

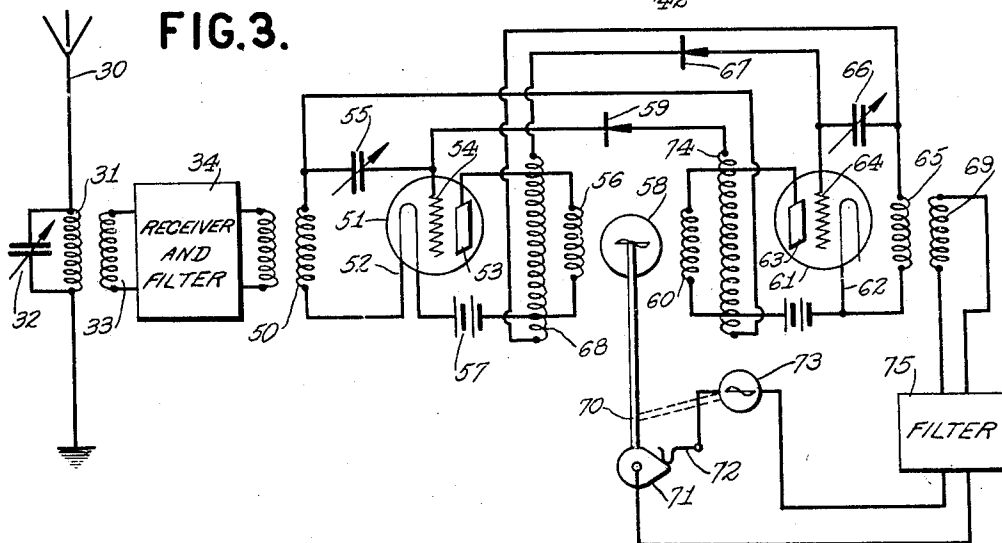
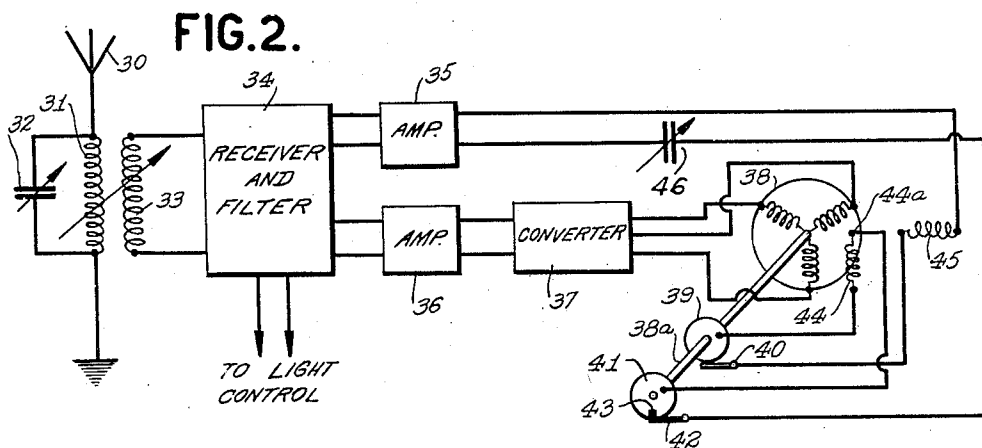
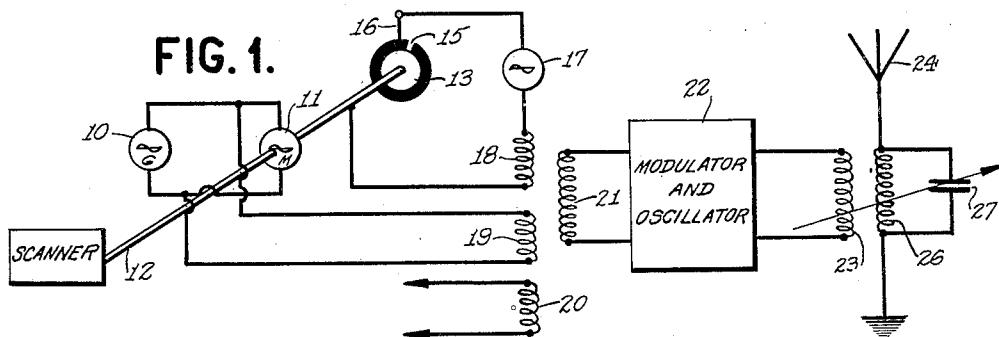
Feb. 13, 1945.

