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E. L. C. WHITE
 SYNCHRONIZING PULSE REFORMING
 SYSTEM FOR TELEVISION RELAYS
 Filed April 27, 1946

2,492,943

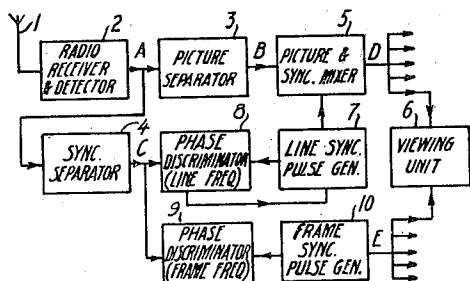


Fig. 1.

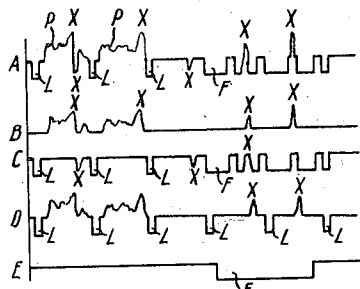


Fig. 2.

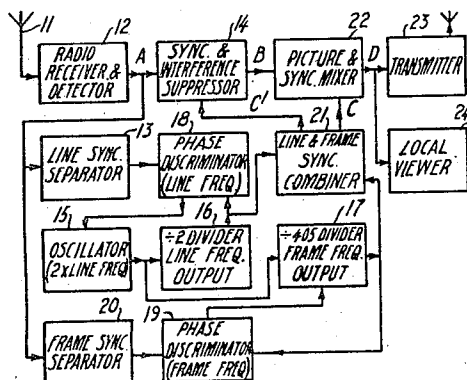


Fig. 3.

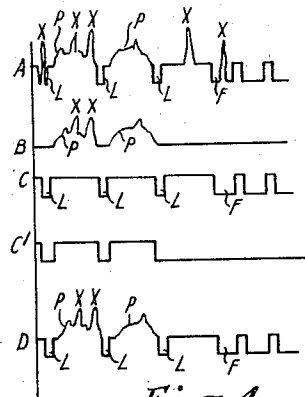


Fig. 4.

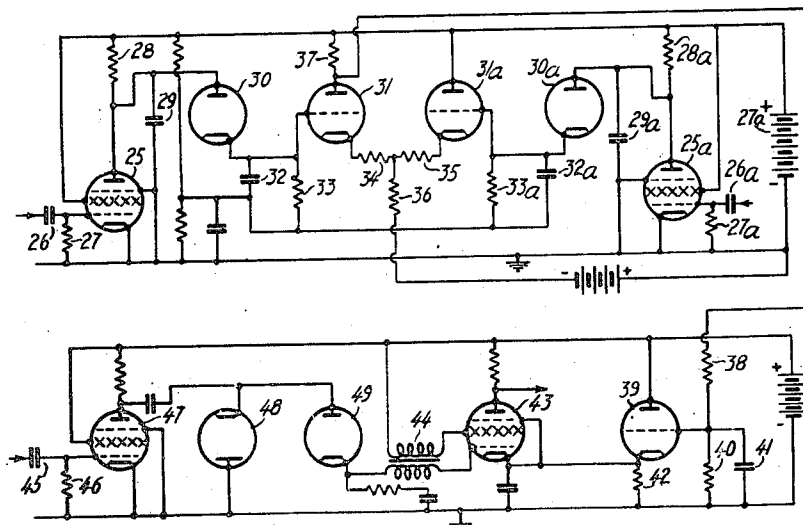


Fig. 5

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SYNCHRONIZING PULSE REFORMING SYSTEM FOR TELEVISION RELAYS

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Patent expires March 14, 1965

2 Claims. (Cl. 178—7.1)

1

This invention relates to television receiving or similar systems and is an improvement in or modification of the system described in United States Patent No. 2,286,450 granted to E. L. C. White et al. June 16, 1942.

