

Jan. 7, 1941.

W. KUMMERER

2,227,505

MODULATION DISTORTION CORRECTION

Original Filed Oct. 31, 1933

2 Sheets-Sheet 1

Fig. 1

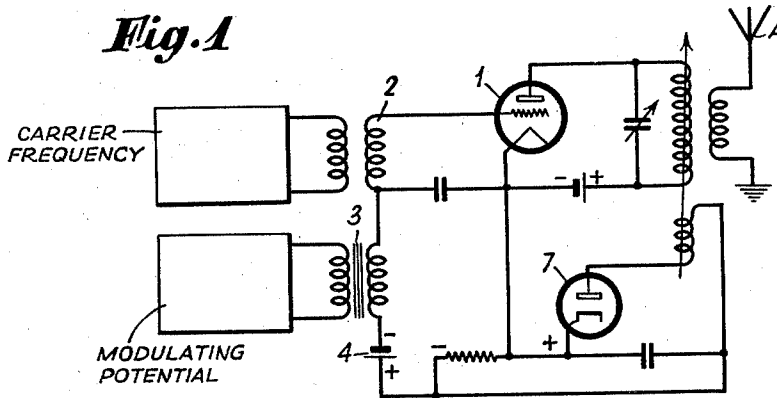


Fig. 2

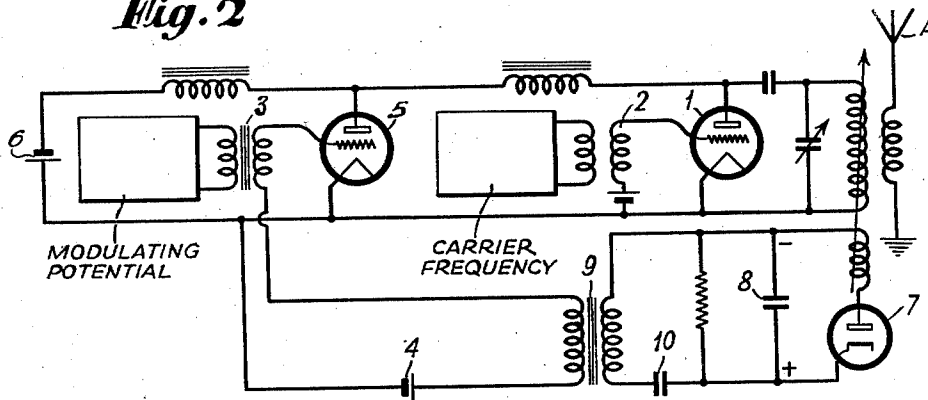
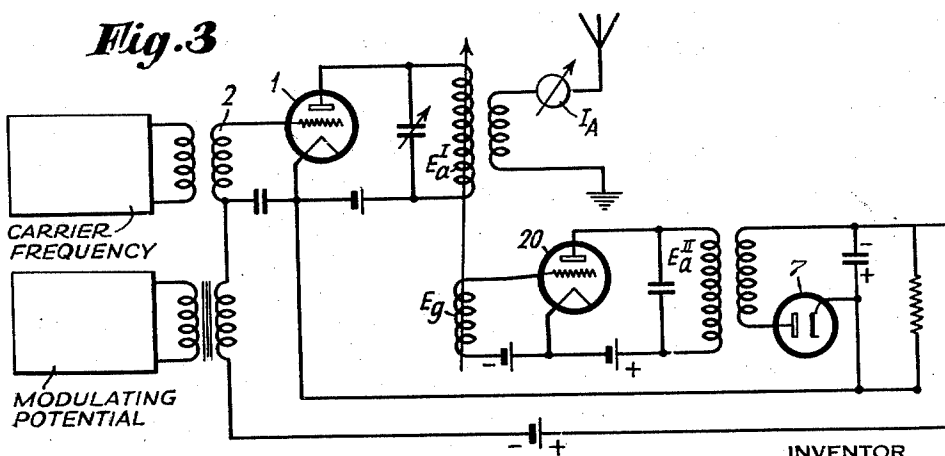


