Sept. 19, 1944. K. R. WENDT 2,358,545

TELEVISION SYSTEM

Filed July 31, 1941 4 Sheets-Sheet 1

FIG. 1.

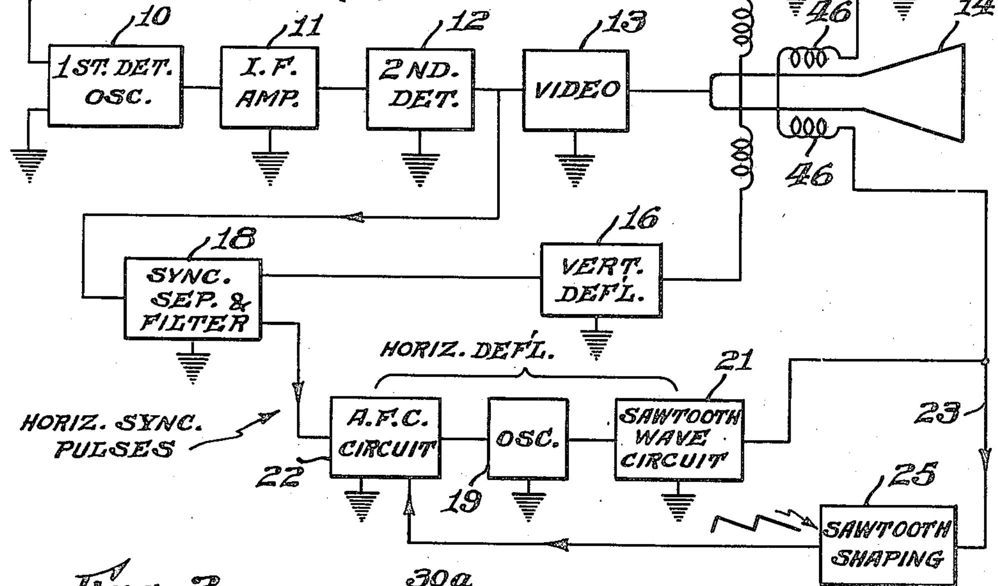
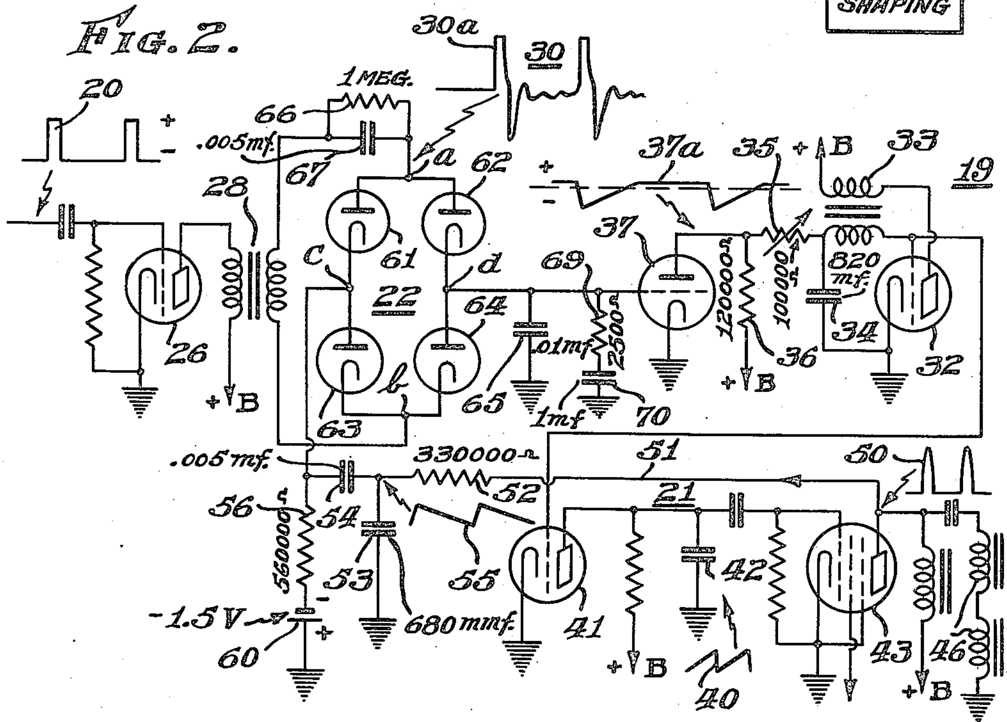


FIG. 2.



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Sept. 19, 1944. K. R. WENDT 2,358,545