A. McL. NICOLSON

2,369,153

COARSE AND FINE FREQUENCY SYNCHRONIZING SYSTEM

Original Filed April 12, 1940 2 Sheets-Sheet 1



INVENTOR.
ALEXANDER McLEAN NICOLSON
BY *Hoguet, Neary & Campbell*
ATTORNEYS

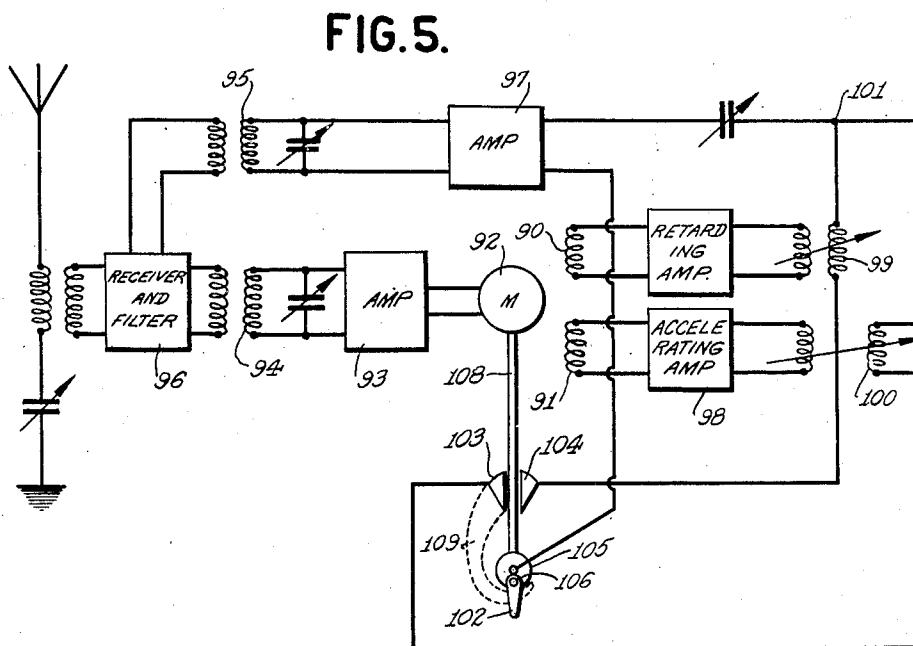
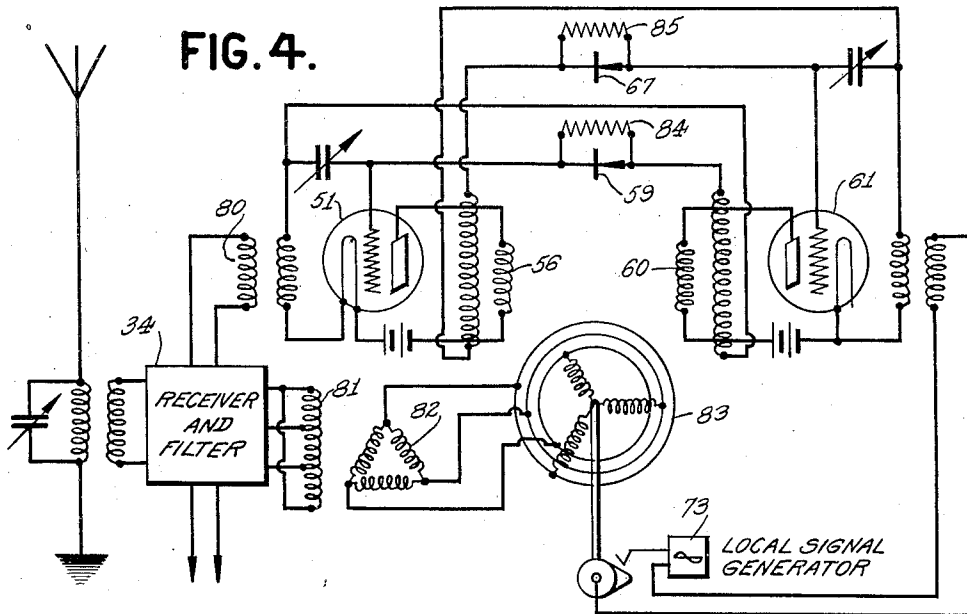
Feb. 13, 1945.

A. McL. NICOLSON

2,369,153

COARSE AND FINE FREQUENCY SYNCHRONIZING SYSTEM

Original Filed April 12, 1940 2 Sheets-Sheet 2



INVENTOR.
ALEXANDER McLEAN NICOLSON
BY *Hoguet, Neary & Campbell*
ATTORNEYS

UNITED STATES PATENT OFFICE

2,369,153

COARSE AND FINE FREQUENCY SYNCHRONIZING SYSTEM

Alexander McLean Nicolson, New York, N. Y.,
 assignor to Communication Patents, Inc., a corporation of Delaware

Original application April 12, 1940, Serial No. 329,324. Divided and this application November 21, 1941, Serial No. 419,886

16 Claims. (Cl. 172—293)

This invention relates to a system for synchronizing by coarse and fine frequencies the operation of a plurality of devices situated at spaced apart locations and more particularly relates to systems for synchronizing the operation of television and facsimile transmitters and receivers. This is a division of my copending application Serial No. 329,324, filed April 12, 1940, now Patent No. 2,263,641, dated November 25, 1941, which is a division of my application Serial No. 275,672, filed May 27, 1928, now Patent No. 2,197,005, dated April 16, 1940.

