June 19, 1945. G. L. BEERS 2,378,746

COLOR TELEVISION SYSTEM

Filed June 28, 1941 3 Sheets-Sheet 1

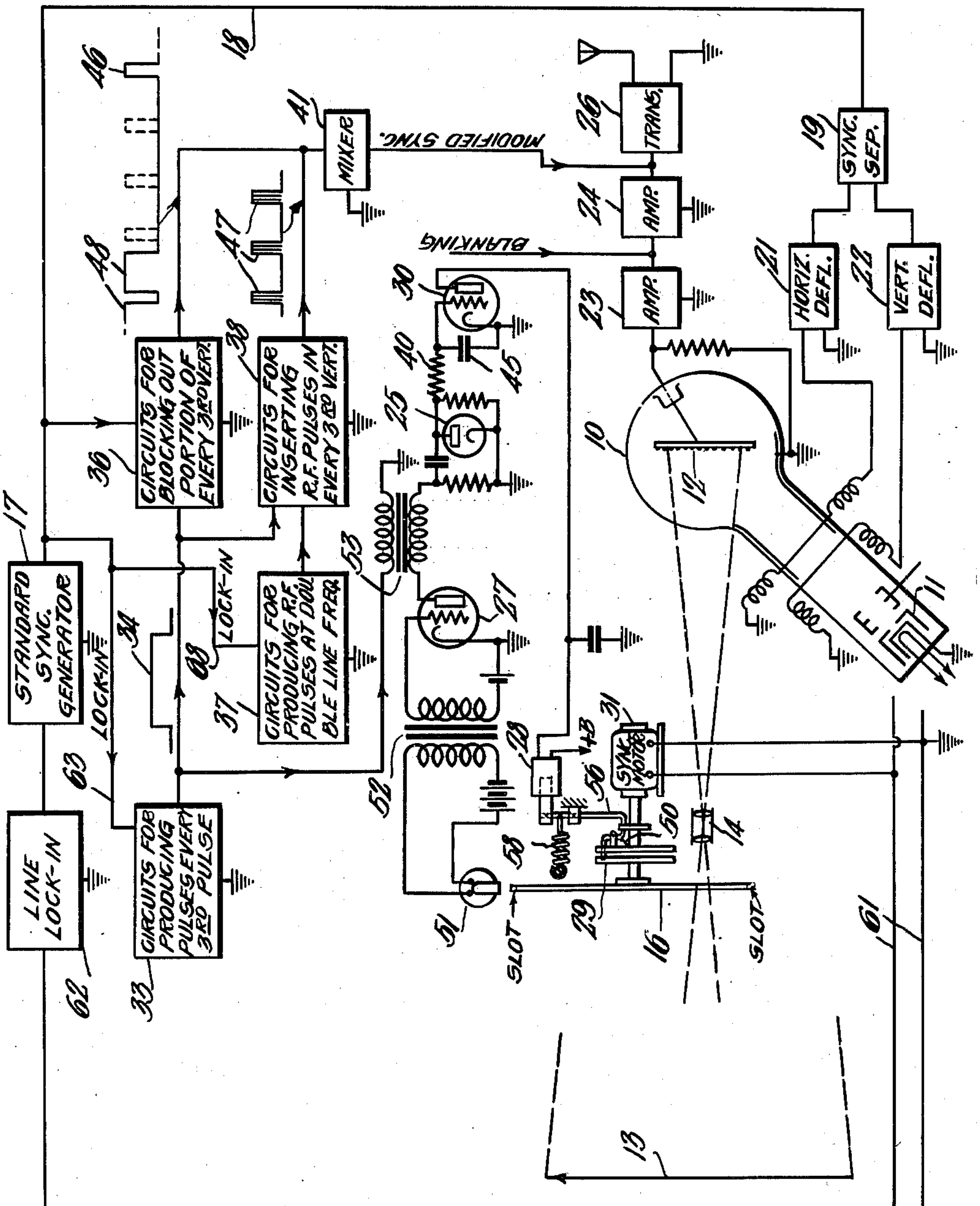


Fig. 1.

