

July 13, 1943.

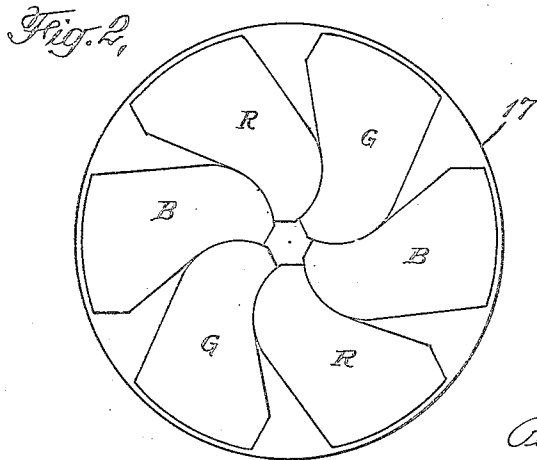
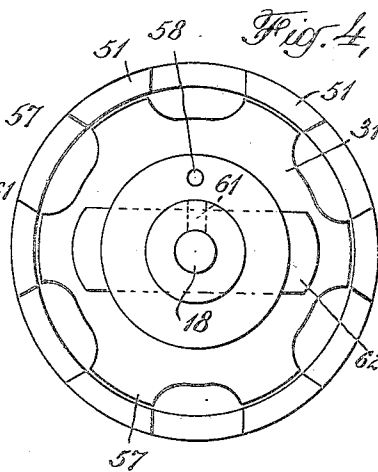
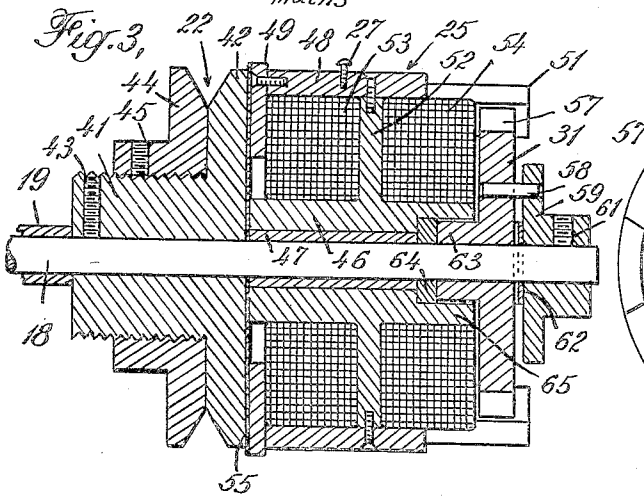
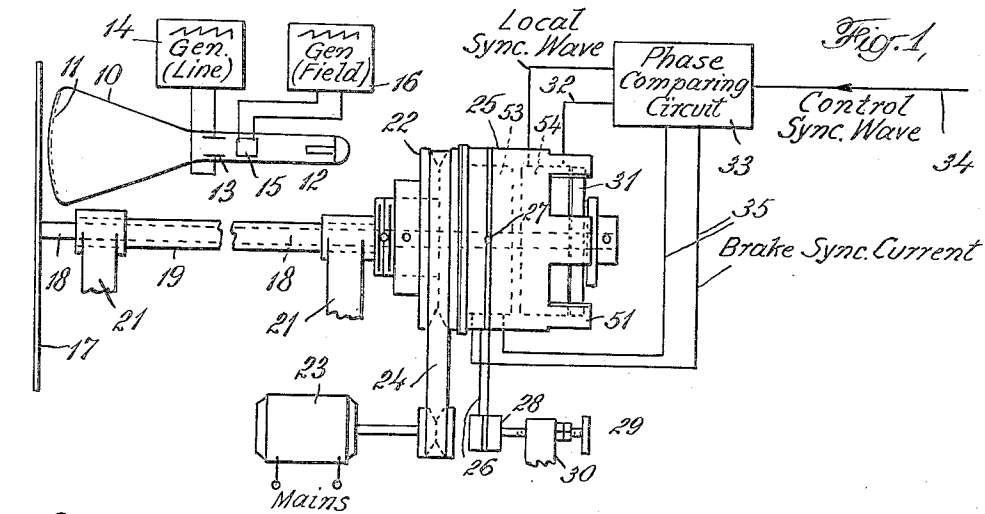
P. C. GOLDMARK

2,323,905

TELEVISION

Filed Oct. 23, 1941

2 Sheets-Sheet 1



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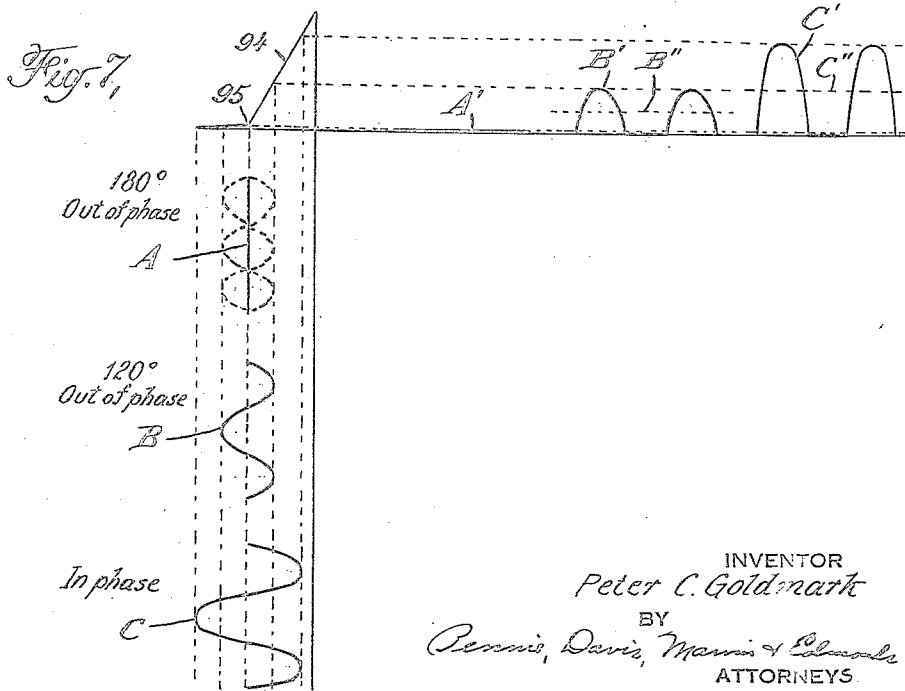
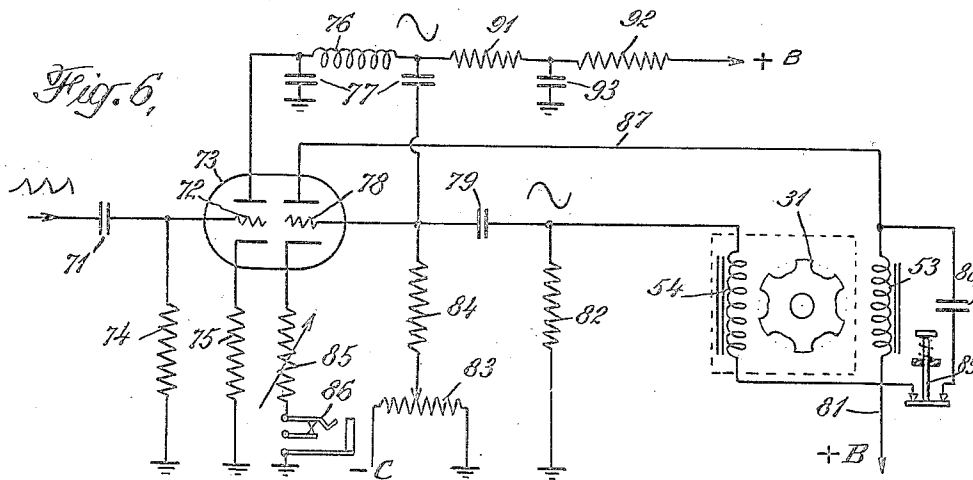
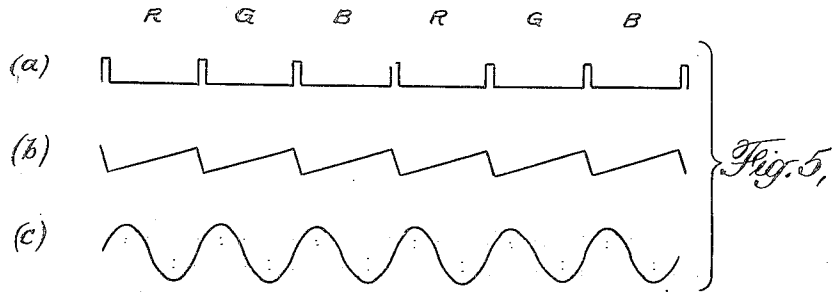
P. C. GOLDMARK