In the specification of the patent just mentioned there is described and claimed a television system in which the television signals are likely to be interfered with by interfering signals, there being provided suppression means for suppressing completely or substantially completely all of the signals occurring during intervals between the transmission of the image signals of consecutive lines or consecutive frames and for a period equal to the whole or to part of said intervals and for re-forming said television signals during said period so as to correspond to the original form of said television signals prior to their being interfered with by said interfering signals. Such a system is particularly applicable where a single receiver is required to supply a number of viewing units the signals being distributed to the viewing units at the video frequency. The system is also particularly applicable in cases where interference is likely to be picked up on a radio or cable relay link between a studio and a broadcast transmitter. Also where picture signals are transmitted from a mobile transmitter it may not be possible in some cases to employ a highly directional aerial or it may be required to pick up the transmitted signals from the mobile transmitter at extreme range, in which case interference may be likely to be severe.

In the system described in Patent No. 2,286,450 above mentioned the signals which are removed during the intervals between the transmission of image signals of consecutive lines and frame synchronizing pulses and such pulses are regenerated by the provision of relaxation oscillators which are triggered by the received line and frame synchronizing pulses, the oscillators thus generating fresh pulses under the control of the received pulses, the regenerated pulses being then added to the picture signals. Such an arrangement is satisfactory except in cases where interference is severe. In such cases interference present on the received synchronizing pulses will cause incorrect operation of the oscillators which regenerate the synchronizing pulses and it is accordingly the object of the present invention to provide an improved system in which more accurate control of the oscillators which regenerate the synchronizing pulses can be obtained.

According to the invention there is provided a television receiving or similar system in which the regenerated pulses are derived from a free-

2

running oscillator, the phase of the oscillatory output of such oscillator being compared with the phase of the received synchronizing pulses in such a manner as to develop a control signal depending upon the phase difference between said oscillatory output and the received synchronizing pulses, said control signals being utilized to maintain a predetermined phase relation between said oscillatory output and the received synchronizing pulses by controlling the frequency of said free-running oscillator. The control signal obtained may be suitably smoothed by a circuit having a time constant of several image-repetition periods in order to smooth out the effects of interference which may be present on the received synchronizing signals. In the case of a television system, both the line and frame synchronizing pulses may be regenerated in such manner and added to the signal train or in the case where such a system is employed for feeding several viewing units the regenerated line synchronizing pulses may be added to the signal train while the frame synchronizing pulses may be separately fed to each viewing unit. In the separate viewing units the synchronizing circuits employed therein may be simple relaxation oscillators which are triggered directly by regenerated pulses.

In systems in which synchronizing pulses are "blacker than black" the synchronizing pulses may be removed from the received signals by mixing with said signals pulses extending in the black direction which are slightly wider than the received synchronizing pulses on both sides thereof and which have an amplitude at least equal to the maximum signal or interference in the white direction which can be present at the mixing point, the combined signals being then limited at the black level. This is to insure that when the regenerated synchronizing pulses are added to the picture train the regenerated pulses will commence from the black level and not from a variable level depending on interference.

While it is possible to provide separate free-running oscillators for separately generating the line and frame synchronizing pulses, it may, in some cases, be preferred to employ a single free-running oscillator which operates at twice the line-scanning frequency, such oscillator feeding suitable dividers which serve to generate the line and frame synchronizing pulses. The free-running oscillator may be controlled by a control signal derived by comparing the phase of regenerated line synchronizing pulses with the phase of the received line synchronizing pulses. In order that the said invention may be clearly

understood and readily carried into effect, it will now be more fully described with reference to the accompanying drawings in which:

Figure 1 is a block diagram of a television receiving system suitable for feeding a number of separate viewing units;

Figure 2 illustrates the waveform of signals present at various points in the circuit shown in Figure 1;

Figure 3 is a block diagram illustrating the invention as applied to a television system suitable for use in a relay link;

Figure 4 illustrates the waveform of signals present at various points in the circuit shown in Figure 3; and

Figure 5 is a circuit diagram of a preferred form of circuit for comparing the phase of the received frame synchronizing pulses and the frame regenerated pulses together with a portion of a frequency divider for regenerating frame synchronizing pulses from an oscillator operating at twice the line-scanning frequency.