Fig. 3



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Fig. 4

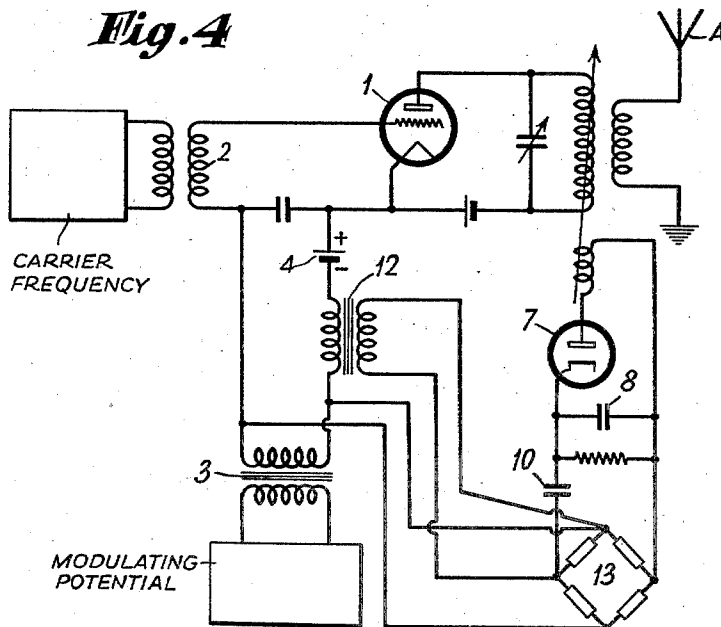
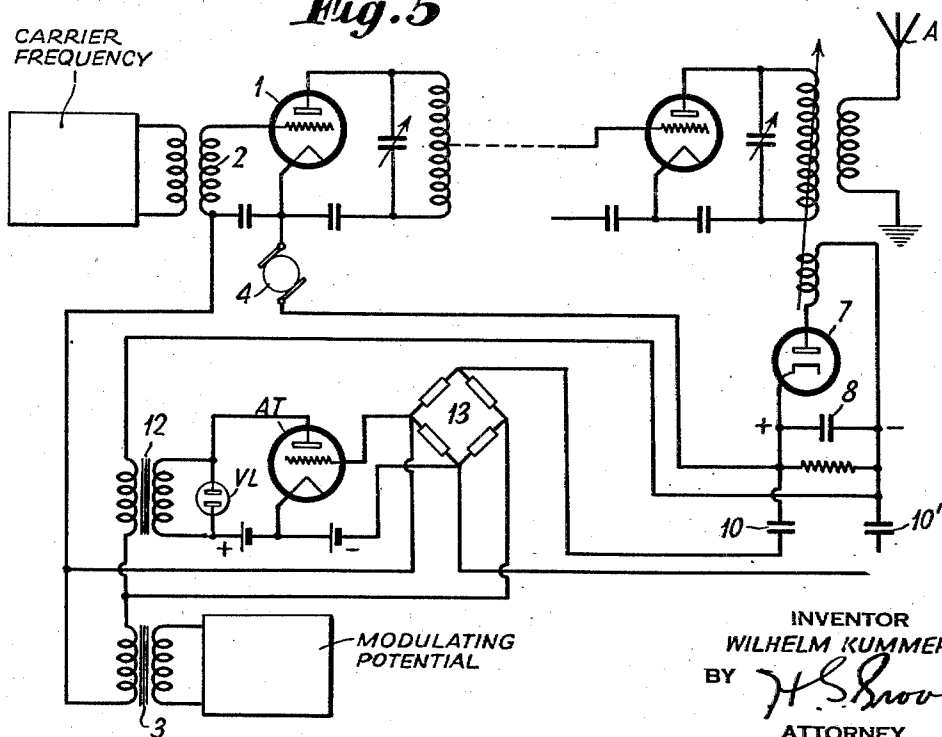


Fig. 5



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MODULATION DISTORTION CORRECTION

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Original application October 31, 1933, Serial No.
695,968. Divided and this application Febru-
ary 15, 1939, Serial No. 256,444

4 Claims. (Cl. 179—171.5)

British Patent #323,823 shows an arrangement wherein the distortions caused by the curvature of the tube characteristic and other factors (such as "slighting" of certain frequencies) may be compensated by anti-regeneration (degeneration) coupling from the output circuit to the input circuit of the said amplifier tube. By the aid of such anti-regeneration, the gain or amplification of the tube is diminished, yet it is feasible in this manner to straighten and at the same time flatten the characteristic curve of the system, thereby diminishing distortion. The distortion compensation justifies the loss in gain involved in many cases.

