June 20, 1944. G. L. BEERS 2,351,760

COLOR TELEVISION SYSTEM

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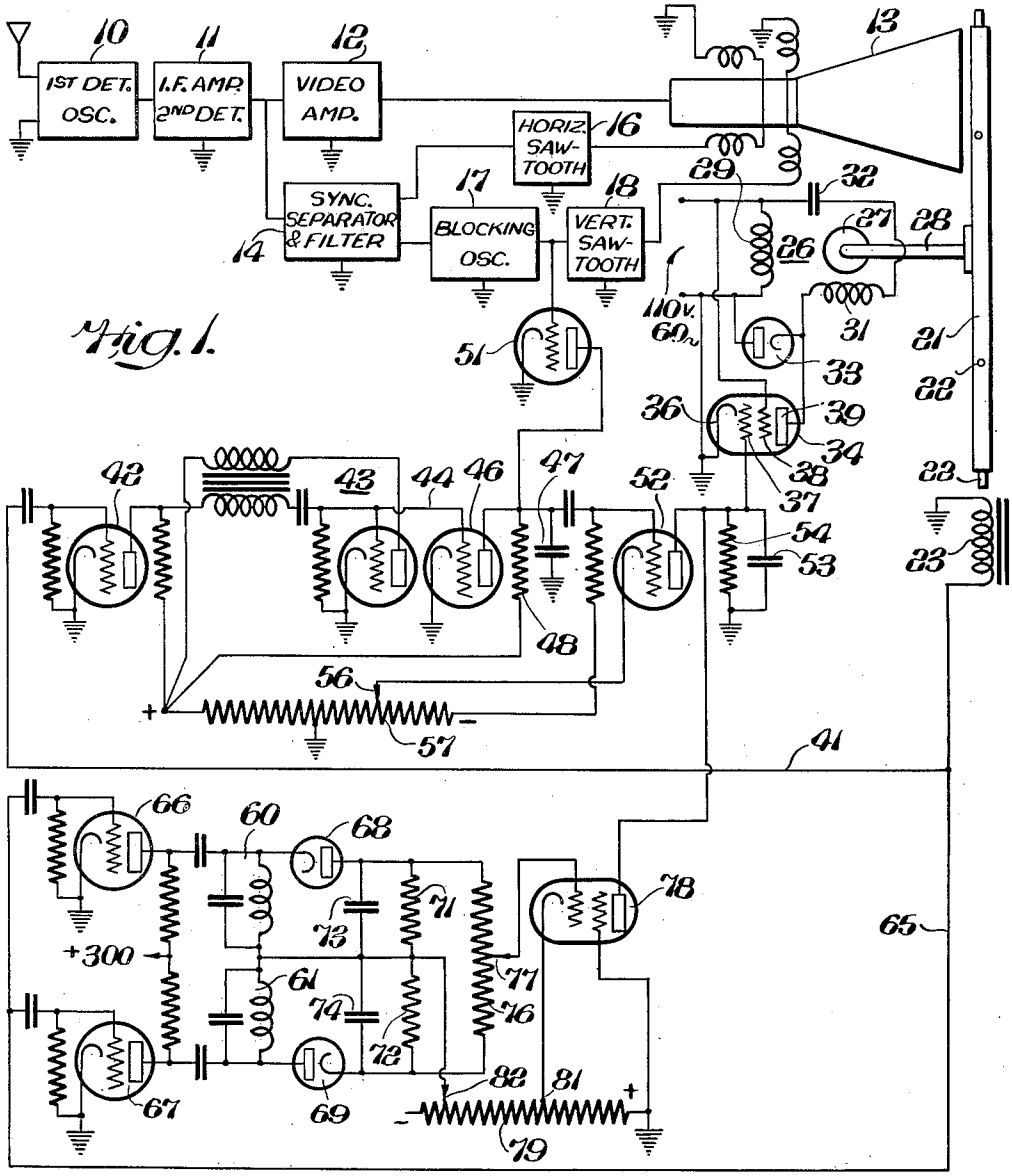


Fig. 1.

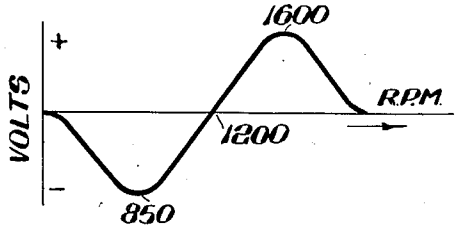


Fig. 2.

