

April 16, 1940.

J. W. CONKLIN

2,197,124

OSCILLATOR WITH AMPLIFIER COUPLING

Filed April 30, 1937

Fig. 1.

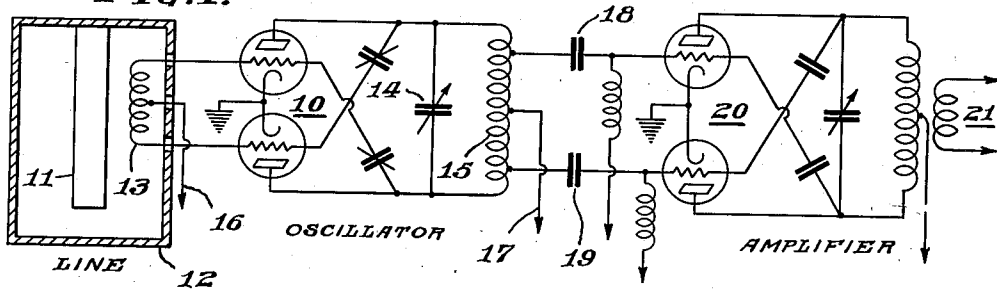


Fig. 2.

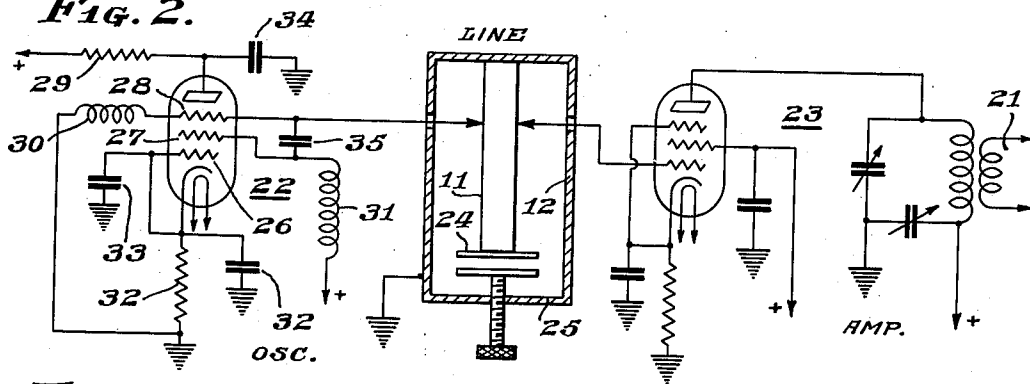


Fig. 3.

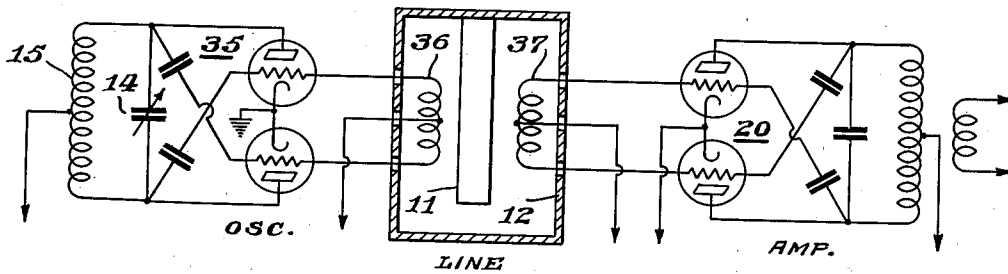
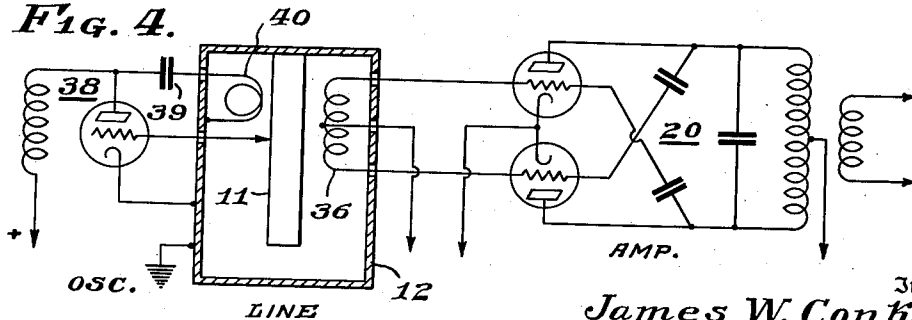


Fig. 4.



