and an output electrode, said tube having a characteristic certain portions of which depart from a straight line whereby there are introduced into the energy fed through the tube certain distortion components which correspond to the departures from rectilinearity of the tube characteristic, resistance means connected between the output electrode and input electrode of the tube for comparing the output voltage of the tube with the input voltage thereto and producing a potential which is substantially proportional to the distortion component present in the output of the tube, a load circuit connected to said output electrode and means connected between said first named means and the load circuit for impressing upon the load circuit said derived potential in opposite sense to the distortion component present in the output of said tube whereby the distortion component present in the energy fed from the output to the load circuit is substantially balanced out in the load circuit.

3. In a relay circuit, a space discharge device having an anode, a cathode and an input grid electrode, an anode circuit for said tube including a load impedance element, a tap on said load impedance, a high resistance between said tap and the input grid electrode, an auxiliary space discharge device having an anode, a cathode and a grid electrode, a connection between the midpoint of the high resistance and the grid electrode of said second named space discharge device, a second high resistance element connected between the anode of said second named space discharge device and the anode of the first named space discharge device, means for applying signalling energy to the input grid electrode of said first space discharge device, a load circuit provided with an input terminal and means for connecting said input terminal from the midpoint of said second named high resistance element.

4. An arrangement as described in the next preceding claim characterized by that said load circuit comprises a thermionic tube having an anode, a cathode and a grid electrode and by that

the input terminal which is connected to the midpoint of the second named high resistance element is connected to the grid of the last named tube.

5. In amplifying apparatus, an electronic tube amplifier having an input circuit and an output circuit, a potentiometer device connected between said circuits, a second electronic tube having an input circuit and an output circuit, said last named input circuit being energized from a point on said potentiometer at which no voltage exists in the presence of undistorted amplified signals in the output circuit of said first named tube, a utilization device connected both to the output circuit of the first tube and to the output circuit of the second tube, said connections being so adjusted that any amplified products of distortion in the output of the second tube transfer equal and opposite effects to said utilization device as the distortion transferred thereto by said first tube.

6. In a relay circuit, a space discharge device having an anode, a cathode and an input electrode, an anode circuit for said tube including a load impedance element, a tap on said load impedance, a high resistance between said tap and the input grid electrode, an auxiliary space discharge device having an anode, a cathode and a grid electrode, means for connecting the grid electrode of said second named space discharge device to an intermediate point of said high resistance, a second high resistance element connected between the anode of the second named space discharge device and the anode of the first named device, means for applying signalling energy to the input electrode of said first device, a load circuit provided with an input terminal, and means for connecting said input terminal to an intermediate point of the second named high resistance element.

GEORGE MAURICE WRIGHT.