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TELEVISION

Filed Oct. 23, 1941

2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

2,323,905

TELEVISION

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Application October 23, 1941, Serial No. 416,232

22 Claims. (Cl. 178—5.2)

This invention relates primarily to television, especially to color television apparatus employing a rotatable color filter element. The invention particularly contemplates the provision of a compact, efficient combined local generator and friction brake for use in effecting synchronism of the rotatable color filter element, and a circuit adapted to effectively utilize the combined generator and brake. Although especially designed for use in television, in their broader aspects the synchronizing circuit and combined generator-brake could be used in other fields.

In one type of color television system which has been successfully operated, successive images corresponding to different color aspects of an object field are transmitted to a receiver and successively reproduced in the corresponding colors. For example, the object field may be scanned once for the red aspect, a second time for the green aspect, and a third time for the blue aspect. At the receiver the successive field scans are reproduced and exhibited in the respective colors. Commonly a rotating color filter element having segments of the selected primary colors is employed at the transmitter, and a similar rotatable color filter element is employed at the receiver. The color filter element may be in the form of a disk, a drum, or other form, as desired.

In order to reproduce successive images in the colors to which they correspond it is necessary to provide means for synchronizing the rotation of the receiver color filter element with the successively reproduced images. Suitable apparatus for effecting synchronism is disclosed by the applicant in co-pending application Serial No. 373,713, filed January 9, 1941, for "Television." As there pointed out, it is not only necessary that the disk or other form of element rotate in synchronism with the successive images, but it is also necessary that the element be properly phased with respect to the images so that filter segments of different color are associated with their respective images. In this prior application the specific embodiment discloses an asynchronous motor for supplying most of the driving power, and a phonic motor for effecting synchronization.

The present application discloses apparatus in which a friction brake is employed to effect synchronization, rather than a phonic motor. It has been found that the friction brake is more efficient than the phonic motor, even when the latter is employed as a brake, and is simpler in construction. Furthermore, the operation of the

friction brake is quieter than that of the phonic motor, which is an important consideration in a receiver where quiet operation is essential.

In accordance with the invention, a generator is mounted on the shaft of the rotatable color filter element, or is directly coupled thereto, so as to generate a frequency which is directly proportional to the frequency at which the filter segments traverse the image reproducing area. A synchronizing wave is derived from the received color television signal and the generator is preferably constructed so that the frequency of the locally generated wave will be equal to that of the control synchronizing wave when the apparatus is in synchronism. The phase of the two waves is compared in a suitable circuit employing an electronic tube and the output of the phase-comparing circuit is supplied to the friction brake. The phase-comparing circuit is designed, by suitably biasing the electronic tube or otherwise, to yield a rectified output current whose value varies with the phase relationship of the two waves, the rectified output current being at a minimum when the waves are out of phase and at a maximum when the waves are in phase. Advantageously, the bias or other circuit constants are selected so that the minimum current for the out of phase relationship is very small. The friction brake is electromagnetically operated by supplying the rectified output current to a suitably positioned operating coil. It is further advantageous to supply the brake operating coil with only the direct current component of the rectified synchronizing current, as by shunting a condenser of fairly large capacitance across the operating coil so as to by-pass the alternating current components.

When the apparatus has been started and synchronism obtained, it may be found that a reproduced image corresponding to the red aspect of the object field is being reproduced through a filter segment of the wrong color, say green. In such case, correct phasing can readily be obtained by placing a push-button switch in the condenser circuit. The switch is designed to normally close the condenser circuit and, when momentarily opened, the synchronizing action of the brake is interrupted. The filter element will thereupon be driven at an asynchronous speed by the asynchronous motor and, when the proper color phase has been reached, the push-button may be released to restore the synchronizing action of the brake.

In accordance with another aspect of the invention, the local generator and friction brake

are combined in a single structure so as to provide a compact, efficient unit which can be readily assembled in a receiver cabinet. In this structure, suitable means are provided for preventing current in the brake operating coil from affecting the operation of the generator, and vice versa. Advantageously, the pulley which is coupled to the asynchronous motor is employed as the brake rotor. The stator is mounted to permit at least slight axial movement to vary the frictional braking force with the brake rotor. The stator is normally restrained from rotating about its axis, but the orientation of the stator about its axis is preferably adjustable so as to permit correct phasing of the color filter element with respect to the scanning area. The combined generator and brake described hereinafter also contains novel features which maintain the generator rotor in proper position with respect to the stator at all times. Provision is also made for preventing the generator current from producing considerable friction between generator rotor and the stator.

The invention will be more fully understood by reference to the specific embodiment illustrated in the drawings and the following description thereof. In the drawings:

Fig. 1 is a diagram illustrating the general arrangement of the apparatus;

Fig. 2 is a face view of a suitable color filter disk;

Fig. 3 is a section of the combined generator and friction brake, taken along the axis thereof;

Fig. 4 is an end view of the combined generator and friction brake of Fig. 3;

Fig. 5 is a diagram illustrating representative field synchronizing pulses and corresponding saw-tooth scanning and synchronizing waves derived therefrom;

Fig. 6 is a circuit diagram of a specific embodiment of the invention; and

Fig. 7 is a diagram illustrating the manner in which a rectified output current may be obtained whose magnitude varies with the phase relationship of the local and control synchronizing waves.