Now, when this known method is applied to valve or tube transmitters, in other words, if anti-regenerative coupling by the modulated oscillations is established from the output to the input, spurious feed-backs will be set up and these cause disturbing or interfering oscillations to be produced. It is known that radio frequency feed-back, upon reversal of phase, nearly always results in a feed-back at a frequency which is generally different from the working frequency with the result that oscillations of this particular undesired frequency are produced in the circuits and are hard to eliminate. These difficulties arise also in the case of a circuit organization as disclosed in British Pat. #172,389, which shows means to modulate by anti-regeneration produced with modulated radio frequency oscillations.

Another demerit residing in anti-regeneration by means of the modulated radio frequency wave itself is that the radio frequency grid alternating voltage furnished from the preceding transmitter stage, because of anti-regeneration reducing the gain or amplification, must be kept at a higher level so that, in the presence of grid current flow, the "control" power required for full utilization of the degeneratively coupled tube is appreciable.

Now, according to this invention, which is a division of my United States application #695,968, filed October 31, 1933, all of the advantages described above can be had by merely raising the modulating potential amplitude. The present invention which also obviates the difficulties outlined above consists in effecting degeneration by means of the audio frequency component or, optionally, also by means of the direct current component which are obtained by rectification of the modulated radio frequency oscillations, while the radio frequency is filtered

out so that it cannot produce spurious feed-back. In types of modulation in which, by means of varying the negative grid bias, the modulation curve can be statically recorded, for instance, in the case of direct grid current or grid voltage modulation, it is usually advisable not to suppress the direct potential portion. This insures that fluctuations in the line voltage entail lesser variations in the antenna current. If, however, the counter coupling is applied to the grid of a tube serving for the amplification of the modulated wave, fluctuations in the high frequency current of the oscillatory circuit should not cause any static displacement of the working point of the amplifier tube and in this case only the alternating current component of the rectifier voltage is utilized for the countercoupling.

The novel features of my invention have been pointed out with particularity in the claims appended hereto.

The nature of my invention and the mode of operation thereof will be better understood from the following detailed description thereof and therefrom when read in connection with the drawings, throughout which like reference characters indicate like parts, and in which:

Figures 1, 2, 3, 4 and 5 show various circuit arrangements including the features of my novel invention.

Figure 1 shows an embodiment of the invention by way of example for a modulating stage with grid voltage modulation. Here tube 1 is a high frequency amplifier to which a high frequency grid potential of constant amplitudes is applied. 7 designates the rectifier tube coupled to the modulated wave output circuit of tube 1, 3 is the modulation frequency transformer to which the audio frequency alternating potential is applied, and 4 is the direct current source supplying the required bias for the grid of tube 1. In the absence of my novel correction scheme and in the presence of normal modulation action the resultant modulation voltage envelope of the carrier wave may be distorted. This distortion will be apparent in a cathode ray oscillograph coupled to the output of tube 1. As pointed out more in detail hereinafter, the distortion may be due to high modulating potentials which swing the grid of tube 1 so that the tube operates on the curved portion of its characteristic curve, thus resulting in flattening of the radio frequency wave peaks. The distortion may also be due to non-linearity of the action of the tube when it is operating on the straight portion of

its characteristic. This non-linearity may result in the peaks of the modulation envelope or the carrier wave being extended or shortened. The countercoupled direct current voltage supplied by rectifier 7 carries a superposed audio frequency alternating current voltage and both voltages are supplied to the input of 1 to oppose the modulating potentials which cause the distortions, thereby limiting the distortion.

