July 12, 1949. L. W. HERSHINGER 2,476,090

RELAXATION OSCILLATOR

Filed March 9, 1948 2 Sheets-Sheet 1

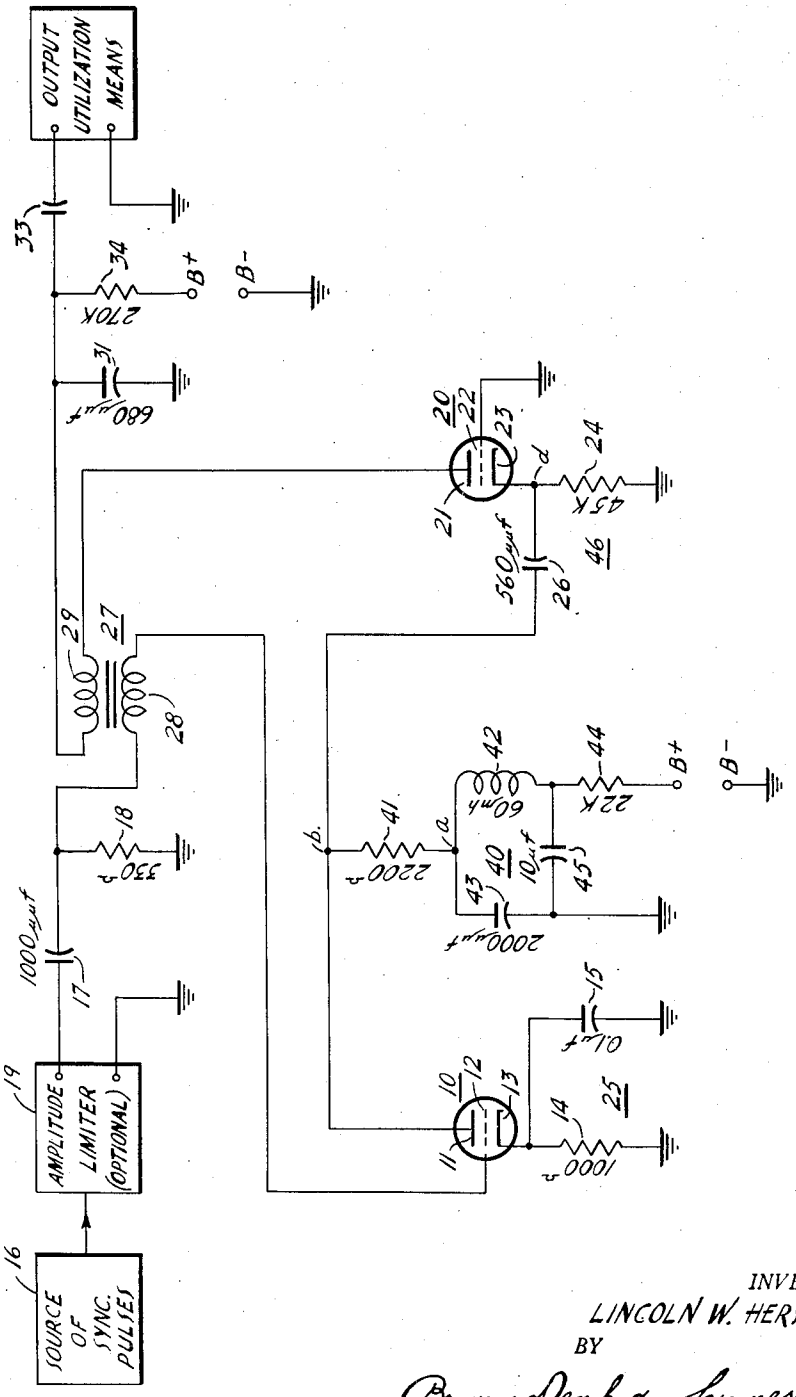


FIG. 1.

INVENTOR.
LINCOLN W. HERSHINGER
BY
Brown, Denk & Synnestvedt
AGENTS

July 12, 1949. L. W. HERSHINGER 2,476,090

RELAXATION OSCILLATOR

Filed March 9, 1948 2 Sheets-Sheet 2

FIG. 2a.