Referring to Fig. 1, the cathode ray receiver tube 10 is provided with a luminescent image reproducing surface 11 on which images are successively reproduced by an electron beam from gun 12. The electron beam is deflected repeatedly over substantially the same area of the reproducing surface 11 by deflecting plates 13, energized at line scanning frequency by a suitable saw-tooth wave generator 14, and by vertical deflecting plates 15, energized by a suitable saw-tooth generator 16 of field scanning frequency. These generators may be synchronized to reproduce images from a received color television video signal in any desired manner. Of course, magnetic deflecting coils may be employed instead of the electrostatic deflecting plates illustrated.

A color filter disk 17 of any suitable design is arranged to rotate in front of the image reproducing surface 11. Disk 17 is provided with color filter segments whose colors correspond to the images successively reproduced. Fig. 2 illustrates a disk having segments of suitable shape. For 3-color television the segments are usually colored red, green and blue, respectively. The disk shown has two sets of filters, but it will be understood that the number of colors, number of segments and shape of the segments may be

changed as desired, the invention in no way depending upon the particular selection illustrated. Furthermore, other shapes of rotatable filter elements may be employed if desired.

Filter disk 17 is attached to shaft 18 which rotates in tube 19 lined with suitable bearing material. Tube 19 is secured to the chassis of the receiver by suitable stanchions 21. Attached to shaft 18 is an adjustable pulley 22 driven by asynchronous motor 23 through belt 24. It is found advantageous to employ an induction motor for the asynchronous motor and to select a motor somewhat larger than is necessary to drive the disk, in order to minimize speed variations caused by variations in line voltage. It is preferred to mount the pulley on the same shaft as the color filter disk, but it could be otherwise coupled thereto if desired.

In the embodiment here specifically illustrated, the pulley 22 also functions as the brake rotor of the electromagnetically operated friction brake. Pulley 22, being driven through a belt, would be prevented from free axial movement even if it were free on shaft 18. Hence in the specific embodiment here shown the stator is constructed to allow at least slight axial movement so as to permit varying the braking force. The stator is restrained from rotating by means of a cord 26 which is wrapped around the stator and secured thereto by pin 27. Cord 26 is also wrapped around a cylinder 28 mounted at one end of an adjusting screw 29. The adjusting screw is mounted in a stanchion 30, attached to the chassis, and is held from turning by a suitable amount of friction. This type of mounting not only permits the stator to move in an axial direction, but permits the orientation of the stator to be changed by rotating the adjusting screw 29. This orientation adjustment is advantageous to permit the accurate phasing of the color filter disk with the successive images. It will be understood that in normal operation the stator does not move about its axis, although it can move along its axis by the amount necessary to change the force with which it engages the brake rotor.

The generator rotor 31 of magnetic material is mounted on the shaft 18 at the end of the stator opposite the brake rotor. The manner in which the generator rotor is mounted will be explained in connection with Fig. 3.

The output of the local generator is fed through line 32 to a phase-comparing circuit 33. The latter circuit is also supplied with a control synchronizing wave 34 derived from the received color television signal. The output of the phase-comparing circuit is supplied through line 35 to the actuating coil of the brake.

Referring now to Fig. 3, the adjustable pulley 22 is shown as comprising a hub section 41 integral with the inner flange 42 of the pulley. The hub section 41 is secured to shaft 18 by set screw 43. The hub section is threaded on the outside and carries the correspondingly threaded outer flange 44 of the pulley. By rotating the outer flange on the hub it may be moved toward or away from the inner flange 42, thereby varying the effective diameter of the pulley and consequently varying the ratio between pulley 22 and the driving pulley of motor 23. When the correct ratio is obtained, the outer flange 44 is secured to the hub section 41 by set screw 45. It will be understood that the particular construction of the adjustable pulley here shown forms no part of the present invention and any suitable

form of pulley, non-adjustable if desired, may be selected.

The stator 25 has a core of magnetic material comprising a hub section 46 provided with a bearing 47 of brass or other suitable material within which the shaft 18 rotates. Encircling the hub section 46 and spaced therefrom is a cylindrical section 48 having on one end thereof an annular ring 49 and at the other end thereof suitably shaped, axially extending teeth 51 for the generator. The hub section 46 and encircling section 48 are joined between the ends thereof by a radially extending section 52, thereby defining two annular spaces in which the brake coil 53 and generator coil 54 are placed. The stator magnetic circuit for the brake is completed through the pulley 22 which is of magnetic material such as steel. This brake magnetic circuit comprises the radial section 52, the pulley 22, and the portions of the hub 46 and encircling cylinder 48 therebetween, the annular plate 49 being considered as part of the encircling cylinder 48.

In Fig. 3 the radial section 52 is shown integral with the hub section 46, and the encircling section 48 and plate 49 are shown as separate pieces secured together by bolts. It will be understood that this is for convenience in constructing the stator core, and that the sections can be integral or sub-divided as desired, the assembly forming an integrated core however. The term "section" as employed herein and in the claims does not require the element to be non-integral with other sections.

A thin fiber disk 55 is advantageously placed between the stator and the pulley. This fiber disk is advantageously not secured to either stator or pulley and serves, in effect, as a brake lining. If desired, it could of course be secured to either the stator or the pulley. The disk could of course be dispensed with if desired, but the employment of such a disk of smooth hard material is found helpful in securing a smooth braking action and in avoiding noise. The disk, being of non-magnetic material, also provides a small "air" gap in the brake magnetic circuit which is found advantageous. If the disk were eliminated, an air gap could still be provided by, for example, cutting down the hub section 46 so that it is out of contact with the pulley.

It will be understood that the pulley or brake rotor may be said to frictionally engage with the stator, even though the engagement is through the disk as an intermediary.

The generator rotor 31 is provided on its periphery with teeth 57 which cooperate with the stator teeth 51 so that as the rotor rotates the reluctance of the generator magnetic circuit varies so as to produce an alternating current in the generator winding 54. Since the stator is allowed to move axially, at least to a slight extent, the generator rotor 31 is also mounted so as to be free to move axially and maintain its position with respect to the stator. To this end, generator rotor 31 is not secured to the shaft 18, but is restrained from rotating with respect to the shaft by a pin 58 mounted in a collar 59 which is secured to shaft 18 by set screw 61. A flat spring 62 is placed on the shaft 18 between collar 59 and generator rotor 31 as a biasing means. This spring continuously presses the generator rotor 31 against the stator, and the stator against the pulley 22. By keeping these three elements in contact at all times, the

braking force is made smooth. Fluctuations in the braking action might result in excessive hunting of the color filter disk and hence the use of spring 62 to bias the two rotors and stator together is distinctly advantageous. It is preferable to make spring 62 just strong enough to maintain the elements in contact, without introducing excessive friction.