Figure 2 shows an arrangement in which plate voltage modulation according to the known Heising method is accomplished. Here, as in Fig. 1, 1 is the high frequency amplifier, to which a high frequency grid voltage of constant amplitude is applied through the coupling coil 2. 5 represents a modulating tube. The grid of tube 5 is negatively biased by means of current source 4 and through transformer 3 there is supplied thereto the alternating audio frequency potential serving for modulation. A plate current source 6 for amplifier 1 and modulator 5 is connected as shown between the anode and cathode of said tubes. 7 is the rectifier tube for the countercoupling circuit coupled to the output circuit of the high frequency oscillator. The alternating audio frequency voltage across the terminals of the condenser 8 at the output of the rectifier when modulating potentials are impressed on the carrier is supplied to the grid circuit of the modulating tube 5 by means of the transformer 9 so that countercoupling is produced. Blocking condenser 10 blocks the direct current voltage out of the primary winding of the transformer 9.

Between the modulated stage 1 and the antenna circuit A one or several high frequency amplifier stages may be connected in the known manner, and the countercoupling to the modulated stage may be carried out from any desired amplifier stage.

The counter coupling reduces the existing distortions to a fraction of the original ones. A complete linearity cannot be obtained through countercoupling. In order to obtain an essential reduction of the distortions, the degree of the counter coupling, i. e. the proportion between the countercoupling voltage and the voltage required for modulation must be chosen large, however this increase of the countercoupling must not be extended too far else difficulties in dimensioning will be encountered. If the hereby obtained reduction of distortion is insufficient, the action of the countercoupling can be essentially augmented by means of inserting between the high frequency stage for which distortions are to be reduced, and the linear rectifier, a high frequency amplifier stage in which the amplification takes a non-linear course.

Figure 3 shows an embodiment of this idea by way of example, in a transmitter modulated according to the principle of grid potential modulation. Here 1 is the high frequency amplifier of transmitter stage, which is to be modulated, 20 designates the amplifier tube of the high frequency amplifier stage connected between the high frequency amplifier 1 and the rectifier. 3 is the rectifier tube. Otherwise the arrangement corresponds with the circuit of Figure 1.

The counter or differential coupling reduces existing distortions to a fraction of their original value. However, perfect linearity is unattainable in this manner because the operation of a countercoupling scheme is based upon the presence of modulation potential amplitudes which extend into the curved portion of the modulation

characteristic, whereby flattening of the peaks of the modulated radio frequency alternating potential occurs because of this very curvature. Because of the countercoupling of the rectified modulated radio frequency distorted in this manner, it will be noted that a correction voltage lower than the voltage from which it is produced is caused to become operative in a sense opposite to the sense of the modulating potentials at the instance when the curvature of the modulation characteristic is reached, with the result that the modulation voltage is distorted. Thus, a less distorted modulated radio frequency voltage arises in the output circuit of the radio frequency circuit of stage 1. Hence, the voltage used for the countercoupling must always be distorted. Inasmuch as according to the described methods it is obtained from the modulated radio frequency energy existing in the output circuit of tube 1, the same normally will be distorted and this is the aim of the present circuit scheme. The more correction of distortion obtained by the countercoupling, the higher the countercoupled correction voltage used must be. The modulation voltage will also have to be higher in order that an adequate grid modulation voltage may be secured in spite of counter action of the countercoupled correcting potentials. Hence, complete correction of distortion will be attainable only in the presence of infinitely high amplitudes of the modulation potential as well as of the countercoupled voltage acting in opposition. Practical limits are imposed upon the correction of distortion.

Now, according to another object of this invention, the requisite distortion of the alternating potential serving for the countercoupling is obtained by the aid of a distinct amplifier stage having a non-linear characteristic, the characteristic of the said stage being similar in form to the characteristic of the transmitter. In such an arrangement as will be seen, a distorted voltage for countercoupling and differential purposes will be available when a perfect voltage free of distortion is available in the radio frequency amplifier stage 1, due to the distorting effect of the countercoupling. In fact, it would be feasible in this manner to accomplish overcompensation.

