

Aug. 11, 1942.

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2,292,798

OSCILLATOR CIRCUIT

Filed July 13, 1939

Fig. 1

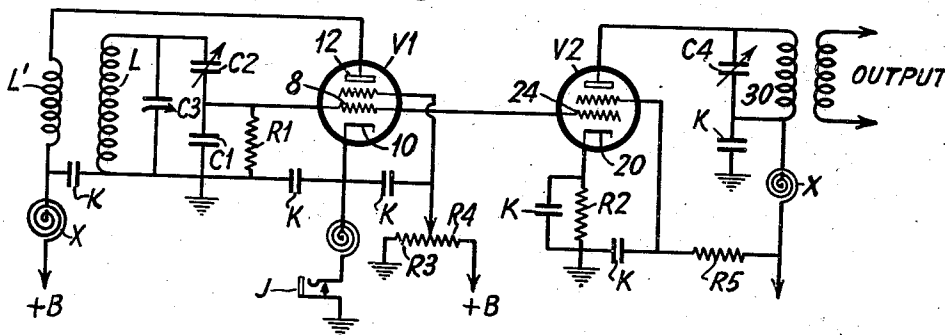


Fig. 2

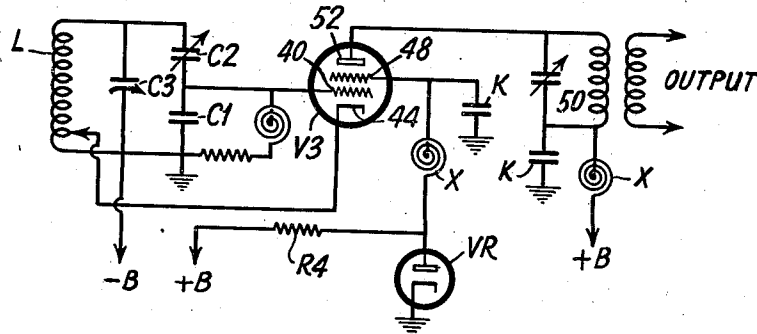
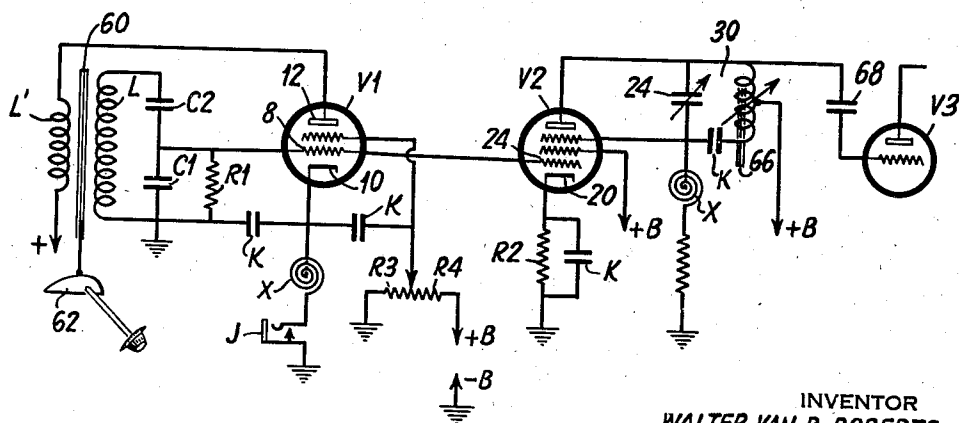


Fig. 3



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2,292,798

OSCILLATOR CIRCUIT

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Application July 13, 1939, Serial No. 284,193

7 Claims. (Cl. 250—36)

This invention relates to an oscillator circuit having as little frequency dependence as possible upon variations of effective impedances between tube electrodes.

It has been recognized for some time that the variation of oscillator frequency with changes of impedance between tube electrodes from whatever cause, may be reduced by using extremely large values of capacity in the frequency determining resonant circuit. This practice has been explained by stating that variations in tube capacity are thus made extremely small in comparison with the circuit capacity. The drawback to this method of improving oscillator stability is that it calls for extremely large values of capacity which are not readily obtainable in a variable condenser of reasonable dimensions. If large capacities are obtained by fairly large plates and extremely close spacing then the microphonic effects of mechanical vibration become serious. On the other hand, unless the frequency determining circuit is given as large a capacity as is possible while still permitting oscillations to be generated, the advantages of the method are not fully exploited.