In the description which is to follow, it will be understood that the terms "picture" and "image" are used interchangeably and that either term refers to subject matter such as a view, object, drawing or the like or an image or representation thereof. Likewise, picture signals, image signals, and video signals are synonymous at appropriate places in the present specification.

The system shown in Figure 1 comprises an aerial 1 which receives television signals comprising image signals interspersed with line and frame synchronizing pulses, the synchronizing pulses being in the "black" direction according to the British or U. S. A. standard waveform or lying in the "whiter than white" direction. The received signals are fed to a radio receiver and detector 2 and after detection are fed to a picture separator 3 which serves to remove the synchronizing pulses from the signal train and to a synchronizing pulse separator 4 which serves to remove the picture signals from the signal train leaving the line and frame synchronizing pulses. Referring to Figure 2 of the drawings, the rectified received signals appearing at the point A in the circuit of Figure 1 are indicated at A in Figure 2, the signals comprising picture signals P, line synchronizing pulses L and frame synchronizing pulses F, the synchronizing pulses being "black" direction, interference being indicated by the reference letters X. After removal of the synchronizing pulses from the signal train the signals appearing at the point B in Figure 1 have the form indicated at B in Figure 2 the signals having been limited at the black level. After removing the picture signals from the signal train in the separator 4 the signals appearing at the point C in Figure 1 have the form indicated at C in Figure 2. The synchronizing pulses may be removed from the signal train in the separator 3 by any suitable means; for example, a non-linear circuit element such as a diode may be employed for this purpose. The picture signals free from the synchronizing pulses and any interference lying in the amplitude range occupied by the synchronizing pulses are mixed with regenerated line synchronizing pulses in a mixer 5 and subsequently fed to a number of viewing units, one of which is indicated at 6. For regenerating the line synchronizing pulses a free-running oscillator 7 is provided which may be of the relaxation type or inductance-capacity type, the frequency of such oscillator being con-

trolled by comparing the phase of the regenerated pulses with the phase of the received synchronizing pulses in a phase discriminator 8. It will be observed that the synchronizing pulses from the separator 4 are fed to the phase discriminator 8 together with regenerated pulses from the generator 7, the relative phases of the inputs to the discriminator 8 being compared so as to derive a control potential which depends on the phase difference between the two inputs the control potential being fed back to the oscillator 7 so as to maintain the output of this oscillator in synchronism with the synchronizing pulses of the separator 4. The control potential from the phase discriminator 8 may be smoothed by feeding it into a circuit having a time constant of several picture repetition periods so as to smooth out the effects of interference and the control potential so obtained may be applied to the grid leak of the free-running oscillator 7 if the latter is of the relaxation type or to a variable reactance valve where the oscillator 7 is of the inductance capacity type.

The regenerated line synchronizing pulses which are thus synchronized with the received line synchronizing pulses are then fed to the mixer 5 for mixing with the picture signal, the output from the mixer 5 at the point D in the circuit shown in Figure 1 being as indicated at D in Figure 2 from which it will be observed that the effect of interference which is likely to destroy the line synchronization is substantially removed. The synchronizing pulses from the separator 4 are also fed to a further phase discriminator 9 which serves to compare the phase of the received frame synchronizing pulses with the phase of regenerated frame synchronizing pulses generated by a further free-running oscillator 10. A control signal derived from the phase discriminator 9 is fed back to the oscillator 10 so as to maintain the regenerated frame synchronizing pulses in synchronism with the received frame synchronizing pulses. The output appearing at the point E in Figure 1 is as shown at E in Figure 2, these frame synchronizing pulses being fed separately to the individual viewing units 6.