In using the countercoupling of the present invention it is obvious that the alternating voltage serving for the modulation, must be increased by the value of the countercoupling voltage. In case of intensive countercoupling this is often held to be detrimental. It is possible to avoid this drawback by applying the modulating voltage in opposition to the correcting voltage furnished by the rectifier to the countercoupling. This may be done by means of a bridging arrangement known as such, so that in case of a modulating curve the course of which follows a straight line and in the presence of proper phase relation between the voltages, the voltage supplied by the rectifier and the modulating voltage to the bridge circuit eliminate each other. This leaves only the voltages produced by distortions in the modulation process utilized for reducing distortions.

Figure 4 shows an embodiment of the modification described above. Here 1 is again the high frequency amplifier in which modulation takes place, 7 is the rectifier tube. The alternating audio frequency voltage of the linear rectifier, which is blocked against direct current voltage by condenser 10 is applied to the two corner points of bridge 13, while to the other two corners of 75

the bridge, the modulation input voltage supplied by transformer 3 is applied. Both alternating voltages are made equal. The voltage resulting from the distortions is taken from one arm of the bridge in which the difference of the two applied voltages appears and this voltage is connected by transformer 12 to the input of tube 1 in opposition to the modulating voltage from transformer 3.

10 In Figure 5 a circuit is shown in which, by utilizing a bridging circuit, as in Figure 4, also a static countercoupling takes place.

Such coupling is often desired in view of reduction of the steepness of the modulation curve and the hereby entailed greater stability of the plate current at fluctuations of the operating means and of the antenna. Thus the circuits according to Figures 3 and 4 are combined in such manner that on the one hand a countercoupling to the input circuit of tube 1 occurs across the transformer 12 in series with transformer 3 also connected to the corners of bridge 13 as in Fig. 4, while on the other hand the resistance passed by the output current of rectifier 7, by which static countercoupling is effected, is connected in series as in Fig. 3 with the grid bias source 4 of tube 1. An amplifying tube AT may be included in the circuit between the arm of 13 and the primary of 12. Voltage limiting means VL may be coupled across the output of AT.

Having thus described my invention and the operation thereof, what I claim is:

1. Signalling means comprising, a thermionic relay tube having input and output electrodes and input and output radio-frequency circuits connected therewith, a source of oscillations of carrier frequency connected with said input circuit, a source of modulating potentials, two modulation potential impedances connected in series between a pair of electrodes in said tube, means for impressing modulating potentials from said source of modulating potentials on one of said impedances, a bridge circuit, said bridge circuit having pairs of nodal points, a circuit connecting said one of said impedances to one of said pairs of nodal points, a rectifier coupling another pair of said nodal points to the output circuit of said

relay tube, and a circuit coupling an arm of said bridge circuit to the other of said impedances.

2. In a modulation system an electron discharge device having input electrodes and output electrodes coupled in alternating current circuits in which wave energy to be modulated is caused to flow, a source of modulating potentials, two modulation potential impedances connected in series between the input electrodes of said discharge device, means for impressing modulating potentials from said source of modulating potentials on one of said impedances, and means for improving the linearity of said modulation comprising a bridge circuit having pairs of nodal points connected by impedance arms, rectifier means having electrodes excited by wave energy from the output electrodes of said device, a resistance connected with said rectifier electrodes, means coupling said resistance to a pair of said nodal points, means for impressing modulating potentials on another pair of said nodal points and means for impressing potentials from one of the impedance arms of said bridge on the other of said modulation potential impedances.

3. A system as recited in claim 1 wherein said last named means includes potential amplifying means.

4. Signalling means comprising, a thermionic relay tube having input and output electrodes coupled in alternating-current circuits in which wave energy to be modulated is caused to flow, a source of modulating potentials, two modulation potential impedances and a resistance connected in series between a pair of electrodes in said tube, means for impressing modulating potentials on one of said impedances, a bridge circuit having pairs of nodal points, means for impressing modulating potentials on a pair of said pairs of nodal points, a rectifier having electrodes excited by wave energy from the output electrodes of said tube, means coupling electrodes of said rectifier to another pair of said pairs of nodal points, means connecting an arm of said bridge to the other of said modulation potential impedances, and means coupling electrodes of said rectifier in shunt to said resistance.

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