The object of the present invention is to provide an oscillator circuit having the maximum frequency stability that can be obtained with a given physical size of coil while permitting the variable condenser to be chosen of any desired capacity and at the same time to provide a feedback arrangement free of parasitic modes of oscillation.

It may be demonstrated mathematically that the effect upon frequency of a given variation in a tube capacity is independent of the choice of capacity used in the frequency determining circuit provided that in every case a coil of the same ratio of inductance to resistance is used, it being assumed that the condenser is relatively loss-free, and further provided that the couplings between the tuned circuit and the input and output electrodes of the tube are chosen only sufficient to produce oscillations. Since the ratio of inductance to resistance of a coil is determined to a large extent by its physical dimensions and not by its inductance, it will be seen that with a given physical size of coil it is not necessary to use a small inductance and large capacity to produce a stable oscillator. Exactly as much stability may be obtained by using a stiffer circuit having a coil of similar dimensions and employing sufficiently reduced couplings between the circuit and the tube. Unfortunately, however, when it is attempted to reduce these cou-

plings by the simple expedient, for example, of tapping the grid, cathode and plate at points closely adjacent and in the order named along the inductance of a tuned circuit, parasitic oscillations of relatively high frequency arise in a manner well known. Similarly, parasitic oscillations also arise where the grid circuit and plate circuit each include a coil, each of which is inductively coupled with the tuned circuit. It is also known that these parasitic oscillations can be prevented by the insertion of sufficiently large resistances in the parasitic circuits. However, this reduces the tendency to oscillate at the desired frequency, and hence by requiring increased couplings to produce oscillation, reduces the frequency stability. In accordance with the present invention, such parasitic oscillations are avoided while retaining the advantages of loose coupling by employing a capacity coupling between one pair of tube electrodes and the resonant circuit and an inductive coupling between the other pair of tube electrodes and the resonant circuit. The result of using the two kinds of couplings is to eliminate the chief parasitic modes of oscillation, leaving only such ultra high frequency parasitics possible as may occur on the leads to the tubes themselves, and these latter parasitics are not likely to occur with any tube used ordinarily as an oscillation generator and even if they do occur are relatively easily suppressed by the use of resistances or chokes too small to have any appreciable influence upon the fundamental frequency.

Fig. 1 shows an oscillation generator and output amplifier in accordance with the invention;

Fig. 2 shows an adaptation of a known circuit, to render it capable of attaining the objects of the invention;

Fig. 3 shows an inductively tuned oscillator in accordance with the invention.

In Fig. 1 coil L is chosen to have any value required to cooperate with convenient values of condensers C3 and C2. C1 is chosen very large compared to C2 so that the effect of C1 upon the resonant frequency is small. The range of frequencies over which the oscillator may be tuned by means of C3 is determined by the relative value of the maximum capacity of C3 and the capacity C2. Thus, C3 and C2 may be determined to fit the requirements of range of tuning and convenience of dimensions for these condensers. C1 is made of the order of 10 to 100 times C2. Thus, only a very small fraction of the total voltage developed across the coil L is impressed between the grid 8 and cathode 10 of

the tube V1. The output circuit of the tube, comprising anode 12, inductance L', by-pass condenser K and cathode 10, is coupled to coil L magnetically. When using a screen grid tube having high internal plate impedance, it is desirable to make the coupling between the plate circuit and the tuned circuit somewhat tighter than that between the tuned circuit and the grid circuit since impedance variations in the plate circuit of the tube are likely to be less than in the grid circuit of the tube. By way of illustration, I have found satisfactory constants for the oscillation generating portion of Fig. 1 to be as follows:

C3= 50 mmf.
C2= 100 mmf.
C1=2000 mmf.