Inventor
George L. Beers

By J. Huff

Attorney

June 19, 1945. G. L. BEERS 2,378,746

COLOR TELEVISION SYSTEM

Filed June 28, 1941 3 Sheets-Sheet 2

Fig. 2.

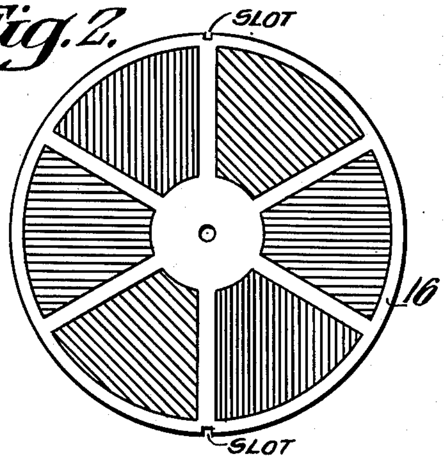


Fig. 3.

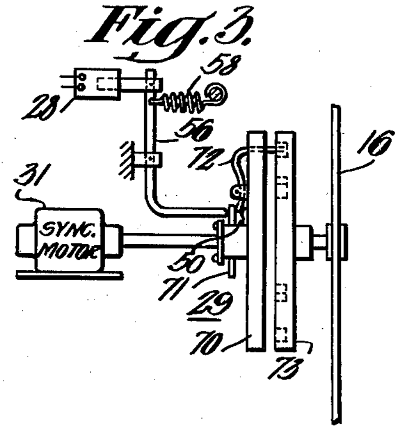
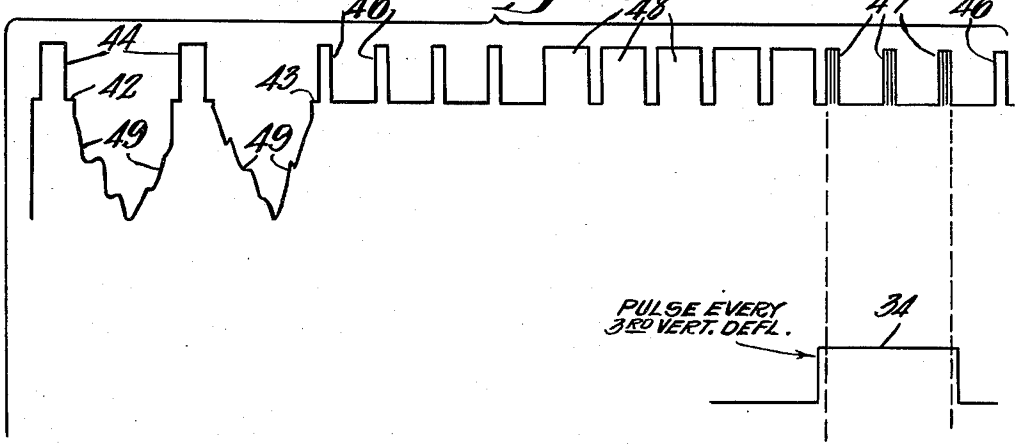


Fig. 4.