Inventor
James W. Conklin

James W. Conklin

Attorney

UNITED STATES PATENT OFFICE

2,197,124

OSCILLATOR WITH AMPLIFIER COUPLING

James W. Conklin, Audubon, N. J., assignor to
Radio Corporation of America, a corporation
of Delaware

Application April 30, 1937, Serial No. 139,839

3 Claims. (Cl. 250—36)

This invention relates to radio transmitting and receiving systems which involve the use of a resonant concentric circuit for controlling the operating frequency of an oscillation generator, and has for its principal object the provision of an improved arrangement and method of operation whereby the generator frequency is rendered independent of variations or adjustments in the amplifiers to which the generator is coupled.

More particularly, the invention involves the use of a resonant concentric circuit for the dual purpose of stabilizing the generator frequency and coupling the generator to the amplifier into which it feeds. Prior to the present invention, it was customary to couple the concentric circuit or line to the oscillator input circuit and to provide the oscillator output with a tank circuit through which the oscillator was coupled to the amplifier. The present invention is based on the discovery that utilization of the concentric line in the oscillator output as a means of stabilizing the oscillator frequency and coupling the oscillator to the amplifier has the advantages of (1) improving the frequency stability for a given line, (2) permitting the oscillator controls to be fixed so that there are no operating controls having an important effect on frequency, (3) permitting greater flexibility in design due to the fact that the oscillator tube is not required to perform a dual function, and (4) generally improving the performance of the system.

The invention will be better understood from the following description when considered in connection with the accompanying drawing, and its scope is indicated by the appended claims.

Referring to the drawing,

Figure 1 is a wiring diagram of the conventional combined oscillator and amplifier circuit heretofore utilized,

Figure 2 is a wiring diagram of the improved oscillator-amplifier system as applied to a generator of the negative transconductance type, and

Figures 3 and 4 are similar diagrams of modified embodiments of the invention.

The well known system of Fig. 1 includes a cross-neutralized oscillator 10, which is provided with an input circuit including concentric conductors 11 and 12 between which is interposed an input winding 13, and with an output circuit including a tank circuit composed of a parallel connected capacitor 14 and winding 15. Suitable potentials are applied to the oscillator input and output circuits, respectively, through leads 16 and 17, the cathodes being connected to the grounded side of the power supply line. In the oscillator

the neutralizing condensers are used for regeneration control.

Coupled to the winding 15, through coupling capacitors 18 and 19, is a cross-neutralized tuned push-pull amplifier 20 which is provided with an output winding 21.

The primary function of the oscillator tank circuit formed by capacitor 14 and inductor 15 is to provide a storage circuit of oscillatory power at the operating frequency for supplying the load requirements, the driving power for the succeeding amplifier in the present illustration. A secondary function of the tank circuit is to provide a plate circuit impedance incidental to the operation of the oscillator. Particularly in a radio transmitter, where the succeeding amplifier may be modulated or otherwise subjected to conditions which may affect the loading imposed on the oscillator tank circuit, it is necessary that the circulating energy in the oscillator tank circuit be large compared to the load supplied, in order that the load variations shall not greatly affect the frequency and/or the oscillation stability of the oscillator.