FIG. 2b.

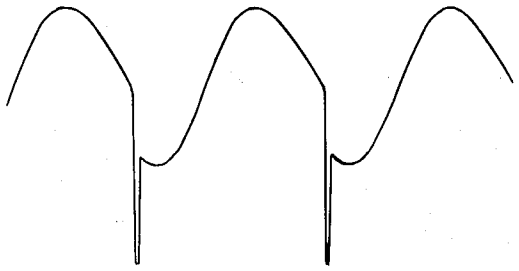


FIG. 2c.

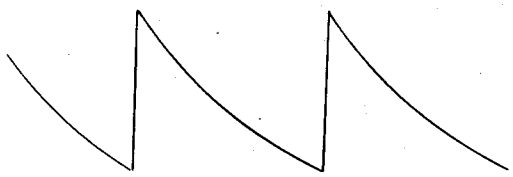
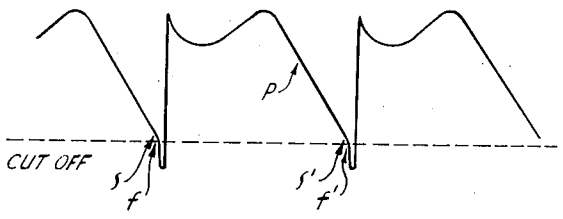


FIG. 2d.



TIME

INVENTOR.
LINCOLN W. HERSHINGER
BY
Brown, Denk & Synnestvedt
AGENTS

Patented July 12, 1949

2,476,090

UNITED STATES PATENT OFFICE

2,476,090

RELAXATION OSCILLATOR

Lincoln W. Hershinger, Oreland, Pa., assignor to Philco Corporation, Philadelphia, Pa., a corporation of Pennsylvania

Application March 9, 1948, Serial No. 13,931

10 Claims. (Cl. 250—36)

1

The invention herein described and claimed relates to a relaxation oscillator of improved frequency stability. More particularly, the present invention provides an improved blocking tube oscillator whose free-running frequency is inherently very stable, being substantially unaffected, for example, by variations in plate voltage. Such variations in plate voltage may be caused either by an unregulated plate voltage supply or may be caused by adjustments made manually to the D.-C. plate voltage to control, for example, the amplitude of the oscillator's output voltage.

Due to the inherent stability of my improved circuit when operating as a free-running blocking tube oscillator, I am able to lock-in the oscillator, in frequency and in phase, with regularly recurring trigger pulses of substantially smaller amplitude than have heretofore been required to effect dependable synchronization. Consequently, in a preferred circuit arrangement, suitable means are included for limiting to a small value the amplitude of the synchronizing pulses. The amplitude of noise pulses are then also limited to a small value. This is very advantageous in that the period of time during which the improved circuit is responsive to noise pulses, when operating as a synchronized blocking tube oscillator, is reduced to an extremely small interval relative to that obtaining in prior art synchronized oscillators. This will become clear as the description proceeds.

It is a broad object of this invention to provide a relaxation oscillator of improved frequency stability.

It is another object of this invention to provide a synchronized blocking tube oscillator whose frequency is stabilized against variations in plate voltage and against electrical noise disturbances.

It is a more specific object of this invention to provide a blocking tube oscillator capable of being synchronized in a dependable manner with regularly-recurring trigger pulses of substantially smaller amplitude than have heretofore been required to insure satisfactory synchronization or lock-in.

Another object of this invention is to provide a blocking tube oscillator of excellent frequency stability adapted for use in the deflection circuits, particularly the horizontal deflection circuits, of a television receiver.

These and other objects, advantages, and features of the present invention, and the manner in which the objects are attained, will become

2

clear from a consideration of the following detailed description and accompanying drawing in which:

Figure 1 is a schematic representation of a preferred form of my improved blocking tube oscillator shown in the environment of the deflection system of a television receiver, and

Figures 2*a*—2*d* are graphical representations of various voltage waveforms which will be helpful in explaining and understanding the present invention.