Inventor
George L. Beers

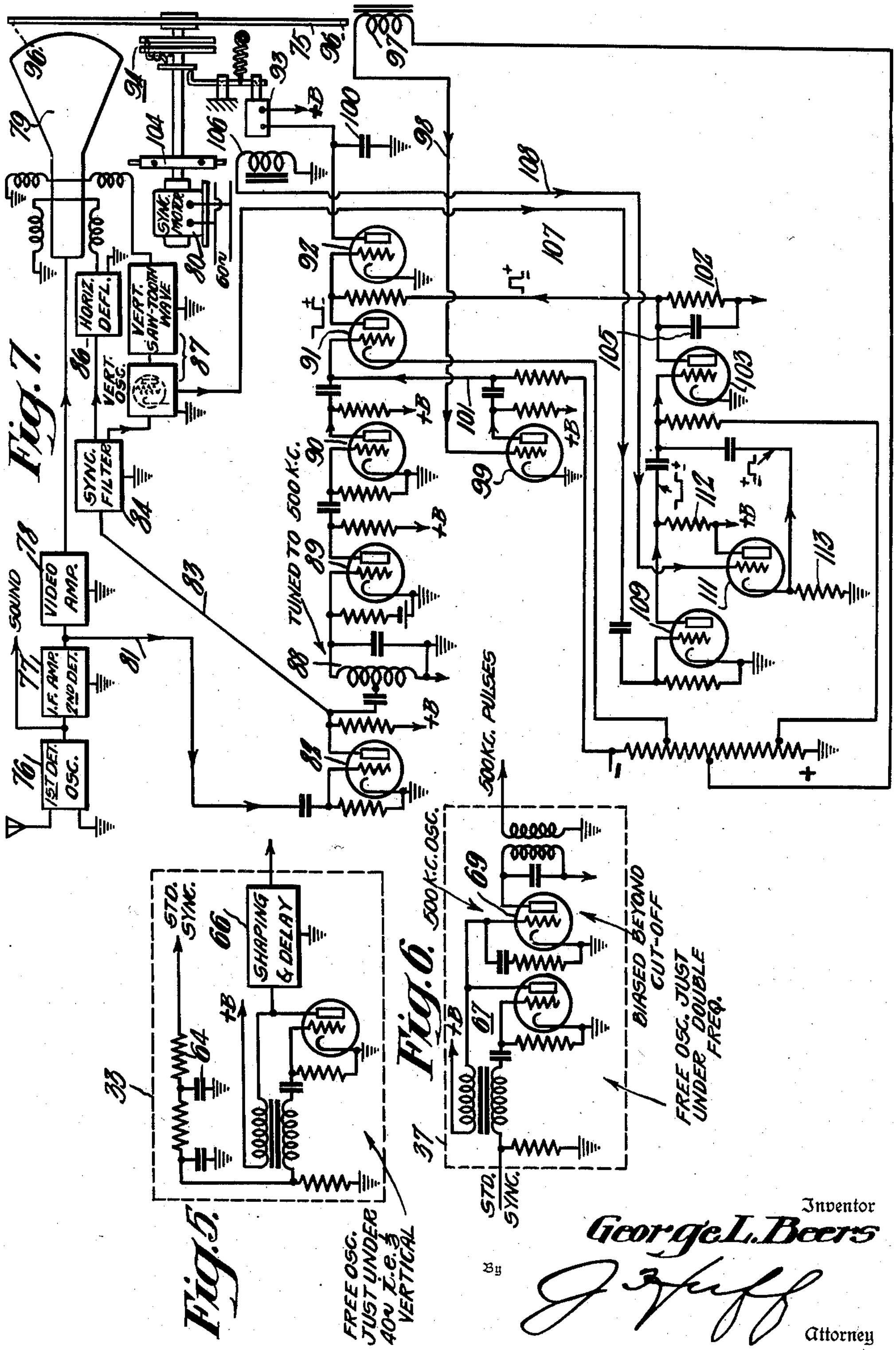
By

Attorney

June 19, 1945. G. L. BEERS 2,378,746

COLOR TELEVISION SYSTEM

Filed June 28, 1941 3 Sheets-Sheet 3



Inventor

George L. Beers

By

Attorney

Patented June 19, 1945

2,378,746

UNITED STATES PATENT OFFICE

2,378,746

COLOR TELEVISION SYSTEM

George L. Beers, Haddonfield, N. J., assignor to Radio Corporation of American, a corporation of Delaware

Application June 28, 1941, Serial No. 400,173

5 Claims. (Cl. 178—5.2)

My invention relates to television systems and apparatus and particularly to systems for the transmission and reception of color images or pictures.

One of the preferred systems for televising color images requires the use of color filters which, preferably, are mounted on a rotatable supporting disc or the like to form what is commonly referred to as the color wheel. The color wheel at the receiver must operate both in synchronism and in the proper phase relation to the color wheel at the transmitter. As an example of the necessity for a proper phase relation, at the instant the image at the transmitter is being imaged through a red filter, the red filter at the receiver must be in front of the image on the receiver tube.