In the combined generator and brake structure of the invention it is important that current in the generator coil 54 be prevented from appreciably affecting the brake action, and it is likewise important that current in the brake coil 53 be prevented from appreciably affecting the generator. In the structure of Fig. 3 the radially extending section 52 provides a common path of low reluctance for both brake and generator magnetic circuits which prevents current in either coil from producing substantial flux in the magnetic circuit of the other coil. Considering the generator coil 54, the magnetic path between the ends of section 52 is of much lower reluctance through section 52 than through the portions of the hub section 46 and encircling section 48 to the left of radial section 52 and brake rotor 22. This is particularly true when there is a small "air" gap between brake rotor and stator core. Hence, most of the flux produced by coil 54 will flow through the radial section 52 and will not pass through the brake rotor 22. Similarly, considering coil 53 with respect to the generator magnetic circuit, the radial section 52 provides a path of low reluctance compared to the path through the teeth 51 and 57 and the generator rotor. Hence, most of the flux produced by coil 53 will pass through the radial section 52 and will not affect the generator voltage.

Inasmuch as the generator rotor 31 is in the field of the stator 25, a certain amount of friction would normally result in an axial direction. To prevent this, the generator rotor 31 is provided with an integral hub section 63 which extends within the hub section 46 of the stator, thereby overlapping the end of the stator core. The clearance between these two sections is made small in order to provide a radial path of low reluctance for the flux in the generator circuit. A washer 64 of brass or other non-magnetic material is inserted between the generator rotor and the stator to prevent substantial axial flux at this point. Similarly, the clearance between the generator rotor and the end 65 of the stator hub is made sufficiently large so that the reluctance in the axial direction is fairly high.

It is also advantageous to design the rotor and stator teeth so that the rotor teeth are radially within the stator teeth. When so designed, the force produced by varying flux between the teeth is substantially in the radial direction and does not substantially change the friction between generator rotor and stator. Moreover, such a construction permits slight axial displacement of the rotor teeth without appreciably affecting the gap between rotor and stator teeth, thus providing a desirable tolerance.

In operation, the generator coil 54 may be energized with a constant direct current voltage and the rotation of the generator rotor 31 causes the reluctance of the generator magnetic circuit to vary rhythmically and generate an alternating current in coil 54. This operation is well known in the art. The frequency of the alternating current depends upon the number of teeth selected and the speed of rotation and is correlated with the frequency of the control synchro-

nizing signals in a manner hereinafter described.

In the brake, a varying current in coil 53 produces a corresponding varying flux in the brake magnetic circuit which includes the pulley 22 functioning as a brake rotor. The varying flux produces a varying force of attraction between the pulley and the adjacent end of the stator. The resulting friction varies with the force of attraction and increases and decreases the braking force. Fiber disk 55 acts as a buffer between the two metal surfaces to produce a smooth braking action, and also insures that the reluctance between the stator and the pulley is high compared to that of the radial section 52, so that current in the generator coil cannot appreciably affect the braking action.

Referring now to Fig. 5, a series of pulses is shown at *a* which represent the field synchronizing signals customarily transmitted as part of the television signal. Successive field scans are here shown as representing red, green and blue aspects of the object field. The field scans may be interlaced or non-interlaced, as desired. The synchronizing pulses are employed in a conventional manner to generate, or control the generation of, a saw-tooth scanning wave of field scanning frequency such as is shown in Fig. 5b. The line scanning saw-tooth wave is generated in a conventional manner and hence is not shown. For the specific embodiment here shown, the pulses recur at the rate of 120 per second.

The local generator shown in Fig. 3 may be designed so as to generate substantially a pure sine wave. In comparing the phase of the locally generated wave with the control synchronizing wave it is advantageous, although not essential, to have the control synchronizing wave also substantially sinusoidal. Such a sine wave is shown in Fig. 5c. The sine wave of Fig. 5c can be derived directly from the field synchronizing signals of Fig. 5a by suitable amplification and filtering. However, since the field saw-tooth scanning wave of Fig. 5b is customarily generated under the control of the field synchronizing signals, it is more convenient to use this wave to generate the sine wave of Fig. 5c. This may be done by simple amplification and filtering. It will be understood that no attempt has been made in Fig. 5 to show the exact phase relationship between the saw-tooth wave and the corresponding sine wave, since the particular phase relationship can be taken care of by suitably orienting the color filter disk on its shaft.

Referring to Fig. 6, the saw-tooth wave of Fig. 5b is supplied through coupling condenser 71 to the grid 12 of the lefthand elements in electronic tube 73. The tube 73 is in effect two tubes in a single envelope, a tube of the 6F8G type having been employed with success. The lefthand elements act simply as an amplifier, and a suitable input resistance 74 and cathode resistance 75 are employed. The resulting plate current passes through a filter circuit composed of a choke coil 76 and condensers 77 to yield a resulting wave which is substantially sinusoidal. This voltage is supplied to grid 78 of the righthand elements of tube 73. Resistance 91 and 92 and condenser 93 are provided in the output circuit of the lefthand elements of tube 73 to act as a filter for the plate supply. Any desired filtered supply may of course be employed.

The locally generated voltage from generator coil 54 is also supplied to grid 78 through coupling condenser 79. It is considered advantageous to have the locally generated voltage equal

in frequency to that of the control synchronizing wave when the disk is rotating synchronously. Hence the number of teeth on the generator rotor and stator are selected to give a 120-cycle per second voltage for the specific case given.

The generator coil 54 is energized from a source of constant voltage at 81, which is conveniently the B+ supply, the circuit being completed through resistance 82 to ground. The magnitude of resistance 82 is selected with respect to the voltage supplied at 81 to yield a suitable value of energizing current. The bias for grid 78 is supplied from a potentiometer 83 through grid resistance 84. For the 6F8G tube, a C-supply of -50 volts and a resistance 84 of one-half megohm has been employed with success. In order to properly adjust the apparatus it is found advantageous to also provide a variable cathode resistance 85 in order to conveniently change the amplification factor of the righthand elements of tube 73. A variable resistance of 1000 ohms has been employed with success. A jack 86 is provided in order to insert conveniently an ammeter for measuring the brake current. The output current of the righthand elements is fed through line 87 to the actuating coil 53 of the friction brake. A condenser 88 of relatively large capacitance is shunted across the brake coil in order to by-pass the alternating frequency components of the output wave. While the capacitance can be selected over a wide range, and depends on the constants of the brake coil, etc., a 2 mfd. condenser has been employed with success. Although shunting the brake coil is a very satisfactory way of supplying only the direct current component to the coil, other means for accomplishing the result may be employed if desired.

A normally-closed pushbutton switch 89 is inserted in the condenser circuit to permit convenient color phasing of the color filter disk. The voltage applied at 81 is also utilized as the plate voltage supply for the righthand elements of tube 73 through brake coil 53. A B+ supply of about 375 volts has been employed with success.