L is a coil $2\frac{1}{4}$ " in diameter, 2" long, and having 40 turns of wire wound with about one half of one wire diameter spacing between turns. L' is 4 turns wound over the lower end of coil L. Using a 6V6 tube this oscillator can be keyed at the jack J while exciting the subsequent amplifier V2 with no more noticeable chirp or drift in frequency as observed by listening to a harmonic at about 30 mc. than a crystal controlled oscillator with which it was compared. In order to minimize any reaction from the load circuit upon the oscillator, a separate tube V2 is employed in Fig. 1. Cathode self bias is used to cause this tube to draw normal plate current in the absence of excitation. This bias is obtained by resistance R2, shunted by by-pass condenser K, connected between the cathode 20 and ground. The grid 24 of V2 may be loosely coupled to the oscillation circuit in any desired manner, but for simplicity, I prefer to connect this grid directly to the grid 8 of tube V1 whereby the total bias of tube V2 is always greater than that of tube V1 by the amount of drop through cathode resistor R2. In this way the grid loss of tube V2 may be kept smaller at all times than the necessary grid loss in the oscillator so that the loading on the oscillator is negligible. If tube V2 and its output circuit 30 are thoroughly shielded the output circuit may be tuned to the same frequency as the oscillator without appreciable effect upon the oscillator frequency. What little effect there may be can be greatly reduced by tuning the output circuit of tube V2 to a harmonic of the oscillator frequency.

For greatest possible frequency stability it is, of course, desirable to employ known expedients such as optimum electrode voltages, regulated sources of voltages, isolating all heat producing elements from the tuned circuit, making the oscillatory circuit elements as rigid and non-vibratory as possible, and utilizing as V1 a tube having the greatest transconductance together with the least variation in its interelectrode capacities. And finally, in any case, condenser C1 should be made as large as possible consistent with sufficient strength of oscillation to produce satisfactory output.

Fig. 2 shows the invention applied to the well-known so-called electron coupled oscillator. This oscillator comprises a tube V3 having its grid 40, cathode 44, and screen grid 48 connected in regenerative oscillation generation circuits. As far as the fundamental frequency of oscillation is concerned, the behavior is exactly the same as that which would be expected of the usual arrangement (where the grid and cathode are connected across the inductance) if in the latter the

grid connection were brought down from the top of the coil to a position only slightly above the cathode connection. However, since the grid is connected to a point between two condensers C2 and C1 for reasons pointed out in detail in connection with Fig. 1, the arrangement shown in Fig. 2 is free of the parasitic oscillations that occur when the grid is connected to the coil at a point below its top. The produced oscillations appear in the tank circuit 50 connected to the anode 52. As the electron coupled oscillator is of the nature of a triode oscillator circuit with respect to the generation of oscillations, it is perhaps slightly inferior to the screen grid oscillator of Fig. 1 with respect to stability, and for this reason I prefer to include in the direct current supply circuit for the screen grid 48 a voltage regulator tube VR in shunt to that portion of the source connected between the screen grid 48 and cathode 44.

It has been mentioned that the frequency stability of the oscillator depends on the ratio of inductance to resistance of the oscillator coil, that is, on its absolute selectivity. Furthermore, in the case where the fundamental oscillator frequency is multiplied to obtain a higher frequency output wave, the actual number of cycles shift in the frequency of the output wave produced by a given capacity change in the oscillator tube is inversely proportional to the inductance to resistance ratio as measured at the fundamental frequency. Thus the optimum frequency to choose for an oscillator, regardless of the amount of frequency multiplication that may be required to obtain the desired output frequency, is that frequency for which a coil of maximum ratio of inductance to resistance is obtainable. (This is a lower frequency than would be chosen if the coil were to be of maximum "Q".) Now, if for the purpose of improving the stability, I choose an oscillator frequency that is very low, for example in the lowest radio or even the higher audio-frequency range, it becomes impractical to employ variable condensers for tuning on account of their large size and microphonic effects. Therefore, there is shown in Fig. 3 an arrangement employing only fixed condensers and using a moving magnetic core for tuning. This core may be so shaped as to cover a desired range of frequencies, and its composition, that is whether of ordinary thin laminations or of fine iron dust or magnetite, will be chosen in accordance with the frequency employed. It will, of course, be necessary to multiply the frequency of such an oscillator as shown in Fig. 3 many times if a high frequency output is desired, but if each stage, by the aid of regeneration at its output frequency (as indicated in Fig. 3) multiplies the frequency by a considerable factor such as 5, a relatively few stages will give an enormous total multiplication.

Referring more in detail to Fig. 3, the oscillation generator comprising tube V1 and its associated circuits is substantially the same as that shown in Fig. 1 except as otherwise noted hereinbefore and hereinafter. The condensers C1 and C2 are fixed. Tuning is accomplished by moving the core 60 in the field of coupled inductances L and L' by any means such as, for example, a cam 62. The tuning condenser C3 of Fig. 1 is omitted from the circuit of Fig. 3.