The necessary synchronism of the color wheels may be maintained by driving them by synchronous motors operated from a common power line.

The necessary phasing of the color wheels at transmitter and receiver usually may be accomplished manually, for example, by opening momentarily the power circuit of the color wheel driving motor to let the wheel slip, if it happens that the color wheel locks in at the wrong phase. This method of phasing has been proposed by others. Usually the proper phase relation may be obtained by opening the circuit a number of times until the two color wheels are in phase, but it will be apparent that this random method of phasing the wheels is undesirable. Furthermore, in the case of some subject matter such as colored titles or kaleidoscopic patterns, the above method of operation is entirely unsatisfactory since an observer at the receiver cannot tell when proper phasing of the color wheel is obtained. Also, when switching from one pickup camera to another in the studio, or from one studio to another, the color wheels on each pickup camera should be in phase as otherwise it would be necessary to change phase relations at the receiver each time a different camera pickup tube is switched in.

An object of the present invention is to provide a system of the above-described type in which the color wheels are automatically brought into the proper phase relation.

A further object of the invention is to provide a system of the above-described type in which the color wheels are brought into synchronism before the phasing means becomes effective.

In a preferred embodiment, the invention is applied to a three color system in which red, blue and green color filters are mounted on the color wheels. In order to phase the color wheel at the receiver, every third vertical synchronizing pulse is transmitted with a group of 500 kc. pulses replacing a group of the rectangular double frequency pulses of the standard synchronizing signal. At the receiver, the 500 kc. pulses are supplied to a tuned circuit to produce a control pulse which is fed to a clutch control circuit together with a pulse produced by the receiver color wheel. If the two pulses occur simultaneously, the transmitter and receiver color wheels are properly phased and the control circuit does not have any effect. Otherwise, the control circuit causes a clutch to slip until the color wheels come into the desired phase relation.

The invention will be better understood from the following description taken in connection with the accompanying drawings in which

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

Fig. 2 is a view showing the type of color wheel used at transmitter and receiver,

Fig. 3 illustrates a clutch through which the color wheel may be driven,

Fig. 4 illustrates the character of the synchronizing signal produced at the transmitter of Fig. 1,

Figs. 5 and 6 are circuit diagrams of the apparatus included in certain blocks shown in Fig. 1, and

Fig. 7 is a circuit diagram of a television receiver embodying my invention.

Referring to Fig. 1, one embodiment of the invention is shown applied to a color television transmitter comprising a cathode ray pickup tube such as an iconoscope **10**. The tube **10** is of a well-known type which comprises an electron gun **11** for directing a scanning beam against a mosaic of photoelectric elements **12**. An image to be transmitted, such as a studio scene indicated at **13**, is projected upon the mosaic **12** by means of a suitable lens system **14**, the image being projected through a color wheel **16** shown in detail in Fig. 2.

Synchronizing signals are produced by a synchronizing signal generator **17** which may be the same as that described in the J. P. Smith Patent No. 2,132,655, issued October 11, 1938, or in the patent to Alda V. Bedford No. 2,258,943; issued on Oct. 14, 1941. These signals are transmitted over a conductor **18** through a separating circuit **19** to the horizontal and vertical deflecting circuits **21** and **22**, respectively, for causing the beam in the pickup tube to scan the mosaic **12**.

The image signals supplied by the pickup tube

10 are amplified by suitable amplifiers 23 and 24 and are supplied to a radio transmitter 26 for modulating a carrier wave for transmission to television receivers.

In the particular embodiment of the invention shown in Fig. 1, the transmitter color wheel 16, as well as the receiver color wheel (which is shown in Fig. 7 to be described later), is automatically rotated in a fixed phase relation with respect to the output of the synchronizing signal generator 17 by producing a modified synchronizing signal and supplying it to a control tube 27. As will be explained hereinafter, if the color wheel 16 is not in the proper phase relation, the control tube 27 and the following tubes will supply current to a solenoid or relay coil 28, and the clutch 29 through which the color wheel is driven by a synchronous motor 31 will slip.