The preferred operation of the apparatus of Fig. 6 is illustrated in Fig. 7. The characteristic of the right-hand elements of tube 73 is shown as line 94. The tube is biased substantially to cut-off 95 by suitable adjusting potentiometer 83. As illustrated, if the locally generated voltage and control synchronizing voltage are equal in magnitude and 180° out of phase, as shown at A, the two waves cancel and the tube remains substantially at cut-off, yielding a very small output brake current as shown at A'. If the two waves are of equal magnitude and 120° out of phase, the waves combine in the well known manner to yield a resultant voltage of the same amplitude as either of the two waves, illustrated at B. Due to the bias on the grid 78, a resulting rectified wave B' is obtained. Wave B' has an average value corresponding to the direct current component represented by the dotted line B''. When the two waves are of the same magnitude and in phase, the resultant is a wave of twice the amplitude of either, as shown at C. Due to the rectifying action of the tube, the resultant output current wave is as shown at C'. The average direct current value of this wave is shown by the dotted line C''.

It will therefore be seen that as the phase between the locally generated wave and the control synchronizing wave changes, the average direct current component of the output wave

also varies, thus varying the current through the electromagnetic friction brake.

In the initial adjustment of the apparatus the pulley 22 (Fig. 1) is adjusted so that the asynchronous motor 23 tends to drive the disk somewhat above synchronous speed. Then the grid bias potentiometer 83 and the variable cathode resistance 85 are adjusted so as to produce the desired minimum and maximum output currents. As stated above, it is preferred to adjust the bias so that the minimum brake current is very small, thereby obtaining a maximum change in brake current with change in phase with a minimum steady current through the brake, it being realized that the steady current results in heating the brake. It will be understood that the voltage of the power mains commonly available at a receiver will usually fluctuate somewhat. Therefore allowance must be made to take care of such fluctuations. Hence it is advisable to design the brake and circuit components and adjust the circuit so that at the normal operating voltage the disk will be properly synchronized when the brake current is intermediate its maximum and minimum values.

The braking effect is usually not directly proportional to the difference in phase so that a suitable normal operating point is when the two waves are approximately 90° out of phase. The local wave will lag the incoming wave in the stable operating condition. Then, if the disk should be running somewhat below synchronous speed, the locally generated wave will move somewhat farther out of phase with respect to the incoming synchronizing signal, thereby decreasing the brake current and permitting the asynchronous motor to drive the disk faster. On the other hand, if the disk should tend to run above synchronous speed, the two waves will shift more into phase, thereby increasing the brake current and causing the disk to slow down. A change in the voltage of the power mains will commonly affect somewhat the speed of the asynchronous motor and cause the phase-comparing circuit and brake to establish synchronism with the disk at a slightly different phase with respect to the reproduced images. However, by suitably selecting the asynchronous motor, as by employing an induction motor of somewhat greater power than is necessary to drive the disk, and by designing the color filter segments to permit a slight amount of phase variation, correct operation may still be obtained.

If, when the receiver is initially started, images representing certain colors are exhibited through filters of different colors, the pushbutton 89 may be depressed until proper color relationship is obtained, and then released to establish synchronism in the proper color phase. Depressing pushbutton 89 opens the circuit of condenser 88. While the exact manner in which this operates to remove the synchronizing effect is not fully understood, it is believed that the opening of the circuit of condenser 88 alters the plate impedance of the righthand elements of tube 73 to such an extent that the resulting brake current is markedly decreased, thereby preventing the brake from fully counteracting the accelerating effect of the asynchronous motor. The brake coil, being wound on a magnetic core such as iron, of course has a fairly high inductance, much like a choke coil. This theory is not insisted upon, but in any event it is found that the described operation can be obtained.

If desired, other means for momentarily removing the synchronizing action of the brake can be employed, for example, actually interrupting the brake coil circuit or momentarily biasing grid 78 beyond cut-off.

Although locally generated waves and waves derived from the incoming synchronizing signals of approximately sinusoidal form and of equal magnitude have been found satisfactory, other forms and non-equal magnitudes can be employed if desired. Also, instead of using the customary field synchronizing signals, special transmitted signals could be employed.

While the combined generator-brake construction of Fig. 3 and the circuit of Fig. 6 are especially suited to each other, it will be understood that the combined generator-brake may be used with other types of synchronizing circuits and that the circuit of Fig. 6 can be employed with any desired form of local generator and brake. If desired, the combined generator-brake and synchronizing circuit can be employed jointly or separately to synchronize apparatus other than a color filter element.

It will be understood that neither the combined generator-brake nor the synchronizing circuit of the invention is limited to the mere details of construction and design and arrangement of parts disclosed, since many modifications may be made by those in the art without departing from the spirit and scope of the invention.

I claim:

1. In a color television receiver for receiving a color video signal successive portions of which represent different color aspects of an object field and accompanying synchronizing signals, said receiver having a rotatable color filter element for presenting images corresponding to said successive portions in their respective colors, apparatus for synchronizing the rotation of the color filter element with successive images which comprises an asynchronous motor coupled to said rotatable filter element and tending to drive the element over synchronous speed, a friction brake rotor of magnetic material coupled to said rotatable filter element, a stator mounted coaxially with said friction brake rotor and adapted to frictionally engage therewith, said stator having a magnetic circuit completed through the brake rotor and a brake energizing coil positioned to produce flux therein, a generator rotor of magnetic material axially spaced from the brake rotor, said stator having a magnetic circuit completed through the generator rotor and a generator coil positioned to encircle flux therein, said brake and generator magnetic circuits having a common path of low reluctance positioned to prevent the production of substantial flux between stator and brake rotor by the generator coil and between the stator and generator rotor by the brake coil, said generator rotor and stator being adapted to generate a local synchronizing wave in the generator coil of the frequency of said synchronizing signals when the filter element rotates at synchronous speed, means for comparing the phases of said local synchronizing wave and said received synchronizing signals and yielding a rectified output current whose magnitude varies in accordance with the difference in said phases, said brake energizing coil being connected to receive the direct current component of said rectified output current, and means for substantially preventing the alternat-

ing current component of said rectified output current from flowing in said coil.

2. In a color television receiver for receiving a color video signal successive portions of which represent different color aspects of an object field and accompanying synchronizing signals, said receiver having a rotatable color filter element for presenting images corresponding to said successive portions in their respective colors, apparatus for synchronizing the rotation of the color filter element with successive images which comprises an asynchronous motor coupled to said rotatable filter element and tending to drive the element over synchronous speed, a stator having a core of magnetic material, a shaft extending within said stator and coupled to said rotatable filter element, a friction brake rotor of magnetic material attached to said shaft at one end of said stator and adapted to frictionally engage therewith, said stator having a magnetic circuit completed through the brake rotor and a brake energizing coil positioned to produce flux therein, means for restraining the stator from substantial rotational movement and allowing at least slight axial movement thereof to vary the frictional braking force with the brake rotor, a generator rotor of magnetic material on said shaft at the other end of the stator and mounted to allow axial but not substantial rotational movement relative to the shaft, said stator having a magnetic circuit completed through the generator rotor and a generator coil positioned to encircle flux therein, said generator rotor and stator being adapted to generate a local synchronizing wave in the generator coil of the frequency of said synchronizing signals when the filter element rotates at synchronous speed, biasing means for pressing the generator rotor toward the stator and the stator toward the brake rotor, means for applying said local synchronizing wave and a wave corresponding to said synchronizing signals to control the flow of current in an electronic tube, said electronic tube being connected to yield a rectified output current which varies in accordance with the difference in phase of said waves, said brake energizing coil being connected to receive the direct current component of said rectified output current, and a condenser connected across said energizing coil to by-pass the alternating current component of the rectified output current and cause substantially only the direct current component to flow in the coil.