Figure 3 illustrates a block diagram of a system suitable for use as a relay link in a television transmission system and also suitable for odd line interlaced scanning. In this circuit received picture and line frame synchronizing pulses are picked up on an aerial 11 and fed to a radio receiver and detector 12, the signals appearing at the point A in the system being as indicated at A in Figure 4 and comprising picture signals P, line synchronizing pulses L and frame synchronizing pulses F, extending in the "black" direction, interference being indicated by the reference letters X. The picture signals and synchronizing pulses from the point A are fed to a line synchronizing pulse separator 13 which removes the picture signals from the signal train and it may also include a high-pass filter for effectively removing the frame synchronizing pulses from the signal train. The output from the receiver 12 is also fed to a synchronizing pulse and interference suppression unit 14 hereinafter more fully referred to, the output from the unit 14 at the point B being as indicated at B in Figure 4 from which it will be observed that the line and frame synchronizing pulses and any interference thereon have been removed from the signal train. For the purpose of regenerating the line and frame synchronizing pulses a free-run-

5

ning oscillator 15 is provided which generates oscillations at twice the line scanning frequency, the output from the oscillator 15 being fed into a frequency divider 16 which divides the output of the oscillator 15 by two, thus providing line frequency synchronizing pulses, the output from the oscillator 15 also being fed to a further divider 17 which serves to generate frame synchronizing pulses, the divider 17 dividing the output of the oscillator 15 by 405, firstly by dividing the output by five, such divided output being then divided by eighty-one in two division ratios of nine. The output from the divider 16 is fed to a phase discriminator 18 which compares the phase of the regenerated line synchronizing pulses with the phase of the received line synchronizing pulses derived from the separator 13. The control signal so obtained which may be smoothed as above described being fed to the oscillator 15 so as to control the frequency of the latter to maintain synchronism between the regenerated line synchronizing pulses and the received line synchronizing pulses. The output from the divider 17 is fed to a phase discriminator 19 where the phase of the regenerated frame synchronizing pulses is compared with the phase of the received frame synchronizing pulses from the output of a frame synchronizing pulse separator 20 to which the output from the receiver 12 is also fed, as shown. The output from the phase discriminator 19 is fed to the divider 17 and serves to control the division ratio in order to maintain synchronism between the regenerated frame synchronizing pulses and the received frame synchronizing pulses.

The outputs from the dividers 16 and 17 and the oscillator 15 are used to control the generation of line frequency and frame frequency synchronizing pulses of the type required for interlaced scanning in known manner in a combining unit 21. The combined regenerated line and frame synchronizing pulses free from interference as indicated at C in Figure 4 are mixed with the picture signals in a mixer 22. The mixed picture and regenerated line and frame synchronizing pulses at the point D in Figure 3 are of the form shown at D in Figure 4, from which it will be observed that interference has been removed from the synchronizing pulses, the output from the mixer 22 being fed to a transmitter 23 and to a local viewing unit 24 for monitoring purposes.

The unit 21 also serves to generate pulses at the line-frequency but which are wider on both sides compared with the line-synchronizing pulses for use as suppression pulses of the form shown at C' in Figure 4. The unit 21 also generates frame-frequency suppression pulses which exist for the whole frame return period, these pulses also being indicated at C' in Figure 4. The suppression pulses are fed into the suppression unit 14 at a greater amplitude than the maximum positive amplitude of any interference, the resulting signals being then limited in the negative direction at a level corresponding to black so as to afford the waveform shown at B in Figure 4.

If desired, between the point A in Figure 3 and the suppression unit 14 a so-called "black spotting" circuit may be used in order to minimize the effect of interference on the picture signals.