Similarly, as will be described later in connection with Fig. 7, the modified synchronizing signal is supplied to a control circuit in the receiver to slip a color wheel clutch if the color wheel is not in the proper phase relation.

As previously stated, the modified synchronizing signal differs from the standard signal in that a pulse or burst of high frequency signal, such as a pulse of 500 kc. signal, is included in every third framing signal. Before describing one way of generating the modified signal, it may be noted that in the specific system being described, the vertical deflection frequency is 120 per second, and the scanning is double interlaced. The horizontal deflection frequency is 20,580 per second, giving a 343 line image.

The time relation of the vertical deflection and the color wheel rotation is such that while one color filter such as the red filter of the wheel 16 is opposite the camera lens 14, there is one vertical deflection of the beam in the pickup tube 10. In three vertical deflectioins, a three color image has been transmitted. It will be noted that the double interlaced scanning pattern begins to repeat with the third vertical deflection so far as scanning line location is concerned, but that the color sequence begins to repeat with the fourth vertical deflection. Thus, a three color image is built up at the rate of 40 frames per second.

Referring now to the apparatus shown by way of example in Fig. 1 for producing the modified synchronizing signal, the generator 17 supplies horizontal synchronizing pulses at the rate of 20,580 per second, and supplies the usual slotted vertical synchronizing pulses at the rate of 120 per second (this being twice the conventional rate for black and white pictures). Preceding and following each slotted vertical synchronizing pulse there are additional pulses which double the horizontal pulse rate. The modified signal is produced in this particular case by removing three of the double frequency pulses following the slotted vertical synchronizing pulse and replacing them by three pulses of 500 kc. signal.

This may be done by

(1) Producing in a circuit 33 a pulse 34 occurring every third vertical synchronizing pulse,

(2) Utilizing the pulse 34 in a circuit 36 to remove or block out the said three pulses,

(3) Producing in a circuit 37 pulses or bursts of 500 kc. signal at the said double frequency rate,

(4) Utilizing the pulse 34 in a circuit 38 to remove or block out all the 500 kc. pulses of signal except the three pulses that are to replace those removed from the standard signal, and

(5) Mixing the outputs of the circuits 36 and 38 in a mixing circuit 41 to obtain the desired modified synchronizing signal which is illustrated in Fig. 4.

In Fig. 4, the above-described modified synchronizing signal is shown set on top of the usual horizontal and vertical blanking pulses or pedestals indicated at 42 and 43, respectively. The horizontal synchronizing pulses are indicated at 44, the usual double frequency pulses are indicated at 46, the 500 kc. pulses or bursts are indicated at 47, and the slotted vertical synchronizing pulse is indicated at 48. The image signal produced during each scanning line is shown at 49.

The combined signal of Fig. 4, which is transmitted to the television receivers, is obtained by mixing together the image signal, suitable blanking pulses (from a source not shown), and the modified synchronizing pulses in the usual manner as illustrated in Fig. 1.

Before describing in more detail the circuit for producing the modified synchronizing signal, the way in which the color wheel 16 is controlled will be further explained.

As shown in Figs. 1 and 2, the metallic disc or supporting frame of the color wheel has two diametrically opposed slots or notches which, as they rotate past a pickup coil 51, generate voltage pulses therein. These wheel pulses are impressed through a transformer 52 upon the control grid of the amplifier tube 27.

The plate of the tube 27 has the pulses 34 impressed thereon with positive polarity through a transformer 53. If the pulses applied to grid and plate of tube 27 occur simultaneously, there are pulses of plate current which are rectified by a diode 25 and impressed with sufficient negative polarity upon a D.-C. amplifier 30 to bias it beyond cut-off. Therefore, there is no current supplied to the solenoid coil 28 and the arm 56 is pulled to the left by a spring 58 so that the clutch 29 is held engaged by a spring 50. These plate current pulses which are recurring every third vertical deflection, i. e. at the rate of 40 per second, appear at the grid of tube 30 as a direct current bias since the rectified pulses are filtered by the series coupling resistor 40 and a shunt condenser 45.