3. In a color television receiver, a combined local generator and brake for synchronizing a rotatable color filter element which comprises a friction brake rotor of magnetic material coupled to said rotatable filter element, a stator mounted coaxially with said friction brake rotor and adapted to frictionally engage therewith, said stator having a magnetic circuit completed through the brake rotor and a brake energizing coil positioned to produce flux therein, a generator rotor of magnetic material axially spaced from the brake rotor, said stator having a magnetic circuit completed through the generator rotor and a generator coil positioned to encircle flux therein, said brake and generator magnetic circuits having a common path of low reluctance positioned to prevent the production of substantial flux between stator and brake rotor by the generator coil and between the stator and generator rotor by the brake coil.

4. In a color television receiver, a combined local generator and brake for synchronizing a ro-

tatable color filter element which comprises a stator having a core of magnetic material, a friction brake rotor of magnetic material coupled to said rotatable filter element and mounted coaxially with the stator to frictionally engage with one end thereof, said stator having a magnetic circuit completed through the brake rotor and a brake energizing coil positioned to produce flux therein, a generator rotor of magnetic material positioned coaxially with the stator at the other end thereof, said stator having a magnetic circuit completed through the generator rotor and a generator coil positioned to encircle flux therein, said brake and generator magnetic circuits having a common path of low reluctance between the respective coils to prevent current in either coil from producing substantial flux in the circuit associated with the other coil.

5. In a color television receiver, a combined local generator and brake for synchronizing a rotatable color filter element which comprises a stator having a core of magnetic material comprising a hub section, a section encircling the hub section and spaced therefrom, and a radially extending section of low reluctance joining the hub and encircling sections between the ends thereof to define two annular spaces, a friction brake rotor of magnetic material coupled to said rotatable filter element and mounted coaxially with the stator to frictionally engage with one end thereof and complete a brake magnetic circuit between the adjacent ends of the encircling and hub sections of the core, a brake energizing coil positioned in the annular space between the brake rotor and said radially extending section, a generator rotor of magnetic material mounted coaxially with the stator at the other end thereof, the generator rotor and said other end of the stator having cooperating teeth to complete a magnetic circuit between the encircling and hub sections of the core whose reluctance varies as the rotor rotates, and a generator coil positioned in the other annular space of the stator between the generator rotor and said radially extending section.

6. In a color television receiver, a combined local generator and brake for synchronizing a rotatable color filter element which comprises a stator having a core of magnetic material, a shaft extending within said stator and coupled to said rotatable filter element, a friction brake rotor of magnetic material attached to said shaft at one end of said stator and adapted to frictionally engage therewith, said stator having a magnetic circuit completed through the brake rotor and a brake energizing coil positioned to produce flux therein, means for restraining the stator from substantial rotational movement and allowing at least slight axial movement thereof to vary the frictional braking force with the brake rotor, a generator rotor of magnetic material on said shaft at the other end of the stator and mounted to allow axial but not substantial rotational movement relative to the shaft, said stator having a magnetic circuit completed through the generator rotor and a generator coil positioned to encircle flux therein, and biasing means for pressing the generator rotor toward the stator and the stator toward the brake rotor.

7. In a color television receiver, a combined local generator and brake for synchronizing a rotatable color filter element which comprises a stator having a core of magnetic material, a shaft extending within said stator and coupled to said rotatable filter element, a friction brake

rotor of magnetic material attached to said shaft at one end of said stator and adapted to frictionally engage therewith, said stator having a magnetic circuit completed through the brake rotor and a brake energizing coil positioned to produce flux therein, means for restraining the stator from substantial rotational movement and allowing at least slight axial movement thereof to vary the frictional braking force with the brake rotor, a generator rotor of magnetic material on said shaft at the other end of the stator and mounted to allow axial but not substantial rotational movement relative to the shaft, said stator having a magnetic circuit completed through the generator rotor and a generator coil positioned to encircle flux therein, said generator rotor partially overlapping the end of the stator core to provide a substantially radial flux path of relatively low reluctance, the axial flux path between generator rotor and stator being of relatively high reluctance to thereby prevent flux in the generator magnetic circuit from producing excessive friction between generator rotor and stator.

8. In a color television receiver, a combined local generator and brake for synchronizing a rotatable color filter element which comprises a stator having a core of magnetic material, a shaft extending within said stator and coupled to said rotatable filter element, a friction brake rotor of magnetic material attached to said shaft at one end of said stator and adapted to frictionally engage therewith, said stator having a magnetic circuit completed through the brake rotor and a brake energizing coil positioned to produce flux therein, means for restraining the stator from substantial rotational movement and allowing at least slight axial movement thereof to vary the frictional braking force with the brake rotor, a generator rotor of magnetic material on said shaft at the other end of the stator and mounted to allow axial but not substantial rotational movement relative to the shaft, the periphery of the generator rotor and the adjacent portion of the stator having cooperating teeth to complete a generator magnetic circuit with the stator whose reluctance varies as the rotor rotates, the teeth of the rotor being radially within the teeth of the stator, a generator coil positioned to produce flux in said generator magnetic circuit, and biasing means for pressing the generator rotor toward the stator and the stator toward the brake rotor.

9. In a color television receiver, a combined local generator and brake for synchronizing a rotatable color filter element which comprises a stator having a core of magnetic material comprising a hub section, a section encircling the hub section and spaced therefrom, and a radially extending section of low reluctance joining the hub and encircling sections between the ends thereof to define two annular spaces, a shaft extending within said stator and coupled to said rotatable filter element, a friction brake rotor of magnetic material attached to said shaft at one end of the stator to frictionally engage therewith and complete a brake magnetic circuit between the adjacent ends of the encircling and hub sections of the core, a brake energizing coil positioned in the annular space between the brake rotor and said radially extending section, means for restraining the stator from substantial rotational movement and allowing at least slight axial movement thereof to vary the frictional braking force with the brake rotor, a generator

rotor of magnetic material on said shaft at the other end of the stator and mounted to allow axial but not substantial rotational movement relative to the shaft, said generator rotor having a hub extending within the stator hub to provide a substantially radial flux path of relatively low reluctance, the axial flux path between generator rotor and stator being of relatively high reluctance to prevent flux in the generator magnetic circuit from producing excessive friction between generator rotor and stator, the periphery of the generator rotor and the adjacent end of the stator having cooperating teeth to complete a generator magnetic circuit with the stator whose reluctance varies as the rotor rotates, the teeth of the rotor being radially within the teeth of the stator, a generator coil positioned in the other annular space of the stator between the generator rotor and said radially extending section, and biasing means for pressing the generator rotor continuously against the stator and the stator continuously against the brake rotor.