It is preferred to generate the frame synchronizing pulses by dividing the output of the oscillator 15 as described above instead of employing a free-running oscillator having a frequency approximately equal to the frequency of the frame synchronizing pulses since for interlaced scanning

6

a very exact phase relationship is required between the line and frame synchronizing pulses and this relationship can more easily be obtained by the arrangement shown in Figure 3. The output from the phase discriminator 19 controls the frequency of the regenerated frame synchronizing pulses and is only required to distinguish between zero phase difference and the phase difference of one or more half-line periods. If the phase difference is not zero, the output from the phase discriminator 19 is employed to change the division ratio of the first dividing stage in the divider 17 from five to four or six or otherwise as may be required.

The phase discriminator circuits employed in the systems above described may be of any suitable known form, one preferred phase discriminator for use as the phase discriminator 19 being shown in Figure 5. In the circuit shown in this figure, the received synchronizing pulses comprising both line and frame synchronizing pulses from the separator 20 are fed to the control electrode of a thermionic valve 25 via a coupling condenser 26 and grid leak 27, the anode of the valve 25 being connected to a source of anode current 27a through such a high anode resistance 28 that in the intervals between successive synchronizing pulses the anode potential of the valve 25 is substantially zero. When synchronizing pulses are present the control electrode of the valve 25 is driven sufficiently negative to render the valve non-conducting so that the anode potential of the valve rises approximately linearly as the condenser 29 which is connected between the lower end of the resistance 28 and the cathode of the valve 25 charges. A diode 30 is connected between the upper end of the condenser 29 and the control electrode of valve 31 the cathode of the diode 30 being connected to the control electrode of the valve 31 and to one electrode of a condenser 32 the other electrode of which is connected to the lower end of a grid leak 33 associated with the valve 31. When a line synchronizing pulse is applied to the valve 25 from the separator 20 the potential across the condenser 29 does not rise sufficiently to cause the diode 30 to conduct owing to a positive bias applied to the cathode of the diode 30. Since, however, a frame synchronizing pulse is much wider than a line synchronizing pulse the potential set up across the condenser 29, when a frame synchronizing pulse is applied to the valve 25, is such that the diode 30 conducts so that the pulse is effectively applied to the control electrode of valve 31. The condenser 32 is small compared with the condenser 29 so that the rate of rise of potential across the condenser 29 is not reduced substantially when the diode 30 conducts. The resistance 33 is of such a magnitude as to allow the potential set up across the condenser 32 to leak away after the termination of a frame synchronizing pulse with a time period equivalent to several lines. The circuit so far described thus serves to separate the line and frame synchronizing pulses from the output of the separator 20 so that only the frame synchronizing pulses are applied to the valve 31. The regenerated frame synchronizing pulses are fed to a similar circuit consisting of condenser 26a, grid leak 27a, valve 25a, anode resistance 28a, condenser 29a, diode 30a, condenser 32a, grid leak 33a and valve 31a. The valves 31 and 31a form a differential amplifier having their cathodes coupled together by the resistances 34, 35, and 36, the anode of the valve 31 being connected to

the anode current source 27a via a resistance 37. The lower end of the resistance 37 is connected via a resistance 38 to the control electrode of a valve 39 which is suitably biased by a resistance 40 and condenser 41 and having a cathode resistance 42 so that it functions as a cathode-follower. The cathode is connected to the cathode of a pentode valve 43 which has its screening electrode and control electrode coupled together by windings 44 so as to function as a blocking oscillator, the valve 43 and its associated elements constituting the first stage of the divider 17. The pulses which occur at twice the line frequency from the oscillator 15 are fed through a coupling condenser 45 and grid leak 46 to a valve 47 associated with diodes 48 and 49, this circuit functioning in accordance with the specification of British Patent No. 471,731 as a counter serving to trigger the blocking oscillator to cause it to function in the desired first division ratio. If the potentials applied from the diodes 39 and 39a to the control electrodes of valves 31 and 31a occur simultaneously no output is fed from the valve 31 to the valve 39 so that the divider comprising the valve 43 functions to divide the pulses applied to the valve 47 by five. If, however, the voltages applied to the valves 31 and 31a do not occur simultaneously the anode potential of the valve 31 will change. The valve 31a is in effect connected as a cathode follower and, hence, its output will be taken from the common cathode resistor with a predetermined polarity. The output from the valve 31 is taken from its anode and its output will then be of a reversed polarity with respect to the output of the valve 31a. The change will be applied to the valve 39 varying its cathode potential, such change in cathode potential being applied to the cathode of the valve 43 so as to cause such valve to alter the division ratio according to the phase displacement of the potentials applied to the valves 31 and 31a.