TELEVISION SYSTEM

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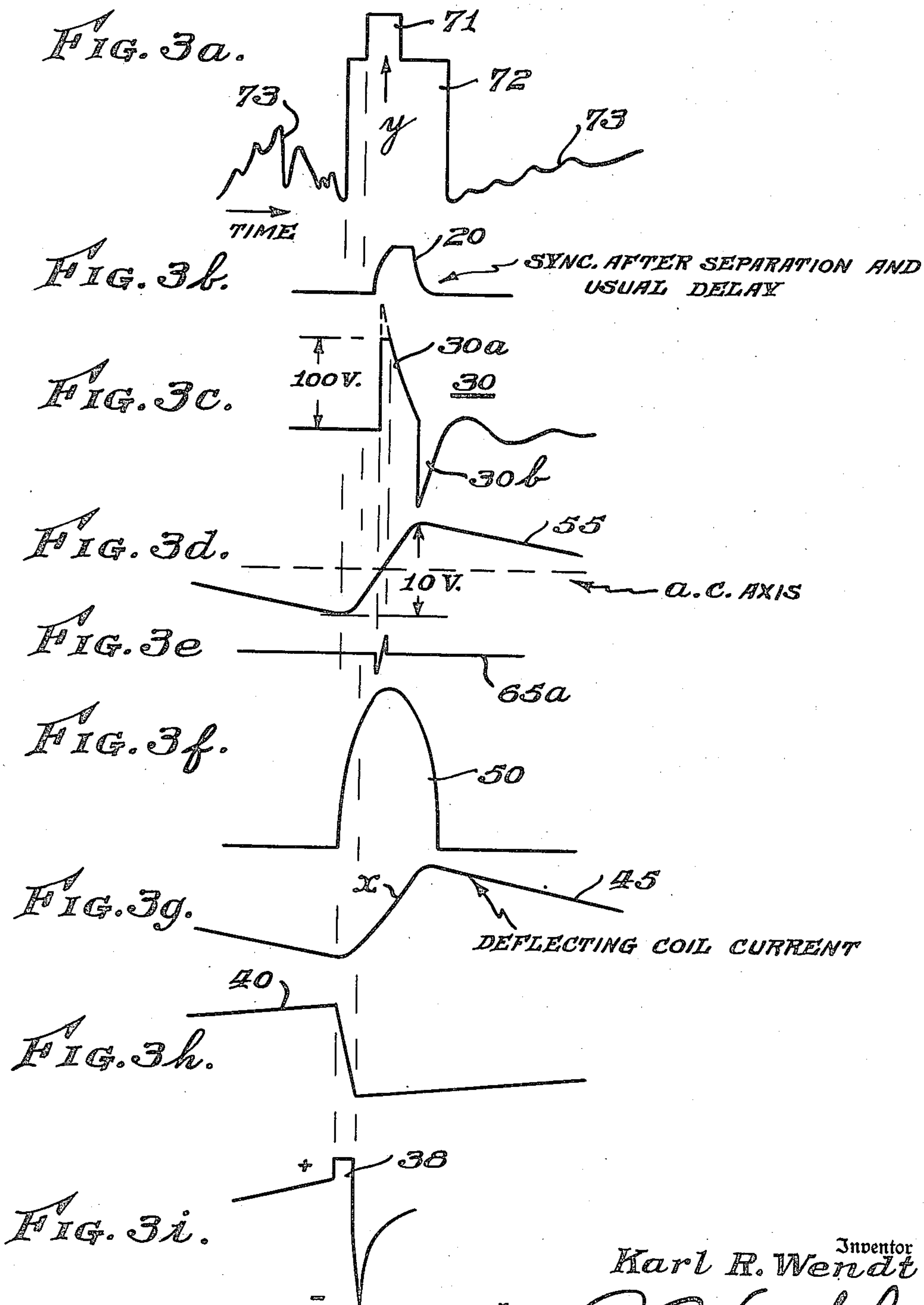

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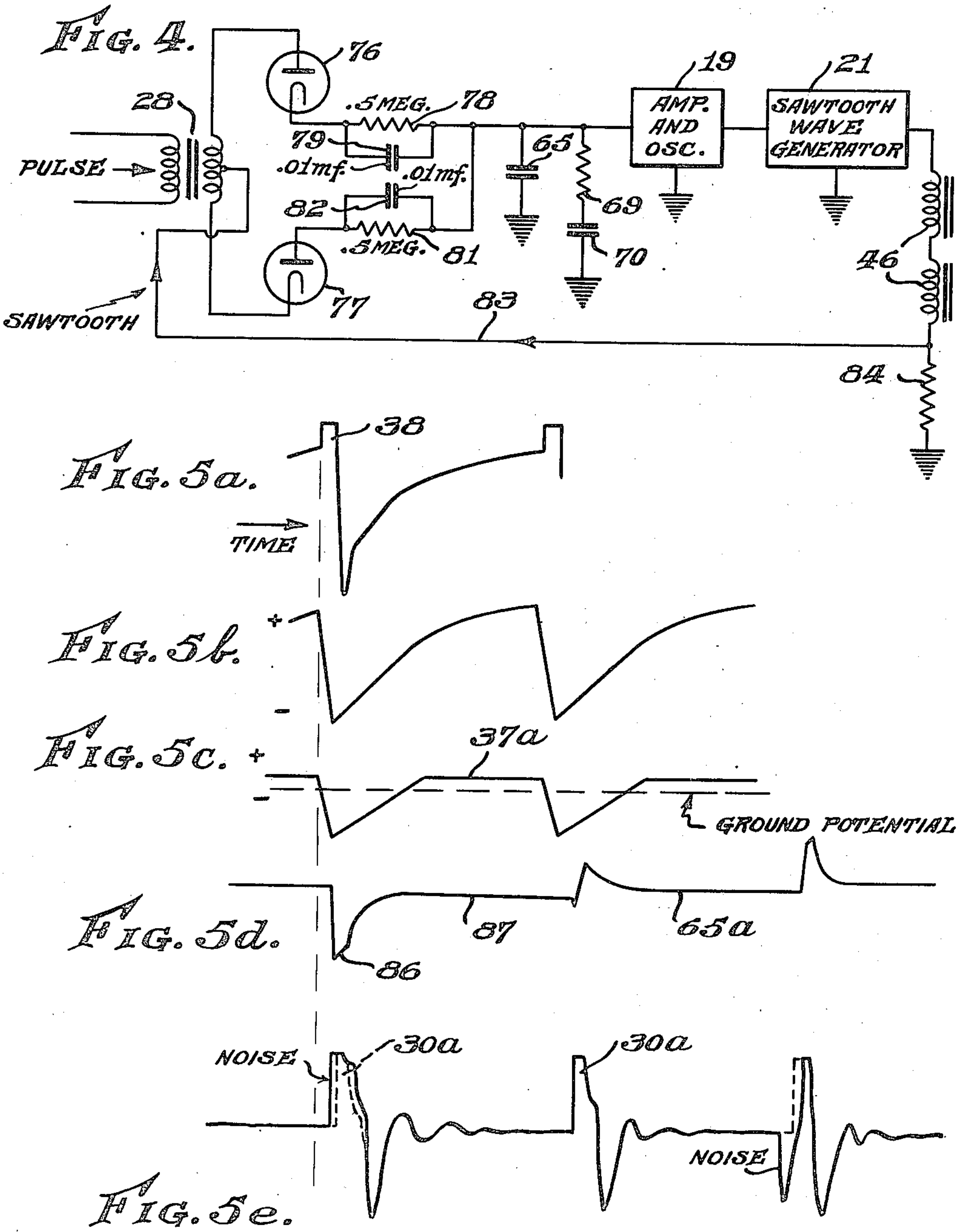