If the color wheel pulses and the pulses 34 are not in phase, there is no negative bias on the tube 30 and current is supplied to the solenoid coil 28 to pull the arm 56 to the right and disengage the clutch, allowing the color wheel 16 to slip through an angle equivalent to one color filter. If the first angular displacement of the disc does not move the proper filter into position the process is repeated. When the wheel 16 comes into the proper phase relation, the clutch 29 then becomes engaged and remains engaged.

It will be noted that the synchronizing signal generator 17 is locked in on the 60 cycle power line 61 so that the color wheel rotation is in a fixed time relation to the recurring pulses 34 when the clutch 29 is engaged. This lock-in may be accomplished by means well-known in the art, the lock-in circuit being indicated at 62.

In Figs. 5 and 6, I have shown, merely by way of example, circuits which may be employed in Fig. 1 in the blocks 33 and 37, respectively.

Referring to Fig. 5, this circuit comprises the well-known blocking oscillator which is adjusted to be synchronized by the vertical synchronizing pulses at one-third their frequency, i. e. at 40 pulses per second. The synchronizing pulses are supplied to the oscillator over a lock-in connection 63 (Fig. 1) and through a filter 64 (Fig. 5) which removes the horizontal synchronizing pulses. Suitable shaping and delay means 66 change the 40 cycle blocking oscillator pulses to the rectangular pulses 34 which occur in the proper time relation to the signal output of generator 17. This time relation is shown in Fig. 4, although the signal 44, 46, 47, 48 illustrated in this figure is the final modified signal.

The block 36 contains suitable clipping tube circuits for mixing pulses 34 and the output of generator 17 to produce a signal in which the pulses indicated by dotted lines have been removed. Circuits for accomplishing this are described in above-mentioned Smith Patent 2,132,655.

Referring to Fig. 6, the block 37 may include a blocking oscillator 67 adjusted to be synchronized at double line frequency from the lock-in connection 68 (Fig. 1). The pulses of oscillator 67 key a 500 kc. oscillator 69 which is so biased that it oscillates only upon the application of a blocking oscillator pulse. The resulting pulses of 500 kc. signal are mixed with the pulses 34 in the circuit 38 where suitable clipping tube circuits, such as described in the Smith patent, remove all 500 kc. pulses except the group of three pulses 47 which recur at the rate of 40 groups per second. By adding or mixing the outputs of circuits 36 and 38 in the mixer circuit 41, the desired modified synchronizing signal is obtained.

In Fig. 3, the clutch 29 is shown in more detail, the parts in this figure which correspond to those in Fig. 1 being indicated by the same reference characters. It will be seen that so long as the arm 56 is held away from an axially movable plate 71 by the spring 58, the clutch is held engaged by the spring 50 which holds an arm or dog 72 (pivoted on a clutch plate 70) against the face of a clutch plate 73.

The said clutch face has six circumferentially spaced depressions into any one of which the dog 72 may drop for locking the two clutch plates together. It will be noted that the clutch may be locked in as many positions (six) as there are filters on the color wheel 16.

Referring now to the television receiver of the system, shown in Fig. 7, it may comprise the usual first detector and tunable oscillator indicated at 76 for converting the incoming image signal and accompanying sound signal to intermediate frequency signals. The *i—f* image signal is supplied to an *i—f* amplifier and second detector indicated at 77 and the output of the second detector is amplified at 78 and applied to the input electrodes of a cathode ray tube 79.

A color wheel 75 driven by a synchronous motor 80 is positioned in front of the fluorescent screen end of the cathode ray tube 79, which may be for either direct viewing or projection. This color wheel may be a duplicate of the color wheel 16 shown in Figs. 1 and 2.

The second detector output, which is like the signal shown in Fig. 4, is supplied over a conductor 81 to a synchronizing pulse separator tube 82 which is grid-leak biased to remove picture signal in a well-known manner. Thus, only the synchronizing pulses are supplied over a conductor 83 to a filter 84 for separating horizontal and vertical synchronizing pulses, these separated pulses being applied to the horizontal and vertical deflecting circuits at 86 and 87, respectively. The vertical deflecting circuit includes the usual vertical deflection oscillator, such as a blocking oscillator, and a saw-tooth wave producing circuit as indicated on the drawings.