As in Fig. 1 a coupling and amplifying tube V2 has its grid 24 connected directly to the grid 8 of tube V1. The tube V2 in the present case

generally is operated as a frequency multiplier and since the fundamental frequency developed in VI is relatively low, the output circuit 30 tuned by a core 66 is tuned to a harmonic of a higher order. The oscillating voltages set up in 30 may be impressed by coupling condenser 68 on the grid of an additional frequency multiplier V3 followed, if desired, by still other multipliers.

What is claimed is:

1. In an oscillation generator, a tunable circuit including an inductance coil and a relatively large condenser and relatively small condenser connected in series across said inductance coil, said large condenser being at least ten times as large as said small condenser, a vacuum tube having input electrodes including a grid and cathode and having an anode, means connecting the input electrodes of said tube in shunt to said relatively large condenser, an inductance in an anode circuit for said tube, there being mutual inductance between said anode circuit inductance and said inductance coil, said mutual inductance being substantially less than said coil inductance, whereby the resulting reactances effective between grid and cathode and between anode and cathode are dissimilar in sign at the frequencies of modes of oscillation other than the desired oscillations.

2. An oscillation generator as recited in claim 1 wherein the mutual reactance between the anode circuit and the coil is greater than the reactance of said relatively large condenser.

3. In an oscillation generator, a tube having input and output electrodes, a coil, a pair of fixed capacities in series connected across said coil, one of said capacities being at least ten times as large as the other, means connecting the input electrodes of said tube in shunt to said one capacity, an output circuit connected with said output electrodes and inductively coupled to said input electrodes, and means for varying the frequency of oscillation of said tube and circuits comprising a movable magnetic core in said coil.

4. In a system for providing oscillations of substantially constant desired frequency, a frequency determining circuit comprising an inductance shunted by a relatively large condenser and a relatively small condenser in series, the ratio of the capacities of said condensers being at least ten to one, an electron discharge tube having a cathode and a plurality of cold electrodes, means coupling said large condenser between one cold electrode and said cathode, and an inductance connected between another cold electrode and said cathode and coupled to said first inductance, said two couplings providing substantially the minimum amount of feedback necessary to the maintenance of reliable oscillations in said tube and circuit.

5. In a system for providing oscillations of a substantially constant desired frequency, a frequency determining circuit comprising an inductance shunted by a capacity potentiometer, said potentiometer comprising in series a pair of capacities of ratio at least ten to one, an electron discharge tube having a cathode and a plurality of cold electrodes, means coupling the large capacity portion of the capacity potentiometer between one cold electrode and said cathode, an inductance connected between another cold electrode and said cathode and coupled to said first inductance, said two couplings providing substantially the minimum amount of feedback necessary to the maintenance of reliable oscillations in said tube and circuit.

6. An oscillation generator including an electron discharge tube having input and output circuits whose impedances vary undesirably by different amounts, and a tuned circuit including an inductance and capacity, said inductance being proportioned to have substantially the maximum ratio of inductance to resistance consistent with a permissible maximum physical dimension, means for coupling the output circuit of said tube to said tuned circuit, and means for coupling the input circuit of said tube to said tuned circuit, said couplings being the minimum couplings which will produce reliable oscillations, and the coupling of said tuned circuit to the one of said first two named circuits which has the greater undesired impedance variation being smaller than the coupling to the other of said first named circuits.

7. An oscillation generator including an electron discharge tube having input and output circuits whose impedances vary undesirably by different amounts, and a tuned circuit including an inductance and capacity, said inductance being proportioned to have substantially the maximum ratio of inductance to resistance consistent with a permissible maximum physical dimension, said inductance and capacity being dimensioned to make the fundamental frequency of oscillation of said generator so low that further reduction thereof produces relatively little further improvement in said ratio of inductance to resistance, means for coupling the output circuit of said tube to said tuned circuit, and means for coupling the input circuit of said tube to said tuned circuit, said couplings being the minimum couplings which will produce reliable oscillations, and the coupling of said tuned circuit to the one of said first two named circuits which has the greater undesired impedance variation being smaller than the coupling to the other of said first named circuits.

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