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COLOR TELEVISION SYSTEM

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Application August 29, 1941, Serial No. 408,785

4 Claims. (Cl. 178—5.4)

My invention relates to motor speed control circuits or systems and particularly to such control circuits and associated apparatus as applied to television receivers for maintaining a color filter disc or wheel in synchronism with a similar color wheel at the transmitter.

In the past it has been common practice in television systems for transmitting color pictures to utilize at both transmitter and receiver color filters mounted on discs or wheels which are rotated in synchronism by means of synchronous motors operated from a common power line. In systems operated in this way the synchronous motors are rather large and expensive, this being true even when part of the power is supplied by a nonsynchronous motor.

In copending application Serial No. 400,271, filed June 28, 1941, in the name of Gustave L. Grundmann, there is described and claimed an improved system for driving color wheels by means of nonsynchronous motors and for maintaining synchronism by the joint action of phase-responsive and frequency-responsive circuits. It was found that, upon the application of power, this system tended sometimes to permit the driving motor to run through and above the speed region where the phase-responsive circuit was effective for holding the motor at synchronous speed. If this happened, it was necessary to open the power switch to let the motor speed drop and again close the switch.

An object of the present invention is to provide an improved method of and means for driving color wheels or the like in synchronism in a television system.

A further object of the invention is to provide an improved speed control or synchronizing system for television or like apparatus.

A further object of this invention is to provide an improved speed control or synchronizing system for a rotatable member which will always bring said member into synchronism automatically after the power is applied.

In accordance with a preferred embodiment of the invention as applied to a television receiver, the required synchronizing control voltage, which is to be applied to the motor driving a rotatable color wheel, is obtained by a phase-responsive circuit and a balanced frequency-responsive circuit. In the phase-responsive circuit, pulses from a tone wheel or the like rotating with the color wheel are mixed with pulses from the vertical deflecting circuit of the receiver. The combined pulses are rectified and filtered to produce the desired control voltage which changes in value in response to any change in the phase relation of the two groups of pulses. The frequency-responsive circuit, which provides a comparatively rough speed control, also receives pulses from the tone wheel and is effective when the speed of the color wheel is either too much below or too much above the synchronous speed for the phase-responsive circuit itself to be effective. It overcomes the difficulty previously encountered because of the motor's tendency, when started, to speed up too much and reach a speed outside the effective range of the phase-responsive circuit.

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

Fig. 1 is a block and circuit diagram of a television receiver embodying my invention, and

Fig. 2 is a curve showing the relation of the motor speed to the control voltage supplied from a frequency responsive circuit.

Referring to Fig. 1, the television receiver is of a well-known type comprising a first detector and a tunable oscillator indicated at 10, an intermediate frequency amplifier and a second detector indicated at 11, a video amplifier 12 and a cathode ray tube 13. The receiver is designed for the reception of the usual composite signal comprising picture signals and horizontal and vertical synchronizing pulses, a horizontal synchronizing pulse following each scanning line and a vertical synchronizing pulse occurring at the end of each vertical deflection.

The same composite signal is supplied both to the cathode ray tube 13 and to a suitable synchronizing pulse separating and filtering circuit indicated at 14. From the circuit 14, horizontal synchronizing pulses are supplied to a horizontal deflecting circuit 16 and vertical synchronizing pulses are supplied to a vertical deflecting circuit comprising the usual blocking oscillator 17 and sawtooth wave shaping circuit 18.

A color wheel 21 is provided for rotating color filters past the cathode ray tube 13. In the specific example being described, there are three color filters (red, blue and green), on each half of the wheel 21, a total of six filters. Also, there are six metallic teeth 22 on the wheel 21, one for each filter, to form a tone wheel which induces voltage pulses in a pickup coil 23 provided with a permanent magnet to provide the necessary flux.

The color wheel 21 is driven by a capacitor type split-phase motor 26 of conventional design except for the speed control connections. The motor comprises an armature 27 to which the color wheel 21 is coupled through a shaft 28, field wind-

ings 29 and 31 which are displaced 90 degrees in space, and a capacitor 32 through which is supplied the current for the winding 31.

The winding 29 is connected directly across the 60 cycle power line. One end of the winding 31 is connected to one side of the power line through the capacitor 32 while the other end of this winding is connected to the other side of the line through a rectifier such as a diode 33. The last mentioned end of winding 31 in the ordinary split-phase motor connection is connected to the other side of the line through a direct connection rather than through a rectifier.

It will be apparent that with the motor connections thus far described, the current flow through coil 31 would be only momentary and would stop as soon as the capacitor 32 became fully charged. As described and claimed in the above-mentioned Grundmann application, the motor speed is controlled by controlling the amount the capacitor 32 can discharge between positive half cycles of the 60 cycle voltage applied to the plate of the diode 33, thus controlling the amount of current flow through winding 31.