Referring now to Figure 1, a blocking tube oscillator embodying the present invention is shown to comprise a first triode 10 and a second triode 20. Plate 11 of first triode 10 is coupled, by way of capacitor 26, to cathode 23 of second triode 20, cathode 23 being connected to ground by way of a cathode load resistor 24. Coupling capacitor 26 and cathode load resistor 24 together form a network 46 whose RC time constant is one of the factors which determines the free-running frequency of the improved blocking tube oscillator, as will be described.

Plate 21 of second triode 20 is connected, by way of the primary winding 29 of transformer 27 and resistor 34, to a source of positive plate voltage, B+. A bypass capacitor 31 is connected between the plate end of resistor 34 and ground. Where the output of the improved blocking tube oscillator is intended to be a sawtooth voltage, as is ordinarily the case where the oscillator is employed in the deflection system of a television receiver, capacitor 31 is the element across which the sawtooth output voltage is developed in conventional manner. In Figure 1, the sawtooth output voltage is shown to be applied, by way of coupling capacitor 33, to output utilization means 35.

The plate-cathode output circuit of second triode 20 is inductively coupled, by means of transformer 27, to the grid-cathode circuit of first triode 10. In the circuit shown in Figure 1, a source 16 of synchronizing pulses is also coupled to the grid-cathode circuit of tube 10 by way of an amplitude limiter circuit 19, a series capacitor 17, a shunt load resistor 18, and the secondary winding 28 of transformer 27. The employment of an amplitude limiter circuit 19 is preferable but not essential. Load resistor 18 is preferably of small value in order that the synchronizing and noise pulse voltages developed thereacross may be of small magnitude. Cathode resistor 14 and capacitor 15 comprise a cathode biasing network 25 for first triode 10. It is to be understood that, when my improved circuit is employed as

a free-running blocking tube oscillator, the connection of source 16 to grid 12 is not made, in which case the low potential end of secondary winding 28 is connected directly to ground.

In accordance with the present invention, the plate-cathode output circuit of first triode 10 includes, in addition to the branch previously described (comprising coupling capacitor 26 and cathode load resistor 24), another branch which includes a load resistor 41, and an LC network 40 comprising an inductance 42 in shunt with a capacitance 43. Capacitance 45 is a large bypass capacitor. The low potential ends of inductance 42 and capacitance 43 are consequently at ground potential with respect to the operating frequency of the oscillator. The low potential end of inductance 42 is connected, by way of a voltage-dropping resistor 44, to a source of plate supply voltage, B+.

The operation of my improved blocking tube oscillator will now be described. It will facilitate the description to assume that the circuit is in oscillation. It will further facilitate the first portion of the description to assume that the circuit is operating as a free-running blocking tube oscillator without application of synchronizing pulses to either tube 10 or tube 20.

The description will begin at that point in the cycle of operation at which tube 20 fires. When tube 20 goes into conduction, plate current flows through primary winding 29 of transformer 27 and the potential at the plate end of winding 29 drops sharply. A pulse of positive voltage is thereupon induced, by well known transformer action, at the grid end of secondary winding 28. This positive pulse appears, of course, at grid 12 of tube 10. The constants of the cathode biasing network 25 may, if desired, be such as to permit some plate current to flow in tube 10 prior to the time the said pulse arrives at grid 12. When the pulse appears on grid 12, the plate current of tube 10 increases sharply, the potential of plate 11 drops sharply, and the potential of cathode 23 of second triode 20 drops in a corresponding manner. The plate current of tube 20 then increases still further. The potential of plate 21 becomes more negative, the induced voltage at the grid end of winding 28 becomes more positive, and the plate current through tube 10 undergoes a further increase. This action is cumulative and continues until the plate current in second triode 20 reaches its maximum value. This plate current will not remain constant at its maximum value because the cathode and plate potentials of tube 20 will change due to the charging of capacitor 26 by the cathode current of tube 20 and the failure of primary inductance 29 to sustain a constant voltage across its terminals. Consequently, after reaching its maximum value, the plate current of tube 20 will start to decrease. This decrease results in a decrease in the positive voltage applied to grid 12, an increase in the voltage at plate 11, an increase in voltage at cathode 23, and a further decrease in the plate current of tube 20. This action is cumulative, as before, and continues sharply until tube 20 ceases to conduct. In general practice, the conduction periods of tubes 10 and 20 are short compared to the non-conduction periods.