It is well known to the art that in oscillator circuits employing frequency stabilizing or control means of the low power factor type, such as a piezo-electric crystal or a concentric resonant line, it is desirable that the circulating or stored energy be confined primarily to the stabilizing devices. In the prior art, particularly in high power ultra-high frequency oscillators of the resonant line controlled type, it has been necessary, for reasons explained in the foregoing description, to have considerable circulating energy in the oscillator tank circuit, represented by elements 14 and 15 of Fig. 1, which results in an undesired division of the primary frequency determination between line 11 and tank circuit 14 and 15. To confine the primary oscillator frequency control to line 11, the tank circuit 14 and 15 would preferably have low energy storage and be of the "broadly" tuning type.

As indicated above, this system leaves something to be desired in that operation of the generator 10 is not altogether independent of changes in the operating conditions or adjustments of the amplifier 20. The present invention avoids this difficulty by transferring the concentric line 11—12 to the oscillator output circuit, where it functions both as the oscillator tank circuit and as a coupling between the oscillator output and amplifier input circuits.

In the prior art practice, it has been considered of prime importance to minimize the load coupled

to the control line, in order to obtain a high "Q" circuit with maximum frequency stability, and the method of my invention would have been considered improper, as it couples several devices, including the load circuit, to the control line.

To prove the merit of my invention, let E_1 and E_2 represent the total circulating energy present in the control line 11—12 and the oscillator tank circuit 14—15, respectively, referring to Fig. 1. Also let W_1 and W_2 represent the coupled load to these respective circuits, W_1 representing the oscillator grid losses and line losses, and W_2 representing the output load or amplifier grid excitation power. Now it is a fact that the virtue of the line in controlling frequency is in one sense due to the rapidity with which the phase angle between the input voltage and current changes when the frequency changes. This rate of change of phase is inversely proportional to the power factor which, in the present case, is equal to

$$\frac{W_1}{E_1}$$

Similarly, the power factor of the tank circuit is equal to

$$\frac{W_2}{E_2}$$

Now in the case of a high power ultra-high frequency oscillator, where the oscillator and amplifier will likely be similar, W_2 will probably equal W_1 and E_2 will necessarily be of the same order as E_1 ; therefore,

$$\frac{W_1}{E_1}$$

and

$$\frac{W_2}{E_2}$$

will be of the same order. Thus, we have two low power factor circuits associated with the oscillator, both capable of having a primary effect on frequency, whereas it is really desired that the line be the sole determinant of frequency.

Now, in the method of my invention, I confine, insofar as is possible, the entire circulating energy associated with the oscillator circuit to the frequency control line, so that the circulating energy of the line is now substantially $E_1 + E_2$, and the load or real power, $W_1 + W_2$. Now, W_1 and W_2 and E_1 and E_2 are in practical cases of the same order of magnitude respectively. Therefore, the power factor

$$\frac{W_1 + W_2}{E_1 + E_2}$$

of the control circuit will be of the same order as

$$\frac{W_1}{E_1}$$

In other words, the method of my invention does not lessen the merit of the control line in stabilizing the oscillator frequency. Further, by no longer requiring high energy storage in the oscillator plate tank circuit or relieving the need of any additional tank circuit for load coupling purposes, it is possible to make the line a true primary frequency control.

Thus, in the system of Fig. 2, an oscillator 22 includes in its output circuit the concentric line or resonant circuit 11—12, which also serves to couple the oscillator output circuit to an amplifier 23 and which may be provided with relatively adjustable plates 24 and 25 for adjusting its capacity. The oscillator 22 is of the negative transconductance type which is characterized by the

fact that its output current varies inversely as the input voltages. It includes an inner grid 26 which functions as a suppressor grid, a second grid 27 which is subjected to a potential higher than that of the plate and functions as an anode, and an outer grid 28 which functions as the control grid of the oscillator. It will be noted that a resistor 29 is provided for reducing the plate voltage and limiting the plate current, that choke coils 30 and 31 are provided in the input and output circuits, that a resistor 32 is interposed in the cathode lead, and that by-pass capacitors are provided at various points in the oscillator circuits. Coupling between the input and output circuits may be effected in part by a capacitor 35 or altogether by the interelectrode capacity of the oscillator tube which may be of the RCA-954 type.