This discharge of capacitor 32 is controlled by a vacuum tube 34 which may be a conventional screen grid tube having a cathode 36, a control grid 37, a screen grid 38 and a plate 39. The tube 34 is connected between the diode end of coil 31 and the diode side of the 60 cycle line in such direction that when the half cycles of the 60 cycle supply are negative at the plate of diode 33, the capacitor 32 may discharge a certain amount through tube 34 depending upon the potential of the control grid 37 with respect to the cathode 36. With this connection, it will be noted, the tube 34 is connected across the diode 33. The screen grid 38 may be connected to the side of the line that is positive during the discharge periods for the capacitor 32, or otherwise provided with a positive operating potential.

The synchronizing control voltage for the grid 37 of tube 34 is obtained as follows:

The pulses produced by the tone wheel in the coil 23 are supplied over a conductor 41 to an amplifier 42 and the amplified pulses are then impressed upon a blocking oscillator 43 of conventional design which produces pulses of large amplitude at the tone wheel frequency. The oscillator 43 is employed merely as a convenient means for converting or amplifying the tone wheel pulses to pulses of the required amplitude.

The blocking oscillator pulses are supplied over a conductor 44 to the discharge tube 46 of a sawtooth wave generator comprising a condenser 47 which receives a charge through a comparatively high resistance resistor 48 and which is discharged suddenly through the tube 46. Thus, there is produced a sawtooth wave which is of sufficient amplitude for control purposes.

To the above-mentioned sawtooth wave there is added a second sawtooth wave occurring synchronously with the vertical deflection. This second sawtooth wave is produced in added relation to the first wave by means of a discharge tube 51 which has its plate-cathode impedance connected across the sawtooth condenser 47 and its control grid connected to the vertical deflecting oscillator 17 for the reception of positive pulses. The control grid of tube 51 may be connected to the grid of a blocking oscillator, for example.

It will be noted that the condenser 47, the resistor 48 and the discharge tubes 46 and 51, in effect, form two sawtooth wave generators which produce sawtooth waves in added relation, the added or combined waves appearing across the condenser 47.

The amplitude of the combined waves depends upon the phase relation of the two sawtooth waves.

The combined waves are applied to a detector tube 52 whereby there appears in its plate circuit a current flow which varies in accordance with the phase relation of said waves. This plate current flow is filtered by a condenser 53 connected across the plate resistor 54 so that, as applied to the grid 37 of the control tube, it is a D. C. control voltage which varies in accordance with any change in the phase relation of the vertical deflection and the color wheel rotation.

As previously explained, an increase in the negative bias on the grid 37 of the control tube will permit less discharge of the motor capacitor 32 and the motor 26 will slow down. Conversely, a decrease in this negative bias will cause the motor to speed up.

Considering the phase responsive circuit operation more in detail, the speed of the motor 26 may first be adjusted manually, as by means of a variable tap 56 on the voltage divider 57, so that the color wheel 21 is running in synchronism with the vertical deflection when the two sawtooth waves have a phase relation where the color wheel sawtooth occurs slightly later than the other sawtooth. Then the automatic control action is as follows:

If the motor starts to speed up, the phase relation of the sawtooth waves changes so that the amplitude of the combined wave increases the plate current of tube 52, whereby the plate end of resistor 54 becomes more negative. This increases the negative bias on the grid 37 of the control tube and the motor 26 is slowed down.

Similarly, if the motor starts to slow down, the phase relation of the sawtooth waves changes so that the amplitude of the wave applied to the tube 52 decreases, the plate current of tube 52 decreases and the grid of tube 37 is made less negative so that the motor speeds up.

It has been found that while the color wheel can be held in synchronism in this manner, the motor may have to be started up several times before it is held in synchronism unless additional control means is provided. In accordance with my invention, the additional control circuit utilizes balanced tuned circuits 60 and 61 to give sufficient control of the motor speed to avoid any difficulty in bringing the motor to and holding it in the speed range where the phase-responsive circuit is effective. The design of this frequency responsive circuit is such that if the motor speeds up past synchronous speed region, it is pulled back to a speed close to synchronism.

It may be noted also that the circuit is substantially independent of line voltage variations because of the balanced connections.

The tone wheel pulses are applied over a conductor 65 to a circuit comprising amplifier tubes 66 and 67 which have their plate circuits connected in balanced relation.