Neglecting for the moment the effect of LC network 40, it will be seen that second tube 20 will remain in a non-conductive state until the positive charge which developed on capacitor 26 during conduction leaks off sufficiently to lower the potential of cathode 23 below the cutoff point

(equivalent to raising the grid potential above the cutoff point), whereupon tube 20 will again conduct. The cycle of operation described above is then repeated. The action thus far described is believed to be sufficiently similar to that which takes place in a conventional single-tube blocking oscillator to make description in greater detail unnecessary.

The important effect of LC network 40 and of resistor 41 upon the operation of the circuit will now be considered. The present invention proposes that, as a preferred matter, inductance 42 and capacitance 43, which form LC network 40, be so chosen that network 40 will be resonant at a fundamental frequency which is slightly lower than the frequency at which the blocking tube oscillator is desired to operate as a free-running device. If desired, the constants may be so chosen that network 40 is resonant to a multiple of the said fundamental frequency.

The pulse of current which flows, as previously described, into plate 11 of tube 10 passes through the resonant circuit 40. Resonant circuit 40 is then shock excited by the pulse and a sine wave voltage is thus developed across the network. When network 40 is tuned to a frequency slightly lower than the free-running operating frequency of the blocking oscillator, as is preferred, LC network 40 is shock excited once during the negative-going portion of each cycle, just prior to the occurrence of the negative peak of the sine wave.

The waveform of the voltage developed across LC network 40, i. e. at point *a* in Figure 1, is shown in Figure 2*a*. When second tube 20 fires, a pulse of plate current from first tube 10 flows into capacitor 43 to replace the energy lost during the sine-wave oscillation. The voltage at point *a* thereupon drops rather sharply, the magnitude of the drop, relative to the amplitude of the sine wave, being a function of the Q-factor of resonant circuit 40. In Figure 2*a*, the sharp drop in the potential of point *a* is indicated by the steep slope just prior to the occurrence of the negative peaks.

The pulse of plate current from tube 10, which flows into capacitor 43 when second tube 20 fires, develops a pulse voltage across resistor 41, which is negative at the plate end. The waveform of the voltage at point *b* in the circuit of Figure 1 is consequently as shown in Figure 2*b*. It will be seen that waveform 2*b* comprises the sine waveform 2*a*, developed across LC network 40, in combination with the negative pulse of voltage developed across resistor 41 when second tube 20 fires and first tube 10 conducts strongly.

The waveform shown in Figure 2*b* is applied, by way of capacitor 26, to cathode 23 of second tube 20. There, waveform 2*b* combines with an exponential sawtooth voltage component 2*c*. The sawtooth waveform 2*c* represents the voltage which is present across capacitor 25 due to its being charged rapidly by the pulse of cathode current in tube 20 and discharged slowly at a rate determined by the RC time constant of network 46. The resultant voltage waveform at cathode 23 (point *d* in Figure 1) is shown in Figure 2*d*. It will be seen that waveform 2*d* comprises the combination of the sine-wave-with-superimposed-pulse waveform 2*b* and the sawtooth waveform 2*c*.

My invention contemplates the circuit parameters of the improved blocking tube oscillator to be so selected that, when the oscillator is operating, tube 20 will not fire until the potential of cathode 23 drops to a selected value which is only attained for a very short period during each

cycle. This is clearly depicted in Figure 2*d* where the cutoff potential of cathode **23** is indicated by the line so marked. Observe that the waveform **2***d* is so shaped that only for a short period during each cycle is the cathode potential sufficiently low (equivalent to the grid potential being sufficiently high) to permit second tube **20** to conduct. This short period begins when two of the three voltage components of which waveform **2***d* is comprised are moving in a negative-going direction. The third component, i. e. the negative pulse component, is not developed, in a free-running blocking oscillator, until second tube **20** fires.