The synchronizing pulse output of the separator tube 82 is also supplied to a color wheel phase control circuit which includes a tuned circuit 88 tuned to the frequency of the oscillator generating the pulses 47 (Fig. 4), in this example, tuned to 500 kc. As a result, the group of three 500 kc. pulses 47 only appear across the tuned circuit 88. At the output of a rectifier tube 89 they appear as a single color wheel phasing pulse, since the output circuit of tube 89 is such as to give poor high frequency response. This phasing pulse, which occurs every third vertical deflection, is passed through the rectifier tube 89 which is normally biased to cut-off and, after amplification by a tube 90, is applied to the grid of a tube 91, the polarity of the pulse being positive at this grid.

It will be understood that the said phasing pulse from the rectifier 89 may be narrowed or otherwise reshaped, if desired, in any suitable manner as by the use of a blocking oscillator.

The pulse output of tube 91 is applied with negative polarity to the grid of an output tube 92 which is connected to supply current to the solenoid 93 of a color wheel clutch 94 similar to the clutch 29 in Fig. 1. This clutch is designed so that it is engaged so long as there is no current flow through solenoid 93.

Color phasing pulses produced in a pick-up coil 97 by diametrically opposed slots 96 in the color wheel 75 are supplied over a conductor 98 to a vacuum tube 99 which is biased to cut-off for passing only positive pulses whereby pulses of negative polarity are applied through a conductor 101 to the grid of tube 91. These pulses appear on the grid of the output tube 92 with positive polarity and, assuming the color wheel 75 has come up to synchronous speed, will produce a current flow through the clutch solenoid 93 to disengage and slip the clutch unless the negative pulses at the tube 92 (from the tuned circuit 88) are occurring simultaneously therewith, that is, unless the color wheels at transmitter and receiver are properly color phased. A filter condenser 100 may be connected in shunt to the solenoid coil 93 to smooth out the current pulses supplied by tube 92 for disengaging the clutch.

Unless the color wheel 75 has come up to synchronous speed, the output tube 92 is held biased beyond cut-off so that the color phasing pulses cannot slip the clutch. This is done so that the clutch will not be disengaged by the pulses from pick-up coil 97 when the color wheel starts to come up to synchronous speed.

The tube 92 is held biased beyond cut-off as the color wheel comes up to speed by means of a current flow through a resistor 102 in the plate circuit of a vacuum tube 103. The resistor 102 preferably is shunted by a smoothing condenser 105. This current flow is produced as follows: Pulses from the vertical deflection oscillator at 87 together with pulses from a synchronizing tone wheel 104 and pick-up coil 106 are supplied over conductors 107 and 108 to the vacuum tubes 109 and 111, respectively. These pulses, which appear across the plate resistor 112 of tube 109 and across the cathode resistor 113 of tube 111, are applied to the grid of the tube 103.

The pulses from the vertical deflection oscillator are the positive polarity pulses taken from the grid of a blocking oscillator, for example. Only positive pulses are passed by the tube 109 since it is biased to cut-off, and they appear at the grid of tube 103 with negative polarity.

The pulses from the pick-up coil 106 are A.-C. pulses and appear as such across cathode resistor 113, but only the positive portion has any effect on the plate current flow in tube 103. Since the tube 103 is biased to cut-off, there is no plate current flow unless such current flow is produced by the positive pulses from the pick-up coil 106. These pulses will cause current flow until the tone wheel 104 and the color wheel 75 come up to synchronous speed, at which time the negative pulses from tube 109 occur simultaneously with the tone wheel pulses from tube 111 and drive the grid of tube 103 so far negative that the positive tone wheel pulses no longer cause plate current to pass through plates resistor 102.

Thus when synchronous speed is reached, the voltage across resistor 102 drops to zero or to a value low enough to hold the bias on the grid output of tube 92 substantially at plate-current cut-off, but not much beyond cut-off, whereby the color phasing circuit may now become effective as described.