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TELEVISION SYSTEM

Filed July 31, 1941 4 Sheets-Sheet 4

FIG. 6.

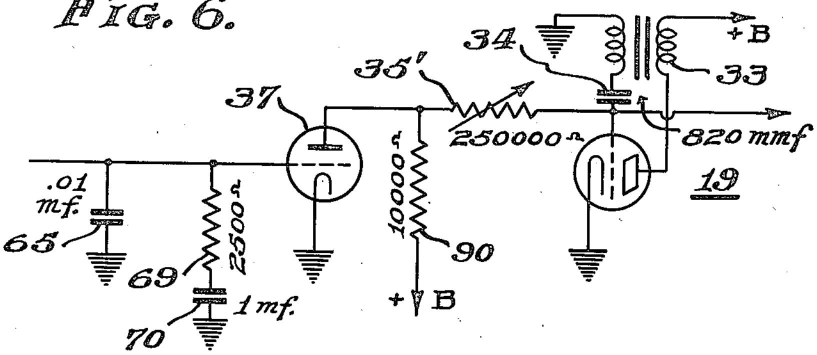


FIG. 7.

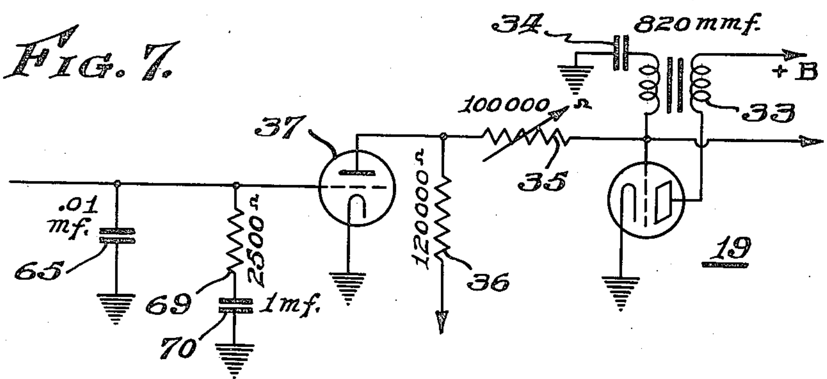
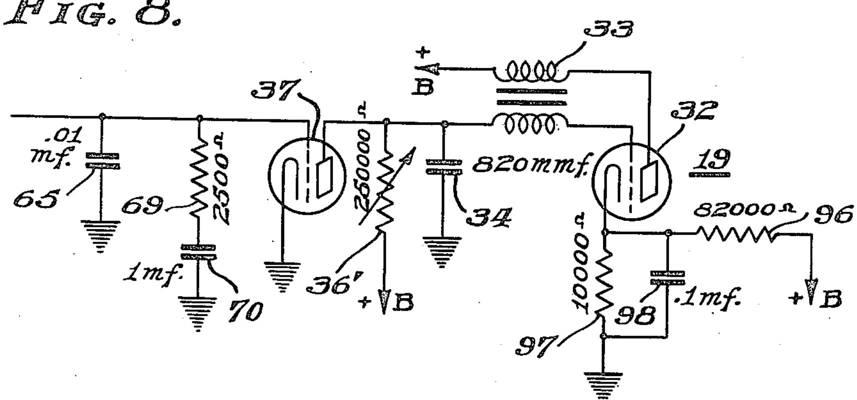


FIG. 8.



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Patented Sept. 19, 1944 2,358,545

UNITED STATES PATENT OFFICE

2,358,545

TELEVISION SYSTEM

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Application July 31, 1941, Serial No. 404,787

17 Claims. (Cl. 178—7.5)

My invention relates to television receivers or the like and particularly to a method of and means for synchronizing cathode ray deflection circuits.

It has been the usual practice to synchronize the cathode ray deflection or scanning at the receiver with the scanning at the transmitter by transmitting to the receiver a mixture of picture signal and synchronizing pulses and by applying the received synchronizing pulses to a blocking oscillator or the like in the deflection circuit for pulling the oscillator into step with the said pulses. This way of synchronizing a deflecting circuit is satisfactory but it usually requires the use of a "speed" or frequency control for the oscillator so that its free running oscillation frequency may be adjusted manually to a frequency close to the rate at which the synchronizing pulses occur.

Also, a circuit so synchronized will fall out of synchronism immediately upon the absence of synchronizing pulses.

An object of the present invention is to provide an improved method of and means for synchronizing a cathode ray deflecting circuit.

A further object of the invention is to provide an improved cathode ray deflecting circuit which will not fall out of synchronism immediately upon the failure of synchronizing pulses.

A further object of the invention is to provide an improved cathode ray deflecting circuit which is not very susceptible to noise signals.

A still further object of the invention is to provide an improved cathode ray deflecting circuit in which the return line period is made to start at or before the front edge of a synchronizing pulse.