Stated another way, the circuit is so arranged and the parameters are so chosen that the ordinarily positive potential of cathode **23** is driven down sufficiently close to ground potential to permit the flow of plate current in tube **20** when the negative-going portion of the sine-wave voltage **2***a* combines with a low potential portion of the sawtooth voltage **2***c* to produce a resultant cathode potential of preselected low magnitude, represented in Figure 2*d* by the line marked "cut-off." When the cathode potential reaches this value, second tube **20** fires, and a negative pulse of voltage is developed at point *b* which, being applied to point *d*, assists and intensifies the conduction taking place in tube **20**. Maximum plate-current flow is quickly reached, and soon thereafter the plate current flow decreases in the manner previously described. The potentials of plate **11** of tube **10** and of cathode **23** of tube **20** thereupon rise rapidly, and second tube **20** cuts off. Thereafter, the potential of cathode **23** follows a path determined by the sine wave voltage component **2***a* in combination with the sawtooth voltage component **2***c* until a value is reached sufficiently close to ground to cause tube **20** to again conduct. The frequency of the oscillation is consequently a function of both the RC time constant of network **46** and the resonant frequency of LC network **40**.

I have observed that the new circuit is capable of operating as a free-running blocking tube oscillator of excellent frequency stability. Its free-running frequency is, for example, substantially independent of variations which may occur in plate voltage. And, to an important extent, the free-running frequency is less affected by variations occurring in certain of the circuit constants which in prior art oscillators have considerable effect on the operating frequency.

The stability of my free-running blocking tube oscillator against variations in plate voltage will first be discussed. As indicated hereinabove, plate voltage variations may be due to an unregulated supply or may be caused by adjustments made manually to the D.-C. plate voltage to control, for example, the amplitude of the oscillator's output voltage. Assume that the plate supply voltage increases. When this occurs, the plate currents of both tubes increase. The increase in the plate current of second tube **20** produces an increase in the amplitude of the exponential sawtooth voltage component developed by RC network **46**. The increase in the plate current of first tube **10** produces an increase in the amplitude of the sine wave voltage developed across LC network **40**, and also in the amplitude of the negative pulse voltage developed across resistor **41**. Observe, however, that an increase in the amplitude of the positive-potential sawtooth voltage component tends to delay the time at which tube **20** fires, whereas an increase in the amplitude of the sine wave voltage component tends to advance the time at which tube **20** fires.

Stated another way, when the plate currents of both tubes increase as a result, for example, of an increase in the D.-C. plate voltages, forces are developed which are in opposition to each other, one tending to increase the frequency of operation of the blocking tube oscillator, the other tending to decrease the frequency of operation. The circuit parameters may consequently be so selected that the opposing forces are of substantially equal magnitude, in which case no appreciable change in oscillator frequency will occur when the D.-C. plate voltage is varied. In my experiments, I have found that the free-running operating frequency remained substantially constant over a two-to-one change in plate voltage.

I indicated above that my improved blocking tube oscillator is less affected by variations which may occur in the values of certain of the frequency-determining circuit constants. I have found, for example, that small variations in the values of resistor **24** and/or capacitor **26** have a smaller effect upon the operating frequency than such variations would have had in prior art blocking oscillators. Assume, for example, that the value of resistor **24** changes during warm-up of the apparatus. In this event, the amplitude and time constant of the sawtooth voltage component **2***c* will change. As a consequence, the free-running frequency of the oscillator will tend to change, but the actual change will be relatively small. This stability is derived from the LC circuit **40**. Observe that the slope of the sine wave voltage component **2***a* (which is substantially unaffected by the change in the constants of RC network **46**) is substantially steeper, at the point corresponding to the time of firing of tube **20**, than the slope of the sawtooth voltage component **2***c*. Consequently, the firing potential of cathode **23** is reached at very nearly the same time that it would have been reached had the constants of RC network **46** not changed slightly. Of course, changes of relatively large magnitude in the constants of RC network **46** will change the free-running frequency of my blocking tube oscillator. As a matter of fact, cathode resistor **24** may, in practice, be a variable resistor for controlling, in a vernier-like manner, the free-running frequency of the oscillator.