More in detail, the line and frame synchronizing pulses applied through the coupling condenser 26 cause the potential at the anode of the tube 25 to be periodically raised charging the condenser 29 and causing the anode of the diode 30 to become more positive. Frame (or field) pulses cause the diode 30 to conduct so that a pulse in the positive direction having a sawtooth wave shape is applied to the grid of the tube 31.

The circuit arrangement including the diode 30a is similar to that which includes the diode 30 so that synchronizing pulses applied through the condenser 26a produces positive pulses having a sawtooth wave shape in accordance with frame (or field) signals for application to the grid of the tube 31a.

When a pulse is applied to the grid of the tube 31a, the current through this tube increases so that the point between the resistors 34 and 35 goes more positive. If the pulses applied to the grid of the tube 31 occur simultaneously, the grid of the tube 31 goes more positive. The circuit arrangement, therefore, may be such that there is no change in plate current of the tube 31 when the pulse from the diode 30 is in phase with the pulse of the diode 30a. When this occurs, there is no change in potential at the junction point of the resistor 40 and the condenser 41. If the pulse from the diode 39 predominates, the junction point of the resistor 40 and the condenser 41 changes in negative direction. If the pulses from the diode 30a predominate, the potential at the point just mentioned goes more positive. The

junction point of the resistor 40 and condenser 41 is connected to the grid of the tube 39 which is connected as a cathode follower, and when the cathode of the tube 39 goes more positive, the frequency of the oscillator 43 is increased. When pulses of sawtooth wave shape applied to the grid of the tube 31 and the grid of the tube 31a are in phase the potential at the grid of the tube 39 is steady. If the phase relationship changes, the potential at the grid of the tube changes to change the oscillator frequency.

Although the invention has been described as applied to television transmission systems in which the picture signals are positive, the invention can equally be applied to a system in which the picture signals are negative. In such a case the "black spotting" device above mentioned would be unnecessary. The invention can be employed in conjunction with systems employing any suitable number of picture lines and for any of the types of synchronizing pulses commonly employed, including the present synchronizing pulse standard. Also although the invention has been described above as applied to a television system, it will be appreciated that the invention is equally applicable to other systems where synchronizing pulses are employed and where interference is likely to be encountered.

Having now described the invention, what is claimed and desired to be secured by Letters Patent is the following:

1. A television system comprising means for receiving and demodulating image and sync signals, means for separating said sync signals, an interference suppressor, a connection from said demodulator to said suppressor, an oscillator, a frequency divider fed from said oscillator, a phase discriminator for comparing the output of said means for separating sync signals and said frequency divider to derive a control signal for said oscillator, means to derive suppression pulses from said divider, means to supply the suppression pulses to the suppressor, and means to mix said image signals and the output of said frequency divider.

2. A television system comprising means for receiving and demodulating image and sync signals including line and frame signals, means responsive to demodulated frame sync signals for separating said sync signals, an oscillator, means for dividing the frequency of said oscillator, means for changing the division ratio of the frequency divider, said last named means comprising a phase discriminator, a connection from said separating means to said phase discriminator, and a connection from said frequency divider to said phase discriminator.

ERIC LAWRENCE CASLING WHITE.

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