Another object of the invention is to provide an improved cathode ray deflecting circuit which is not affected any substantial amount by variations in the amplitude of the synchronizing and/or oscillator pulses.

In practicing one particular embodiment of the invention, I utilize a circuit for producing an oscillator frequency control voltage which changes in value with any change in the phase relation of the incoming synchronizing pulses with respect to the oscillator output. In a specific example, a balanced diode bridge circuit has appled thereto both short pulses derived from incoming synchronizing pulses and waves with steep fronts derived from the deflecting circuit oscillator whereby the bridge circuit output or control voltage varies with changes in the phase relation of the said pulses and the said wave fronts. The said control voltage is applied to the oscillator to control its rate of oscillation whereby its output pulses are held in a fixed phase relation to the synchronizing pulses.

In this embodiment, the synchronizing pulses may be narrow compared with the waves derived from the oscillator and they are utilized to key the bridge circuit at the time a sloping side of one of said waves is impressed upon it.

Other objects, features and advantages of the invention will be apparent from the following description taken in connection with the accompanying drawings in which

Figure 1 is a block diagram of a television receiver embodying my invention,

Fig. 2 is a circuit diagram of the horizontal deflection circuit of Fig. 1 designed in accordance with my invention,

Figs. 3*a*, 3*b*, 3*c*, 3*d*, 3*e*, 3*f*, 3*g*, 3*h* and 3*i* are curves which are referred to in explaining the invention,

Fig. 4 is a circuit diagram illustrating another embodiment of the invention,

Figs. 5*a* to 5*e* are curves which are referred to in explaining an improved embodiment of the invention, and

Figs. 6, 7 and 8 are circuit diagrams illustrating various embodiments of the invention.

Corresponding parts in the several figures are indicated by like reference characters.

Fig. 1 shows a television receiver of the usual superheterodyne type comprising a first detector and tuning oscillator indicated at 10, an I. F. amplifier 11, a second detector 12, a video amplifier 13 and a cathode ray receiver tube 14.

The vertical deflecting circuit 16 and the horizontal deflecting circuit (indicated by the bracket and legend) are synchronized by the usual vertical and horizontal synchronizing pulses which have been separated from the picture signal and from each other by suitable separating and filtering circuits indicated at 18 as is well known in the art.

The horizontal deflecting circuit, to which my invention is applied in this particular embodiment, comprises an oscillator 19, a sawtooth generating circuit 21, and an automatic frequency control circuit 22. The oscillator pulses are applied through a feedback connection 23 to a circuit 25 which produces a sawtooth voltage and supplies it to the control circuit 22 whereby the output from circuit 22 which is impressed upon the oscillator 19 has a value that depends upon the phase relation of horizontal synchronizing pulses and oscillator pulses. Thus, the oscillator

19 is held in a fixed phase relation to the synchronizing pulses, and the horizontal deflection of the cathode ray of tube 14, likewise, is made to occur in the necessary fixed phase relation with respect to the horizontal deflection at the transmitter.

Fig. 2 shows an embodiment of the invention wherein the horizontal synchronizing pulses indicated at 20 are applied with positive polarity to an amplifier 26. The amplified synchronizing pulses are passed through a transformer 28 which differentiates them to produce the pulses indicated at 30 which are impressed across one diagonal of the diode bridge circuit comprising the A. F. C. circuit 22 as will be described hereinafter.

Referring now to the oscillator 19, it is preferably of the well known blocking oscillator design comprising an amplifier tube 32 having an iron core feedback transformer 33, a grid circuit condenser 34 and a variable grid leak resistor 35. In accordance with one feature of a preferred embodiment of the invention the plate resistor 36 of a D. C. amplifier 37 also provides a large part of the grid leak resistance as will be explained below.

The blocking rate or frequency of oscillation of a blocking oscillator may be varied or controlled by changing the rate at which the blocking charge leaks off the grid condenser 34, assuming the cut-off point of the oscillator tube remains unchanged. In the present circuit, however, it is controlled principally by causing the discharge to reach the said cut-off point at a variable time controlled by a D. C. control voltage from the A. F. C. circuit.

The pulses 38 (shown in Fig. 3*i*) appearing at the grid of the blocking oscillator 19 are impressed upon the grid of a discharge tube 41 of the sawtooth generating circuit 21. Thus the usual sawtooth condenser 42 is discharged periodically to produce a sawtooth voltage wave 40 thereacross (shown in Fig. 3*h*) as is well known in the art.

This sawtooth voltage is impressed upon an output tube 43 to produce a sawtooth current through the deflecting coils 46 in the usual manner. This sawtooth current is shown at 45 in Fig. 3*g*.

Voltage pulses 50 (Fig. 3*f*) which appear across the deflecting coils 46 during the return line period are applied over a conductor 51 to an integrating circuit comprising a series resistor 52 and a shunt condenser 53 whereby there appears across condenser 53 a sawtooth voltage 55 shown in Fig. 3*d*. This voltage, which is being produced by the blocking oscillator, is applied across the other diagonal of the diode bridge circuit by means of a coupling condenser 54, and a resistor 56.

Referring more specifically to the A. F. C. circuit 22, it may comprise four diodes 61, 62, 63 and 64 connected in the form of a Wheatstone bridge as illustrated. The narrowed synchronizing pulses from transformer 28 are applied across the diagonal terminals indicated at *a* and *b*, these being the junction points, respectively, of the anodes of diodes 61 and 62 and of the cathodes of diodes 63 and 64.

The sawtooth voltage waves 55, produced in the integration circuit by the blocking oscillator 19, are impressed across the other diagonal terminals of the bridge indicated at *c* and *d* as previously described. The circuit for so applying the sawtooth voltage may be traced from the terminal *c* through resistor 56, through a biasing source 60 for the tube 37 to ground, and through a control voltage storage condenser 65 to the terminal *d*.