The operation of my improved circuit as a synchronized, rather than as a free-running, blocking tube oscillator will now be described. When the frequency of my improved blocking tube oscillator is to be controlled by regularly-recurring synchronizing or trigger pulses from an outside source, the circuit constants are so selected that, in the absence of the synchronizing pulses, the free-running frequency of the oscillator is slightly lower than the repetition frequency of the synchronizing pulses.

Assume that, in Figure 1, synchronizing pulses of positive polarity from source **16** are applied, by way of amplitude limiter **19**, coupling capacitor **17**, shunt load resistor **18**, and secondary winding **28**, to grid **12** of first triode **10** at a time when the circuit is operating as a free-running oscillator. In practice, amplitude limiter **19** may comprise the synchronizing-separator or pick-off circuit of the television receiver, which, by virtue of plate saturation limits the pulses to a uniform amplitude. When a positive synchronizing pulse arrives at grid **12**, the plate current of tube **10** rises sharply and a pulse of negative-going voltage is developed at point *b* which is applied, by way

of capacitor 26, to cathode 23 of second triode 20. Assume that, at the instant this negative pulse is applied to cathode 23, the instantaneous potential of cathode 23 corresponds to that at point *p* in Figure 2*d*. Observe that the potential at point *p* is relatively high with respect to the cutoff potential of cathode 23. The present invention contemplates the negative pulse developed at point *b* and applied to cathode 23 to be small in amplitude. Such a pulse, occurring at point *p* in Figure 2*d*, is ineffective to drive cathode 23 down sufficiently to cause tube 20 to conduct. Tube 20 therefore remains in non-conductive state. It will be understood that the amplitude of the negative pulse just referred to is substantially smaller than the amplitude of the negative pulse shown in Figure 2*b*. For, the large pulse in Figure 2*b* is developed as a result of second triode 20 firing, whereas in the situation now being described tube 20 remains non-conductive.

Stated another way, the present invention contemplates that the pulses applied to first tube 10, whether they be synchronizing pulses or noise pulses, will be ineffective to fire second triode 20 unless the pulse occurs at an instant coinciding with, or immediately prior to, points *f*, *f'*, in Figure 2*d*, where points *f*, *f'* are the points of time at which tube 20 will fire when operating as a free-running blocking oscillator. Tube 20 will not be driven into conduction by pulses occurring at other times, whether they be intended to synchronize the oscillator or not. However, as stated above, the invention proposes that the free-running frequency of the oscillator be lower than the repetition frequency of the applied synchronizing pulses. Consequently, the time difference, between the occurrence of the synchronizing pulse and the instant at which tube 20 fires during free-running operation, will grow smaller and smaller, and at some point of time the synchronizing pulse will occur substantially coincidentally with the free firing of tube 20. Stated graphically, in Figure 2*d* the position of point *p*, representing the occurrence of the synchronizing pulse, will move to the left until the synchronizing pulse occurs substantially simultaneously with the free firing of tube 20, represented by point *f*. Thereafter, the position of point *p* will move to the left of the free-firing point *f* but only by a small fixed amount. For, when the synchronizing pulse occurs, say at point *s*, cathode 23 will be driven down to a potential permitting the flow of plate current and tube 20 will fire. For the purposes of the present discussion, point *f* in Figure 2*d* may be considered as the point at which the tube 20 would have fired in the absence of a pulse occurring at point *s*. But with a pulse occurring at point *s*, tube 20 fires at point *s*. The succeeding synchronizing pulse *s'* will then occupy the same position, relative to the point *f'* at which tube 20 would have fired in the absence of pulse *s'*, as the preceding pulse *s* occupied with respect to point *f*. The oscillator will therefore fire at point *s'*. It will be seen then that the blocking tube oscillator will lock-in, in phase and frequency, with the applied synchronizing pulses. It will also be seen that pulses, such as intermittent noise pulses, occurring at instants corresponding to points other than the immediate vicinity of the free-firing points *f*, *f'*, are ineffective to fire second triode 20. Consequently, such pulses will not disturb the frequency of operation of the oscillator.