It will be understood that, in the example being described, the tone wheel 104 has six metallic projections for producing one pulse for each vertical deflection.

Preferably, the negative pulses at the grid of output tube 92 (i. e., the pulses from the tuned circuit 88) are wider than the positive pulses applied to this grid to allow the receiver color wheel to get slightly out of phase with the transmitter color wheel the permissible amount without causing the clutch to slip. This permissible amount is not very great; it is only a small fraction of the circumferential arc occupied by a single color filter. More specifically, the said negative pulse should start slightly before and end slightly after the positive pulse. Likewise, at the grid of tube 103, the negative pulse from the tube 109 preferably should be of greater duration than the positive pulse from the tube 113.

From the foregoing description it will be apparent that when the receiver power is switched on, the color wheel 75 is brought up to a speed where it runs synchronously with the color wheel 29 at the transmitter, that the tube 92 is held biased substantially beyond cut-off until this synchronous speed is reached whereby the clutch is held engaged, and that when synchronous speed is reached the color phasing circuit becomes effective to slip the clutch until the color wheel is properly phased. Thus completely automatic color phasing of the color wheels is obtained.

It should be understood that at either the transmitter or receiver or both, the clutch may be omitted and a power supply switch for the synchronous motor substituted. Thus, the solenoid coils 28 and/or 93 may be utilized to open the motor power supply circuit momentarily to permit the phase relation of the color wheel to change by the motor slipping a pole.

It should also be understood that the invention is not limited to a system which transmits the specific type of signal described since the principal requirement is that there be an identifying signal of some kind transmitted at the proper color phasing time.

Also, where the particular type of signal shown and described is transmitted, it may be generated by means other than that described. For example, the entire synchronizing and color phase control signal may be generated by an apertured or toothed disc rotating in fixed relation to the transmitter color wheel. The use of such discs for generating synchronizing pulses is well-known.

I claim as my invention:

1. A television system for transmitting and receiving color images, said system comprising a plurality of color filters at the transmitter and a plurality of color filters at the receiver, means for transmitting an image as viewed successively through said filters at the transmitter, means for generating a color phasing signal, means for transmitting the color phasing signal, means at the receiver for observing the received image as viewed successively through said filters at the receiver, and means for causing said filters at transmitter and receiver to assume automatically a predetermined color phase relation in response to the generated and transmitted color phasing signal.

2. The invention according to claim 1 wherein the said means for transmitting a color phasing signal comprises means for transmitting a synchronizing signal which includes pulses of radio frequency signal occurring in place of certain rectangular synchronizing pulses.

3. A television system for transmitting and receiving color images, said system comprising means for transmitting images in different colors in time sequence, said receiver comprising a reproducing device and a plurality of color filters, means for generating a color phasing signal, means for transmitting the color phasing signal, means at the receiver for observing the received image as viewed successively through said filters, and means for causing said filters to assume automatically a predetermined color phase relation in response to the generated and transmitted color phasing signal when and only when there is a synchronous relation between the time sequence of the received color images and the relative movement of said filters.

4. A television transmitter comprising a cathode ray pickup tube, a plurality of color filters, means for projecting an image through said filters successively upon said pickup tube for transmission, means for producing synchronizing signals including regularly recurring color phasing signals, means for transmitting said signals to receiver stations, and means responsive to said color phasing signals for causing the said image transmission through successive filters to assume a predetermined color phase relation with respect to said color phasing signals.

5. A television transmitter including a plurality of color filters through which the image to be transmitted is viewed successively, means for producing synchronizing signals which include regularly recurring color phasing signals, means for transmitting said signals to receiving stations, and means for moving said filters in a predetermined time relation with respect to said color phasing signals, said last named means comprising control signal generating means for producing signals recurring at a rate which is a function of the movement of said color filters and further comprising means for mixing said control signal together with pulses from said synchronizing signal producing means in a circuit responsive to the phase difference between said two groups of pulses whereby a phasing control voltage is produced, and means for changing the color phase relation of said filters with respect to said color phase signal in response to a predetermined change in said phasing control voltage.

GEORGE L. BEERS.