In series with the secondary of the transformer 28 there is a resistor 66 shunted by a condenser 67. During the circuit operation, a bias voltage is built up across the R—C circuit 66—67 having such polarity as to make the bridge non-conducting unless a synchronizing pulse is being applied through the transformer 28. Thus the narrowed synchronizing pulses act as keying pulses for the bridge circuit and the condenser will receive a charge having a value which depends upon the instantaneous voltage of the sawtooth wave 55 at the instant the bridge circuit is keyed.

The basic diode bridge circuit above described is claimed in my Patent 2,250,284, issued July 22, 1941, and entitled Frequency control circuits.

The control voltage of condenser 65 is impressed upon the grid circuit of the oscillator tube 32 by means of a D. C. amplifier 37. The plate of amplifier tube 37 is direct current connected to the grid of oscillator tube 32 through the resistor 35 and the secondary of the transformer 33. The plate resistor 36, in the preferred embodiment, has a resistance approximately as high as that of the resistor 35 or higher so that the periodic negative voltage appearing on the oscillator grid will drive the plate of tube 37 negative for an instant until after the voltage applied to the grid of tube 37 has reached a stable value. As will be explained hereinafter, this circuit action functions in cooperation with a filter 69—70 across condenser 65 and improves the stability of operation of the circuit. It is evident that a change in the control voltage across condenser 65 will change the point at which the discharge of the blocking oscillator condenser 34 reaches the cutoff point whereby the instant at which the oscillator can and will unblock is changed.

The operation of Fig. 2 will be better understood by referring to Figs. 3*a* to 3*i*.

Fig. 3*a* shows a horizontal synchronizing pulse 71 set on a blanking pulse 72 which is preceded and followed by picture signals 73. The synchronizing pulse 71 after separation from the picture signal is shown at 20 in Fig. 3*b*. It will be seen that this pulse is delayed a certain amount by the inherent action of the usual picture separation and synchronizing pulse filtering circuits. If any additional delay is desired it may be provided by well known delay circuits.

Fig. 3*c* shows the voltage pulse produced by passing the pulse 20 through transformer 28. It has a positive portion 30*a* and a negative portion 30*b* as it is applied to the anodes of the diodes 61 and 62. The amplitude of the pulse 30*a* is several times that of a sawtooth wave 55, this being indicated in Figs. 3*c* and 3*d* in volts by way of example.

As shown by Figs. 3*c* and 3*d*, the narrowe synchronizing pulse 30*a* and the sawtooth wa 55 occur in such time relation that the pulse keys the bridge circuit to make the four dio conducting during the occurrence of the slo front of the wave 55. It follows that the ch received by condenser 65 and the voltage thereacross (Fig. 3*e*) depends upon the pha relation of the two voltages 30*a* and 55. If t sawtooth wave 55 occurs later than shown on drawings as a result of the oscillator 19 tend to slow down, the control voltage across condenser 65 will be decreased to make the grid of amplifier tube 51 more negative whereby the grid of the blocking oscillator tube 32 is made less negative. This permits unblocking of the oscillator tube an instant sooner than before and the oscillator is prevented from slowing down. The opposite control action takes place if the oscillator 19 tends to speed up. The curve 65a (Fig. 3e) represents a condition where the oscillator frequency was correct when the bridge circuit was keyed by the pulse 30a.

In the foregoing description of the circuit operation, it has been assumed that the sawtooth wave 55 is produced with the necessary delay to make the keying pulse 30a occur on the steep front of said wave. Such a delayed sawtooth or other voltage pulse with a steep front can be obtained by various methods, one of them being that illustrated in Fig. 2. This method of obtaining the delayed sawtooth 55 will be understood by comparing Figs. 3f to 3i.

First it may be noted that the control circuit is in a stable or equilibrium condition only when the entire circuit adjustment, including the initial speed or frequency adjustment of the oscillator 19, is such that the relative phase relations of the various voltage waves are substantially as illustrated in Figs. 3a to 3i. This means that during its normal operation the oscillator pulses 38 at the grid of oscillator tube 32 occur in the time relation shown in Fig. 3i. They discharge the condenser 42 through tube 41 to produce the sawtooth 40 (Fig. 3h) which, when applied to the high plate impedance tube 43, produces the sawtooth current 45 (Fig. 3g) in the deflecting coils 46. A voltage pulse 50 (Fig. 3f) appears at the plate of tube 43 during the return line period. The pulse 50, when integrated by the elements 52—53, produces the desired delayed sawtooth voltage 55 (Fig. 3d) across condenser 53. It will be apparent that the delay for the steep slope of voltage 55 is here obtained as a result of the comparatively long return line period of the deflecting coil current.

It has been found that the above described control action locks the oscillator 19 with the synchronizing pulses so tightly that no speed control knob is required on the television receiver panel as one of the controls. The only speed control adjustment may be a "screw driver" adjustment for initially adjusting the grid leak resistor 36.

It may be noted that while the A. F. C. circuit should be keyed on the steep slope of a wave, such as the wave 55, for best operation, this steep slope may be the back of the wave instead of the front provided the polarity of the control signal applied to the oscillator is reversed.

While the invention has been described as applied to the horizontal deflection, it is equally applicable to the vertical or frame frequency deflection.

An additional advantage of the invention is that the return line period of the deflection current 45 can be made to start at, or even before, the beginning of the blanking pulse 72. This is especially desirable in the horizontal deflection circuit since it is a difficult problem to make the horizontal return line period as short as the blanking period without increasing the cost too much. The present invention may even permit shortening of the blanking period (shortening of pulse 72, Fig. 3a) so that an increased amount of picture detail may be transmitted.