I have previously described the fact that my free-running blocking tube oscillator is inherently frequency stable against variations in plate voltage and also, to a limited extent, against such variations in circuit parameters as may occur during warm-up of the apparatus. It is because of this inherent frequency stability that a synchronizing pulse of relatively small amplitude is sufficient to effect dependable lock-in of the oscillator with the incoming synchronizing pulses. The present invention therefore contemplates that, in the preferred manner of use as a synchronized oscillator, means will be provided to limit the amplitude of the synchronizing pulses to a substantially smaller value than has heretofore been required to assure satisfactory lock-in. Incoming noise pulses will then be limited to the same small amplitude. It will be seen from an inspection of the wave-form shown in Figure 2*d* that the period of time during which the improved blocking oscillator is responsive to pulses of small amplitude is very short, being limited to the immediate vicinity of the free-firing points *f*, *f'*. As a consequence, the synchronized blocking tube oscillator is substantially immune to noise pulses. Nevertheless, the oscillator will lock-in, in very dependable manner, with the regularly-recurring synchronizing pulses, even though they may be of small amplitude. This, as previously described, is due to the fact that the new oscillator, operating as a free-running device, is inherently stable at a frequency slightly lower than the repetition frequency of the synchronizing pulses. Prior art blocking tube oscillators, on the other hand, because they are not inherently stable as free-running devices against, for example, variations in plate voltage, require that the synchronizing pulses be of relatively large amplitude in order to assure dependable lock-in.

Observe that, after the improved blocking tube oscillator of the present invention has locked-in with the synchronizing pulses, the frequency and phase of the oscillator will not be appreciably disturbed by a missing synchronizing pulse or by a variation in the amplitude of the synchronizing pulse, for the free-running instant of firing, in the absence of a synchronizing pulse, is very close to the instant at which the synchronizing pulse, if present, would have caused firing to take place. Furthermore, the inertia of the resonant circuit 40 prevents rapid changes in the phase of the sine wave voltage which largely determines the time of firing.

The blocking tube oscillator of the present invention is being used in the horizontal deflection system of television receivers now being manufactured on a production basis by the assignee of my invention, and has been found to constitute a substantial improvement over previously employed deflection oscillators. In the production receiver referred to, tubes 10 and 20 comprise a 6SL7 twin-triode. The values of pertinent circuit elements employed in the production receiver are given in Figure 1. These values are intended to be illustrative only and are not intended to be limiting. Since the line frequency, under present United States television standards, is 15,750 lines per second, the repetition frequency of the horizontal synchronizing pulses, delivered by source 16 and applied to grid 12, is 15,750 pulses per second. The resonant frequency of LC network 40 is slightly lower than the pulse repetition frequency, and is of the order of 14,500 cycles per second. The RC time constant of network 46 is preferably of the order of from one-third to two-thirds the time

duration of one cycle of operation, which is 63.5 microseconds. At the instant tube 20 fires, capacitor 26 has therefore discharged to an appreciable extent, and the voltage thereacross is consequently changing at a relatively slow rate. The free-running operating frequency of the oscillator is therefore determined largely by the resonant frequency of the sine wave voltage developed across network 40.

The synchronizing pulse voltages (and also the noise pulse voltages) applied to grid 12 are developed across load resistor 18, which is shown in Figure 1 to be of small value. Hence, the amplitude of the pulse voltages is small.