The amplified pulses from tubes 66 and 67 are applied to the pair of tuned circuits 60 and 61 which are connected in balanced relation both to the tubes 66 and 67 and to a pair of diode rectifiers 68 and 69. These tuned circuits are so tuned with respect to the tone wheel frequency at color wheel synchronism that the voltage across them changes with any change in the speed of the color wheel 21.

Specifically, in the example being described,

the circuit 60 is tuned to resonate slightly below the tone wheel frequency at synchronism while the circuit 61 is tuned to resonate slightly above said frequency. Thus an increase in the color wheel speed will increase the voltage across the diode 69.

The rectified outputs of the diodes 68 and 69 appear across the load resistors 71 and 72, respectively, which are connected in balanced relation to the diodes. The load resistors are shunted by filtering condensers 73 and 74 and by an output resistor 76 having a variable tap 77.

The output of the balanced circuit is applied from the tap 77 to a direct current amplifier 78 which has its output added to the output of the phase responsive circuit. Thus, the outputs of the two control circuits are impressed upon the grid 37 of the motor control tube 34.

The tap 77 preferably is set at the electrical midpoint of resistor 76 so that when the color wheel is at synchronous speed the voltage at 77 with respect to the cathode of amplifier tube 78 is only the voltage from a voltage divider 79, which voltage appears between the cathode tap 81 and a variable tap 82. The tap 82 is initially adjusted to make the color wheel run approximately at synchronous speed.

It will be apparent that if the color wheel tends to run too fast when power is applied to the receiver, the output of diode 69 will increase, the control grid of tube 78 will go less negative and the grid 37 of motor control tube 34 will go more negative whereby the motor 26 will be slowed down. The opposite action takes place if the motor tends to run too slow.

From the foregoing, it will be seen that the color wheel driving motor is held in synchronism, rather than merely at a speed close to synchronism, by the first-described portion of the circuit which is responsive to the phase difference of tone wheel pulses and vertical deflection pulses, while the motor speed is held within certain limits by the frequency-responsive balanced circuit to insure proper control by the first circuit.

I claim as my invention:

1. In combination, a motor which is to run in synchronism with a synchronizing signal, means actuated by said motor for producing a control signal as a function of the motor speed, means comprising a frequency responsive circuit for either increasing or decreasing the speed of said motor in response to a change in said control signal for holding said speed between predetermined limits, circuit means responsive to a change in the phase relation of two applied voltages, said phase responsive circuit being independent of said frequency responsive circuit, means for applying said synchronizing signal and said control signal to said phase responsive circuit means whereby there is produced a synchronizing output, and means for further controlling the speed of said motor in accordance with said synchronizing output.

2. In a television receiver, a non-synchronous motor for moving color filters successively into position for color picture reproduction, means actuated by said motor for producing a control signal, means for receiving a synchronizing signal, means comprising a frequency responsive circuit for either increasing or decreasing the speed of said motor in response to a change in said control signal for holding said speed between predetermined limits, additional control means which is independent of said frequency responsive circuit, for producing a voltage output which changes in value in response to a change in the phase difference of two signals applied thereto, means for applying said control signal and said synchronizing signal to said additional control means whereby its voltage output varies with any phase difference between said signals, and means for further controlling the speed of said motor in accordance with said voltage output.

3. In combination, a motor which is to run in synchronism with a synchronizing signal, means actuated by said motor for producing a control signal in a fixed time relation to the speed thereof, a balanced frequency responsive circuit, means for applying said control signal to said balanced circuit whereby its output changes in response to frequency changes in said control signal, means for controlling the speed of said motor in accordance with the output of said balanced circuit whereby said speed is held within a certain range, and means independent of said frequency responsive circuit for further controlling the speed of said motor within said range in response to changes in the phase relation of said synchronizing signal and said control signal.

4. In a television receiver, a split-phase motor for moving color filters successively into position for color picture reproduction, said motor having two field windings, a capacitor and a rectifier connected in series with each other and in series with one of said windings, said series combination and the other of said windings being connected in parallel with each other, and a variable impedance device connected across said rectifier, means actuated by said motor for producing a control signal, means for receiving a synchronizing signal, control means for producing a voltage output which changes in value in response to a change in the phase difference of two signals applied thereto, means for applying said control signal and said synchronizing signal to said control means whereby its voltage output varies with any phase difference between said signals, means for controlling the impedance of said variable impedance device in accordance with said voltage output, and means comprising a frequency responsive circuit for either increasing or decreasing the speed of said motor in response to a change in said control signal for holding said speed between predetermined limits.

GEORGE L. BEERS.