This additional advantage is illustrated by Fig. 3g when compared with Fig. 3a. Fig. 3g shows the sawtooth current which flows through the horizontal deflecting coils 46, the return line being indicated at x. It will be seen that this return line starts at the beginning of the blanking pulse 72 in the particular example shown.

From the foregoing it is apparent that with my improved method of deflection control the return line x does not extend into the picture signal region 73 (Fig. 3a) as it would if it began in accordance with the usual method at a later time such as indicated by the arrow y in Fig. 3a.

The present invention has other desirable features which may be noted. For one thing, since the narrowed synchronizing pulses 30a of large amplitude are utilized for keying the bridge circuit, any variation in the amplitude of the incoming synchronizing pulses will have no effect upon the deflecting circuit because of the bridge balance.

Also, since the sawtooth waves 55 which are applied to the bridge circuit are substantially symmetrical with respect to the A. C. axis, and since a keying pulse 30a occurs at or near the time the steep front of a wave 55 crosses the A. C. axis, any changes in the amplitude of these sawtooth waves caused by changes in oscillator voltage or the like will have little or no effect on the deflecting circuit control. This symmetry of the waves 55 with respect to their A. C. axis also increases the lock-in range of the A. F. C. circuit.

Figure 4 shows a simplified embodiment of the invention wherein the bridge circuit of four diodes is replaced by a bridge circuit containing only two diodes 76 and 77 which are in two arms of the bridge. The other bridge arms contain the upper and lower halves of the secondary winding of transformer 28. The bridge arms which contain the diodes 76 and 77 also contain the resistor-capacitor networks 78—79 and 81—82, respectively, which function like the network 66—67 of Fig. 2 to keep the diodes nonconducting between keying pulses 30a (Fig. 3c) supplied from transformer 28.

The sawtooth voltage wave 55 (Fig. 3d) which is applied to the bridge circuit through a conductor 83 is obtained in this embodiment of the invention from a resistor 84 in series with the deflecting coils 46. This same method of obtaining the sawtooth wave 55 may be employed in the circuit of Fig. 2, if desired.

The circuits of Figs. 2 and 4 preferably include the series R—C combination 69—70 connected across the control voltage storage condenser 65 to make the circuit more stable and less susceptible to noise. The condenser has a large capacity compared with that of the condenser 65.

Perhaps the simplest way to consider the function of the R—C combination 69—70 is to note that it prevents any sudden changes in the charge of the storage condenser 65. This reduces the tendency of the circuit to oscillate since it reduces the A. C. gain in the loop circuit although it does not reduce the D. C. gain.

With respect to noise accompanying the synchronizing pulses, such noise is random so that the probabilities are that the frequency control circuit will not have successive incorrect signals applied thereto at the instant the circuit is keyed by an oscillator pulse. Since a single incorrect signal will be removed from the storage condenser 65 by the R—C combination 69—70, it follows that this R—C combination reduces the susceptibility of the circuit to noise. In this connection it may be noted that a single synchronizing pulse by itself has but little synchronizing effect on the oscillator; a train of successive synchronizing pulses are necessary to produce substantial control of the oscillator.

As previously mentioned, the feature of coupling the D. C. amplifier 37 (Fig. 2) to the oscillator 19 so that the plate of the amplifier is driven negative periodically is one that is related to the action of the filter 69—70. This can be more readily understood by referring to Figs. 5a to 5e. The curves of Figs. 5a and 5e are the oscillator pulses at the grid of oscillator tube 32 and the keying pulses at the bridge terminal *a*, respectively. Except for noise mixed with two of the keying pulses, these two curves are the same as those in Figs. 3i and 3c. They are repeated here to show their time relation with respect to the voltage waves in Figs. 5b, 5c and 5d and to show the effect of noise mixed with the synchronizing pulses.

Fig. 5b shows the voltage appearing across the oscillator condenser 34. A large percentage of this voltage, 50% or more for example, appears on the plate of amplifier tube 37, the resistors 35 and 36 forming a potentiometer across condenser 34 for this voltage transfer.

Fig. 5c shows the resulting voltage 37a appearing on the plate of tube 37, the dashed line representing ground potential. It is evident that the plate of tube 37 is negative with respect to its cathode for about one-third of the oscillator cycle, and that, during this time, the amplifier 37 does not pass any signal. The advantage of this is apparent from an inspection of Fig. 5d which shows the voltages which will appear across condenser 65 under different noise conditions, these voltages also being impressed upon the grid of tube 37.

In Fig. 5d it is assumed that disturbances, such as noise pulses which occur added to the keying pulse 30a, cause the bridge circuit to be keyed at wrong times and put a variable and comparatively large initial charge on the condenser 65 with the resulting initial voltage indicated for instance at 86. The R—C filter 69—70, however, quickly removes most of this transient charge to bring the voltage across condenser 65 to a value indicated at 87 which is very close to the proper control voltage.

While the R—C filter 69—70 is bringing the voltage of condenser 65 back to the proper value, the amplifier 37 cannot transfer any signal to the oscillator 19 and, therefore, the transient voltage 86 has substantially no effect upon the oscillator frequency.

While the A. F. C. voltage preferably is supplied to the oscillator 19 from the D. C. amplifier 37 by means of a coupling circuit operating to "disconnect" the amplifier periodically as described above, it should be understood that this feature of the invention may be omitted if desired. For example, the connection between amplifier 37 and the oscillator 19 may be as shown in Fig. 6.

In Fig. 6 the connection from the plate of tube 37 to the grid of the oscillator is through the grid leak resistor 35' only, while the plate resistor 90 of tube 37 has a low resistance compared with that of resistor 35 in accordance with conventional practice. With this arrangement, there is insufficient oscillator voltage appearing across resistor 90 to drive the plate of tube 37 negative.