Having described a preferred embodiment of my invention, I claim:

1. A blocking tube oscillator comprising: a first vacuum tube having at least plate, cathode and grid electrodes; a second vacuum tube having at least plate and cathode electrodes; an external path interconnecting the plate and cathode electrodes of said second tube, said path including an inductance and a cathode load resistance; means for connecting a source of direct-current voltage to the plate of said second tube; a first external path interconnecting the plate and cathode electrodes of said first tube, said path including a sine wave-forming parallel-resonant inductance-capacitance network; a second external path interconnecting the plate and cathode electrodes of said first tube, said second path including a capacitance and said cathode load resistance of said second tube, said second path being in shunt with at least a portion of said first path; means for connecting a source of direct-current voltage to the plate of said first tube; and an external path interconnecting the grid and cathode electrodes of said first tube, said path including an inductance mutually coupled to said first-mentioned inductance.

2. A blocking tube oscillator comprising: a first vacuum tube having at least plate, cathode and grid electrodes; a second vacuum tube having at least plate and cathode electrodes; an external path interconnecting the plate and cathode electrodes of said second tube, said path including an inductance and a cathode load resistance; means for connecting a source of direct-current voltage to the plate of said second tube; a first external path interconnecting the plate and cathode electrodes of said first tube, said path including a sine wave-forming parallel-resonant inductance-capacitance network tuned to a frequency slightly lower than n times the frequency at which the oscillator is desired to operate, n being an integer; a second external path interconnecting the plate and cathode electrodes of said first tube, said second path including a capacitance and said cathode load resistance of said second tube, said second path being in shunt with at least a portion of said first path; means for connecting a source of direct-current voltage to the plate of said first tube; and an external path interconnecting the grid and cathode electrodes of said first tube, said path including an inductance mutually coupled to said first-mentioned inductance.

3. A blocking tube oscillator as claimed in claim 2 characterized in that said first plate-to-cathode circuit of said first tube includes a pulse-forming resistor.

4. A blocking tube oscillator as claimed in claim 2 characterized in that the factor n is one.

5. A blocking tube oscillator as claimed in claim 2 characterized in that the factor n is an integer greater than one.

6. A blocking tube oscillator comprising: first and second vacuum tubes having at least plate, cathode and grid electrodes; an external path interconnecting the plate and cathode electrodes of said second tube, said path including an inductance and a cathode load resistance; means for connecting a source of direct-current voltage to the plate of said second tube; a first external path interconnecting the plate and cathode electrodes of said first tube, said path including a sine wave-forming parallel - resonant inductance - capacitance network and a pulse-forming load resistance, said inductance-capacitance network being resonant to a frequency slightly lower than n times the frequency at which the oscillator is desired to operate, n being an integer; a second external path interconnecting the plate and cathode electrodes of said first tube, said second path including a capacitance and said cathode load resistance of said second tube, said second path being in shunt with at least a portion of said first path, said capacitance and cathode load resistance functioning as an RC biasing network for said second tube, the RC time constant of said network being shorter than the time duration of one cycle of oscillation at the desired operating frequency; means for connecting a source of direct-current voltage to the plate of said first tube; and an external path interconnecting the cathode and grid electrodes of said first tube, said path including an inductance mutually coupled to said first-mentioned inductance.

7. A blocking tube oscillator as claimed in claim 6 characterized in that the factor n is one.

8. A blocking tube oscillator as claimed in claim 6, characterized in that the factor n is an integer greater than one.

9. A blocking tube oscillator as claimed in claim 6 characterized in that means are provided for applying to a grid-cathode circuit of said oscillator regularly recurring voltage pulses whose repetition frequency is substantially equal to the frequency at which said oscillator is desired to operate, whereby said oscillator is synchronized in frequency and in phase with said regularly recurring pulses.

10. A blocking tube oscillator as claimed in claim 1, characterized in that said second vacuum tube has also a grid electrode and in that said grid electrode is connected effectively to the low-potential end of said cathode load resistance of said second tube.

LINCOLN W. HERSHINGER.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,125,732	Bowman-Manifold et al.	Aug. 2, 1938
2,182,555	Geiger	Dec. 5, 1939
2,277,000	Bingley	Mar. 17, 1942