10. In a color television receiver having a rotatable color filter element driven by an asynchronous motor, a combined local generator and brake for synchronizing said rotatable color filter element which comprises a stator having a core of magnetic material comprising a hub section, a cylindrical section encircling the hub section and spaced therefrom, and a radially extending section joining the hub and cylindrical sections between the ends thereof to define two annular spaces, a shaft extending through the stator and coupled to said rotatable filter element, a pulley of magnetic material attached to said shaft at one end of the stator to frictionally engage therewith and complete a brake magnetic circuit between the adjacent ends of the hub and cylindrical sections of the core, said pulley being coupled to said asynchronous motor, a brake energizing coil positioned in the annular space of the stator between the pulley and said radially extending section, means for restraining the stator from substantial rotational movement and allowing at least slight axial movement thereof to vary the frictional braking force with the pulley, a generator rotor of magnetic material on said shaft at the other end of the stator and mounted to allow axial but not substantial rotational movement relative to the shaft, the magnetic reluctance between the inner and outer ends of the radially extending section through the section being low relative to the reluctance of the path through the pulley and of the path through the generator rotor, a generator coil positioned in the other annular space of the stator between the generator rotor and said radially extending section, and biasing means for pressing the generator rotor continuously toward the stator and the stator continuously toward the pulley.

11. In a color television receiver having a rotatable color filter element driven by an asynchronous motor, a combined local generator and brake for synchronizing said rotatable color filter element which comprises a stator having a core of magnetic material comprising a hub section, a cylindrical section encircling the hub section and spaced therefrom and a radially extending section joining the hub and cylindrical sections between the ends thereof to define two annular spaces, a shaft extending through the stator and coupled to said rotatable filter element, a pulley of magnetic material attached to said shaft at one end of the stator to frictionally engage therewith and complete a brake magnetic circuit be-

tween the adjacent ends of the hub and cylindrical sections of the core, said pulley being coupled to said asynchronous motor, a thin disk of non-magnetic material between the pulley and the stator core, a brake energizing coil positioned in the annular space of the stator between the pulley and said radially extending section, means for restraining the stator from substantial rotational movement and allowing at least slight axial movement thereof to vary the frictional braking force with the pulley, a generator rotor of magnetic material on said shaft at the other end of the stator and mounted to allow axial but not substantial rotational movement relative to the shaft, said generator rotor having a hub extending within the stator hub to provide a substantially radial flux path of relatively low reluctance, the axial flux path between generator rotor and stator being of relatively high reluctance to prevent flux in the generator magnetic circuit from producing excessive friction between generator rotor and stator, the periphery of the generator rotor and the adjacent end of the stator having cooperating teeth to complete a generator magnetic circuit whose reluctance varies as the rotor rotates, the teeth of the rotor being radially within the teeth of the stator, the magnetic reluctance between the inner and outer ends of the radially extending section through the section being low relative to the reluctance of the path through the pulley and low relative to the reluctance of the path through the generator rotor, a generator coil positioned in the other annular space of the stator between the generator rotor and said radially extending section, and biasing means for pressing the generator rotor continuously against the stator and the stator continuously against the pulley.

12. Apparatus for synchronizing a rotatable element which comprises a friction brake rotor of magnetic material coupled to said rotatable element, a stator mounted co-axially with said friction brake rotor and adapted to frictionally engage therewith, said stator having a magnetic circuit completed through the brake rotor and a brake energizing coil positioned to produce flux therein, a generator rotor of magnetic material axially spaced from the brake rotor, said stator having a magnetic circuit completed through the generator rotor and a generator coil positioned to encircle flux therein, said brake and generator magnetic circuits having a common path of low reluctance positioned to prevent the production of substantial flux between stator and brake rotor by the generator coil and between the stator and generator rotor by the brake coil.

13. Apparatus for synchronizing a rotatable element which comprises a stator having a core of magnetic material comprising a hub section, a section encircling the hub section and spaced therefrom, and a radially extending section of low reluctance joining the hub and encircling sections between the ends thereof to define two annular spaces, a friction brake rotor of magnetic material coupled to said rotatable element and mounted co-axially with the stator to frictionally engage with one end thereof and complete a brake magnetic circuit between the adjacent ends of the encircling and hub sections of the core, a brake energizing coil positioned in the annular space between the brake rotor and said radially extending section, a generator rotor of magnetic material mounted co-axially with the stator at the other end thereof, the generator rotor and said other end of the stator having cooperating teeth

to complete a magnetic circuit between the encircling and hub sections of the core whose reluctance varies as the rotor rotates, the magnetic reluctance between the inner and outer ends of the radially extending section through the section being low relative to the reluctance of the path through the brake rotor and of the path through the generator rotor, and a generator coil positioned in the other annular space of the stator between the generator rotor and said radially extending section.

14. Apparatus for synchronizing a rotatable element which comprises a stator having a core of magnetic material comprising a hub section, a cylindrical section encircling the hub section and spaced therefrom, and a radially extending section joining the hub and cylindrical sections between the ends thereof to define two annular spaces, a shaft extending through the stator and coupled to said rotatable element, a friction brake rotor of magnetic material attached to said shaft at one end of the stator to frictionally engage therewith and complete a brake magnetic circuit between the adjacent ends of the hub and cylindrical sections of the core, a brake energizing coil positioned in the annular space between the brake rotor and said radially extending section, means for restraining the stator from substantial rotational movement and allowing at least slight axial movement thereof to vary the frictional braking force with the brake rotor, a generator rotor of magnetic material on said shaft at the other end of the stator and mounted to allow axial but not substantial rotational movement relative to the shaft, said generator rotor completing a generator magnetic circuit between the adjacent ends of the hub and cylindrical sections of the core and partially overlapping said ends to provide a substantially radial flux path of relatively low reluctance, the axial flux path between generator rotor and stator being of relatively high reluctance to prevent flux in the generator magnetic circuit from producing excessive friction between generator rotor and stator, the magnetic reluctance between the inner and outer ends of the radially extending section through the section being low compared to the reluctance of the path through the brake rotor and of the path through the generator rotor, a generator coil positioned in the other annular space of the stator between the generator rotor and said radially extending section, and biasing means for pressing the generator rotor continuously toward the stator and the stator continuously toward the brake rotor.

15. In a color television receiver for receiving a color video signal successive portions of which represent different color aspects of an object field and accompanying synchronizing signals, said receiver having a rotatable color filter element for presenting images corresponding to said successive portions in their respective colors, apparatus for synchronizing the rotation of the color filter element with successive images which comprises an asynchronous motor coupled to said rotatable filter element and tending to drive the element over synchronous speed, a local generator coupled to the rotatable filter element and adapted to generate a local synchronizing wave of the frequency of said synchronizing signals when the filter element rotates at synchronous speed, means for comparing the phases of said local synchronizing wave and said received synchronizing signals and yielding a rectified output current whose magnitude varies in accordance

with the difference in said phases, a friction brake having an electro magnetic operating coil and coupled to brake the rotatable filter element, said operating coil being connected to receive the direct current component of said rectified output current, and means for substantially preventing the alternating current component of said rectified output current from flowing in said coil.