When such a pentode tube is used as a negative-transconductance tube, the grid 26 is operated at zero or slightly negative potential, the grid 27 at high positive potential, the grid 28 at negative potential, and the plate at low positive potential. Under these conditions, the grid 27 functions as the primary anode, but, it being a mesh structure, part of the electrons pass through and are attracted to the slightly positive plate. If the interposed grid 28 be given a sufficiently negative charge to overcome the velocity of the electrons, they will return to the screen grid, resulting in an increased screen current. Considering the grid 27 as the anode and the grid 28 as the control electrode, the resulting transconductance is negative, i. e., within the range of operation, the anode current decreases when the control electrode is made more positive. Utilized as an oscillator, this permits a two-terminal tuned circuit, the grid 28 being directly coupled to the grid 27 through the capacitor 35.

It will be observed that the negative-transconductance action consists largely of an interchange of current between the plate and the grid 27. This interchange is not complete, however, as part of the returning electrons again pass through the grid 27, with the result that the increase in grid current is slightly less than the decrease in plate current as the grid 28 is made more negative. Further, while the control grid 26 plays no part in the normal action, it may be used to control the space current, with a resulting great effect on the negative resistance and amplitude of oscillations produced by the tube.

The oscillator output potential is applied to the concentric circuit 11—12, which is tuned to the output frequency either by its structural dimensions or by adjustment of the plates 24—25 and which also functions to couple the oscillator output circuit to the input circuit of the amplifier 23, with the advantages previously discussed.

The system of Fig. 3 differs from that of Fig. 2 in that it includes a cross-neutralized oscillator 35 of the push-pull triode type, provided with an output winding 36 interposed in the oscillator grid circuits and located between the concentric conductors 11 and 12. The oscillator tank circuit 14—15 is of the low energy storage, broadly tuning type. Coupling between the oscillator 35 and the amplifier 20 is effected by means of an amplifier input winding which is immersed in the field induced between the conductors 11 and 12 by the current of the oscillator output coil 36.

The system of Fig. 4 differs from that of Fig. 3 in that the output circuit of a single tube oscillator 38 is connected between the concentric con-

ductors 11 and 12 and coupling between the oscillator input and output circuits is effected by means of a capacitor 39 and a coil 40 located between the conductors 11 and 12.

5 It will, of course, be apparent that the invention is applicable to other types of oscillators likely to be adversely affected by reaction from an amplifier to which they are coupled.

I claim as my invention:

10 1. In a stabilized oscillator-amplifier, the combination which includes a thermionic discharge device, a resonant line stabilizer, means coupling said discharge device and said stabilizer for generating and controlling the frequency of ultra
15 high frequency oscillations, a radio frequency amplifier tuned to the frequency of said oscillations, and means coupling said amplifier directly to said line so that the concentration of circulating energy in said stabilizer provides energy to
20 drive said amplifier and to control the frequency of said oscillations in the presence of changes in the load presented by said amplifier to said oscillator.

25 2. In a stabilized oscillator-amplifier, a concentric line resonator, a thermionic discharge

tube, means coupling said discharge tube and said line so that sustained oscillations are produced whose frequency is maintained at a predetermined value corresponding to the resonant frequency of said line, a load device comprising
5 a radio frequency amplifier tuned to the frequency of said oscillations, means directly coupling said load device to said concentric line resonator so that the concentration of circulating currents in said resonator provides frequency stabilization
10 and reduces the effect of changes in said load on said oscillations.

3. In a stabilized oscillator-amplifier, a thermionic tube having grid cathode and anode electrodes, a resonant line stabilizer, means coupling
15 said stabilizer to said grid electrode, means including said tube and stabilizer for generating ultra high frequency oscillations whose frequency is determined by said stabilizer, an amplifier
20 tuned to said high frequency oscillations provided with input and output circuits, and means coupling said amplifier input circuits directly to said stabilizer for impressing oscillations on said amplifier.

JAMES W. CONKLIN. 25