As illustrated in Figs. 7 and 8, the feature of causing the oscillator 19 to drive the plate of amplifier tube 37 negative periodically may be employed by utilizing other circuit connections than those shown in Fig. 2.

In Fig. 7 the coupling between amplifier 37 and oscillator 19 is similar to that shown in Fig. 6 but differs in that the plate resistor 36 of tube 37 has high enough resistance compared with the resistance of resistor 35 to cause the appearance of sufficient oscillator voltage on the plate of tube 37 to drive it negative.

In Fig. 8 the plate of tube 37 is connected directly to the high voltage side of the oscillator condenser 34 and the cathode of the oscillator tube 32 is held positive with respect to ground by means of a voltage divider 96—97. There is a bypass condenser 98 connected between said cathode and ground. The reason for holding the cathode above ground potential is that otherwise, since the grid of oscillator tube 32 is always negative with respect to its cathode, the plate of tube 37 could never go positive. The operation of this circuit is the same as previously described, the plate of tube 37 being alternately positive and negative.

It should be understood that the above-described "disconnect" feature of the invention may be employed in A. F. C. circuits other than the particular ones described in this application. It may be employed, for example, in the system described in my copending application Serial No. 400,177, filed June 28, 1941, and entitled "Television system."

On the drawings various circuit constants have been indicated by way of example in ohms, megohms, microfarads and micromicrofarads.

The phrase "effective amplitude" includes polarity changes as well as amplitude changes. For example, if the charge on condenser 65 goes from a positive value to an equal but opposite negative value, the "effective amplitude" has been changed.

I claim as my invention:

1. In a cathode ray deflection circuit of the type containing an oscillator, the method of synchronizing said oscillator with synchronizing pulses which comprises producing electrical waves under the control of said oscillator, each of said waves having a steep edge, said oscillator waves being at least approximately symmetrical with respect to their A. C. axis, producing periodically recurring pulses which change in effective amplitude in response to any change in the phase relation of said pulses and said waves, integrating the pulses thus produced to provide a frequency control voltage, impressing said control voltage upon said oscillator to control its frequency and so adjusting said oscillator that the steep edge of each wave starts earlier than a synchronizing pulse.

2. The method of holding a cathode ray deflection circuit of the type containing an oscillator in synchronism with incoming synchronizing pulses which comprises the steps of obtaining voltage waves from said oscillator each of which has a steep sloping side, delaying said synchronizing pulses and combining them with said voltage waves with the delayed synchronizing pulses occurring during the occurrence of said sloping sides to produce recurring pulses having a value which varies with any variation in the phase relation of said two groups of pulses, integrating said pulses thus produced to provide a frequency control voltage, controlling the frequency of said os-

cillator in accordance with said control voltage whereby said oscillator is locked in with said synchronizing pulses and so adjusting said oscillator that the steep side of said waves starts earlier than a synchronizing pulse.

3. A cathode ray deflection circuit comprising an oscillator which is to be synchronized by synchronizing pulses, a frequency control circuit which includes a balanced bridge rectifier circuit, means for producing waves under the control of said oscillator which have a steep edge and which are at least approximately symmetrical with respect to their A. C. axis, push-pull circuit means for applying said synchronizing pulses across one diagonal of said bridge circuit, single-ended circuit means for applying said sawtooth waves across the other diagonal of said bridge circuit, means including said control circuit for producing periodically recurring pulses which change in effective amplitude in response to any change in the phase relation of said pulses and said waves, means for integrating the pulses thus produced to provide a frequency control voltage, and means for impressing said control voltage upon said oscillator for synchronizing it with said synchronizing pulses.

4. A cathode ray deflection circuit comprising an oscillator which is to be synchronized by synchronizing pulses, a frequency control circuit which includes a balanced bridge rectifier circuit, means for producing sawtooth waves under the control of said oscillator, push-pull circuit means for applying said synchronizing pulses across one diagonal of said bridge circuit, single-ended circuit means for applying said sawtooth waves across the other diagonal of said bridge circuit, means including said control circuit for producing periodically recurring pulses which change in effective amplitude in response to any change in the phase relation of said pulses and said waves, means for integrating the pulses thus produced to provide a frequency control voltage, and means for impressing said control voltage upon said oscillator for synchronizing it with said synchronizing pulses.

5. A cathode ray deflection system comprising an oscillator, a balanced bridge circuit which may be keyed by signal applied across one diagonal to pass signal applied across the other diagonal, push-pull circuit means for applying synchronizing voltage pulses in push-pull relation to the terminals of said one diagonal, single-ended circuit means for applying voltage waves obtained from said oscillator across said other diagonal from a single-ended circuit, means for integrating the resulting output pulses of said bridge to obtain a frequency control voltage, and means for controlling the frequency of said oscillator in accordance with said control voltage.

6. A cathode ray deflection system comprising an oscillator, a balanced bridge circuit which may be keyed by signal across one diagonal to pass signal applied across the other diagonal, push-pull circuit means for applying synchronizing pulses of comparatively large amplitude across said one diagonal from a push-pull circuit to key said bridge circuit, single-ended circuit means for obtaining pulses from said oscillator, each of which has a steep sloping edge, and applying them across said other diagonal from a push-pull circuit with the steep edges occurring during the occurrence of said synchronizing pulses, means for integrating the resulting output pulses of said bridge to obtain a frequency control voltage, and means for controlling the frequency of said oscillator in accordance with said control voltage.