16. In a color television receiver for receiving a color videosegment successive portions of which represent different color aspects of an object field and accompanying synchronizing signals, said receiver having a rotatable color filter element for presenting images corresponding to said successive portions in their respective colors, apparatus for synchronizing the rotation of the color filter element with successive images which comprises an asynchronous motor coupled to said rotatable filter element and tending to drive the element over synchronous speed, a local generator coupled to the rotatable filter element and adapted to generate a local synchronizing wave of the frequency of said synchronizing signals when the filter element rotates at synchronous speed, means for applying said local synchronizing wave and a wave corresponding to said synchronizing signals to the control means of an electronic tube, said control means being biased to yield a rectified output current, whereby said rectified output current varies in accordance with the difference in phase of said waves, a friction brake having an electromagnetic operating coil and coupled to brake the rotatable filter element, said operating coil being connected to receive the direct current component of said rectified output current, and means for substantially preventing the alternating current component of said rectified output current from flowing in said coil.

17. In a color television receiver for receiving a color video signal successive portions of which represent different color aspects of an object field and accompanying synchronizing signals, said receiver having a rotatable color filter element for presenting images corresponding to said successive portions in their respective colors, apparatus for synchronizing the rotation of the color filter element with successive images which comprises an asynchronous motor coupled to said rotatable filter element and tending to drive the element over synchronous speed, a local generator coupled to the rotatable filter element and adapted to generate a local synchronizing wave of the frequency of said synchronizing signals when the filter element rotates at synchronous speed, means for applying said local synchronizing wave and a wave corresponding to said synchronizing signals to control the flow of current in an electronic tube, said electronic tube being connected to yield a rectified output current which varies in accordance with the difference in phase of said waves, a friction brake having an electromagnetic operating coil and coupled to brake the rotatable filter element, said operating coil being connected to receive the direct current component of said rectified output current, and a condenser connected across said operating coil to by-pass the alternating current component of the rectified output current and cause substantially only the direct current component to flow in the coil.

18. In a color television receiver for receiving a color video signal successive portions of which represent different color aspects of an object field and accompanying synchronizing signals,

said receiver having a rotatable color filter element for presenting images corresponding to said successive portions in their respective colors, apparatus for synchronizing the rotation of the color filter element with successive images which comprises an asynchronous motor coupled to said rotatable filter element and tending to drive the element over synchronous speed, a local generator coupled to the rotatable filter element and adapted to generate a local synchronizing wave of the frequency of said synchronizing signals when the filter element rotates at synchronous speed, a phase-comparing circuit comprising an electronic vacuum tube having control grid means, means for applying said local synchronizing wave and a wave of similar wave-shape derived from said received synchronizing signals to said control grid means, said control grid means being biased to yield a rectified output current which varies in accordance with the difference in phase of said waves, said bias being sufficient to yield a relatively low plate current in said tube when said waves are 180° out of phase, a friction brake having an electromagnetic operating coil and coupled to brake the rotatable filter element, said operating coil having a relatively high inductance and being connected in the plate circuit of said tube, and a condenser connected across said operating coil to by-pass the alternating current component of the rectified output current and cause substantially only the direct current component to flow in the coil.

19. In a color television receiver for receiving a color video signal successive portions of which represent different color aspects of an object field and accompanying synchronizing signals, said receiver having a rotatable color filter element for presenting images corresponding to said successive portions in their respective colors, apparatus for synchronizing the rotation of the color filter element with successive images which comprises an asynchronous motor coupled to said rotatable filter element and tending to drive the element over synchronous speed, a local generator coupled to the rotatable filter element and adapted to generate a local synchronizing wave of the frequency of said synchronizing signals when the filter element rotates at synchronous speed, a phase-comparing circuit comprising an electronic vacuum tube having control grid means, means for applying said local synchronizing wave and a wave of similar wave-shape derived from said received synchronizing signals to said control grid means, said control grid means being biased to yield a rectified output current which varies in accordance with the difference in phase of said waves, a friction brake having an electromagnetic operating coil and coupled to brake the rotatable filter element, said operating coil having a relatively high inductance and being connected in the plate circuit of said tube, a condenser in shunt with said operating coil to by-pass the alternating current component of the rectified output current and cause substantially only the direct current component to flow in the coil, and a switch in said shunt circuit biased to establish said circuit and operable to break the circuit to remove the synchronizing action of the brake and thereby change the colors in which successive images are presented.

20. In a color television receiver for receiving a color video signal successive portions of which represent different color aspects of an object field and accompanying synchronizing signals, said

receiver having a rotatable color filter element for presenting images corresponding to said successive portions in their respective colors, apparatus for synchronizing the rotation of the color filter element with successive images which comprises an asynchronous motor coupled to said rotatable filter element and tending to drive the element over synchronous speed, a local generator coupled to the rotatable filter element and adapted to generate a local synchronizing wave of the frequency of said synchronizing signals when the filter element rotates at synchronous speed, a phase-comparing circuit comprising an electronic vacuum tube having cathode, plate and grid control means, means for applying said local synchronizing wave and a wave of similar wave-shape derived from said received synchronizing signals to said control grid means, said control grid means being biased to yield a rectified output current which varies in accordance with the difference in phase of said waves, said bias being sufficient to yield a relatively low plate current in said tube when said waves are 180° out of phase, an impedance in the cathode circuit of said tube, a friction brake having an electromagnetic operating coil and coupled to brake the rotatable filter element, said operating coil having a relatively high inductance and being connected in the plate circuit of said tube, a condenser in shunt with said operating coil to by-pass the alternating current component of the rectified output current and cause substantially only the direct current component to flow in the coil, and a switch in said shunt circuit biased to establish said circuit and operable to break the circuit to remove the synchronizing action of the brake and thereby change the colors in which successive images are presented.

21. Apparatus for synchronizing a rotatable element with control synchronizing signals 40

which comprises an asynchronous motor coupled to said rotatable element and tending to drive the element over synchronous speed, a local generator coupled to the rotatable element and adapted to generate a local synchronizing wave of the frequency of said synchronizing signals when the rotatable element rotates at synchronous speed, means for comparing the phases of said local synchronizing wave and said control synchronizing signals and yielding a rectified output current whose magnitude varies in accordance with the difference in said phases, a friction brake having an electromagnetic operating coil and coupled to brake the rotatable element, said operating coil being connected to receive the direct current component of said rectified output current, and means for substantially preventing the alternating current component of said rectified output current from flowing in said coil.

22. The method of synchronizing a rotatable element with control synchronizing signals which comprises driving said rotatable element with an asynchronous motor tending to drive the element over synchronous speed, locally generating a synchronizing wave of frequency proportional to the speed of rotation of said element and equal to the frequency of said control synchronizing signals when the element rotates at synchronous speed, comparing the phases of the local synchronizing wave and said control synchronizing signals and deriving a rectified output current whose magnitude varies in accordance with the difference in said phases, and supplying substantially only the direct current component of said rectified output wave to the operating coil of an electromagnetic friction brake coupled to brake said rotatable element.

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