7. A cathode ray deflection system comprising a blocking oscillator which produces voltage pulses, a balanced bridge circuit which may be keyed by signal applied across one diagonal to pass signal applied across the other diagonal, means for producing voltage waves having a steep edge under the control of said oscillator, single-ended circuit means for applying said voltage waves across one of said diagonals from a single-ended circuit, push-pull circuit means for applying synchronizing pulses across the other of said diagonals from a push-pull circuit to key said bridge circuit while said steep edges are impressed thereon, means for integrating the resulting output pulses of said bridge to obtain a frequency control voltage, and means for controlling the frequency of said oscillator in accordance with said control voltage.

8. In combination, an oscillator adapted to have its rate of oscillation controlled by the application thereto of a frequency controlling signal, automatic frequency control means for producing a frequency controlling signal in which there are pulses occurring in harmonic relation to said rate of oscillation, signal transfer means for applying said controlling signal to said oscillator, and means for making said transfer means ineffective to transfer signal for substantially the entire duration of said pulses.

9. In combination, an oscillator adapted to have its rate of oscillation controlled by the application thereto of a frequency controlling signal, automatic frequency control means for producing a frequency controlling signal in which there are pulses occurring in harmonic relation to said rate of oscillation, a vacuum tube through which said controlling signal is applied to said oscillator for controlling its frequency, and means for making said vacuum tube periodically nonconducting at said harmonic rate with each nonconducting period occurring during substantially the entire duration of said pulses.

10. A cathode ray deflection circuit comprising an oscillator which is to be synchronized with synchronizing pulses, a frequency control circuit, means for supplying to said control circuit both said synchronizing pulses and a periodic voltage from said oscillator, means including said control circuit for producing periodically recurring pulses which change in effective amplitude in response to any change in the phase relation of said pulses and said periodic voltage, means including a condenser for integrating the pulses thus produced to provide a frequency control voltage which includes recurring transient pulses, filter means for reducing said transient pulses, means for impressing said control voltage upon said oscillator for synchronizing it with said synchronizing pulses, and means for making said last means ineffective for the duration of each of said transient pulses.

11. A cathode ray deflection circuit comprising an oscillator which is to be synchronized with synchronizing pulses, a frequency control circuit, means for supplying to said control circuit both said synchronizing pulses and a periodic voltage from said oscillator, means including said control circuit for producing periodically recurring pulses which change in effective amplitude in response to any change in the phase relation of said pulses and said periodic voltage, means including a condenser for integrating the pulses thus produced to provide a frequency control volt-

age which includes periodically recurring transient pulses, a filter connected across said condenser, said filter comprising a resistor in series with a condenser of large capacity compared with the first condenser, means for impressing said control voltage upon said oscillator for synchronizing it with said synchronizing pulses, and means for making said last means ineffective for the duration of each of said transient pulses.

12. A cathode ray deflection circuit comprising an oscillator which is to be synchronized with synchronizing pulses, a frequency control circuit, means for supplying to said control circuit both said synchronizing pulses and a periodic voltage from said oscillator, means including said control circuit for producing periodically recurring pulses which change in effective amplitude in response to any change in the phase relation of said pulses and said periodic voltage, means including a condenser for integrating the pulses thus produced to provide a frequency control voltage which includes periodically recurring transient pulses, a filter connected across said condenser, said filter comprising a resistor in series with a condenser of large capacity compared with the first condenser, means including an amplifier tube for impressing said control voltage upon said oscillator for synchronizing it with said synchronizing pulses, said amplifier tube having a plate electrode which is so coupled to said oscillator that it is driven negative for the duration of each of said transient pulses.

13. A cathode ray deflection system comprising an oscillator, a balanced bridge circuit which may be keyed by signal applied across one diagonal to pass signal applied across the other diagonal, means for applying synchronizing voltage pulses across one of said diagonals, means for applying voltage waves obtained from said oscillator across another of said diagonals, means including a condenser for integrating the resulting output pulses of said bridge to obtain a frequency control voltage, filter means for reducing transient voltages appearing across said condenser, a vacuum tube through which said control voltage is applied to said oscillator to control its frequency in accordance with said control voltage, and means for making said vacuum tube nonconducting for the duration of each of said transient pulses.

14. A cathode ray deflection system comprising an oscillator, a balanced bridge circuit which may be keyed by signal applied across one diagonal to pass signal applied across the other diagonal, means for applying synchronizing voltage pulses across one of said diagonals, means for applying voltage waves obtained from said oscillator across another of said diagonals, means including a condenser for integrating the resulting output pulses of said bridge to obtain a frequency control voltage, filter means for reducing transient voltages appearing across said condenser, a vacuum tube through which said control voltage is applied to said oscillator to control its frequency in accordance with said control voltage, and means for so coupling said vacuum tube to said oscillator that the oscillator output renders it nonconducting for the duration of each of said transient pulses.

15. A cathode ray deflection system comprising a blocking oscillator, a balanced bridge circuit which may be keyed by signal applied across one diagonal to pass signal applied across the other diagonal, means for applying synchronizing voltage pulses across one of said diagonals, means for applying voltage waves obtained from said oscillator across another of said diagonals, means including a condenser for integrating the resulting output pulses of said bridge to obtain a frequency control voltage, filter means for reducing transient voltages appearing across said condenser, a vacuum tube through which said control voltage is applied to said oscillator to control its frequency in accordance with said control voltage, and means for so coupling said vacuum tube to said oscillator that the oscillator output renders it nonconducting for the duration of each of said transient pulses.

16. The invention according to claim 7 wherein the means for producing said voltage waves includes means for producing a flow of saw-tooth current through a pair of deflecting coils whereby a voltage pulse appears thereacross and means for integrating said last pulse to obtain the said voltage wave having a steep edge.

17. The invention according to claim 7 wherein the means for producing said voltage waves includes means for producing a flow of saw-tooth current through a pair of deflecting coils and a resistor of comparatively low impedance connected in series with said deflecting coils whereby voltage waves having a steep edge appear thereacross.

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