In order for a television system to be capable of wide and effective use, the apparatus should require no greater intelligence and skill on the part of the operator than can be exercised by the average person, as clearly it is impractical to require a highly skilled operator at every station, as for instance at every receiver in a television broadcasting system.

The operation of a receiver controlled in speed by a distant transmitter presents two principal difficulties. First, there is the difficulty of maintaining exactly the same speed at both stations, and secondly, there is the difficulty of bringing the scanning apparatus mechanically in step at both stations as well. This latter difficulty may result in parts of the received image being displaced with respect to the other parts. For example, if the scanning apparatus is operating at exactly the same speed at the transmitting station and at the receiving station, and if the receiving scanner is half way across the screen at the instant the transmitting scanner is operating on the beginning of the image, it will be apparent that at the receiver, the image will be cut in half and the two halves transposed in position.

It is clear that since there is only one space position of the receiving scanning apparatus relative to the transmitting scanning apparatus which will be correct, when synchrony is established, and there are many possible positions which will be incorrect, some means should be provided which will not only cause the receiving apparatus to come to synchronous speed, but which will also cause the receiving scanning apparatus to run faster or slower than the transmitting scanning apparatus, until it occupies the same position relatively to the image, and when this identity of relative position is attained, synchronous speed is to be maintained; and furthermore, should the receiver and transmitter get out of step, they must be brought

back in step, and the receiver again brought to synchronous speed.

The images at transmitter and receiver may be considered as fixed within what I term a frame of reference, and each comprises a large number of picture elements scanned in a unit of time and in a predetermined pattern or sequence, each frame being repeatedly scanned at the rate of 16 to 18 frames per second. If the scanners at the receiver and transmitter are operating at the same speed and pass corresponding points in the frame of reference at the same time, the received image will at all times be properly placed in its frame of reference or "framed."

It is an object of this invention to provide a synchronizing system in which the synchronizing at one or more stations is controlled by a master source of synchronizing currents.

It is a further object of this invention to provide a synchronizing system in which a plurality of elements at different stations may be caused to operate at the same or synchronous speed, and to take and maintain the same relative position, regardless of a difference in position at the beginning of operation, or at any time therein.

It is still a further object of this invention to provide a synchronizing system in which devices at any station may be set into operation and synchronized with a master source of synchronizing currents in the same relative position in each station without the necessity of manual adjustments.

Still other objects and advantages of my invention will be apparent from the specification.

In accordance with the present invention, I provide apparatus for transmitting periodic impulses or signals of some sort at definite time intervals representing definite space positions of the transmitting scanner, and I provide at the receiver apparatus such that if these signals are received at times when the receiving scanner is in an incorrect position, then the receiving scanner is caused to accelerate or retard as the case may be, until the space position of the receiving scanner is correct at the instant of receipt of such signals; when this condition is reached, the accelerating or retarding force is rendered inoperative or ineffective, as long as the desired condition obtains.

For a better understanding of the invention reference may be had to the accompanying drawings, in which:

Figure 1 is a circuit diagram of a transmitter

for transmitting signals controlling light intensity, speed and position of a receiving scanner;

Figure 2 is a circuit diagram of a receiver adapted for operation on signals received from apparatus such as shown in Figure 1;

Figure 3 is a circuit diagram of a receiver utilizing vacuum tubes for speed and position control;

Figure 4 is a circuit diagram of a slightly modified form of apparatus such as shown in Figure 3; and

Figure 5 is a circuit diagram of receiving apparatus utilizing the phenomenon of resonance for speed and position control.

A typical form of transmitter is disclosed in Figure 1 in which 10 designates diagrammatically a generator driven by any suitable prime mover, and generating currents of the desired frequency for operating motor 11, which in turn operates scanning apparatus of any suitable type, such as herein shown and described, or any other form of scanner known in the art. The apparatus for sending a signal at predetermined recurrent points, representing definite space positions of the scanner, I term a "metronome," and the signal transmitted thereby I term the "metronome signal."

The metronome comprises a suitable source of high frequency currents, such as a vacuum tube oscillator 17, from one terminal of which a connection passes to coil 18, thence to the shaft 12, which drives the scanning apparatus. Mounted on shaft 12 I provide a suitable device for periodically closing a circuit through source 17 and coil 18. In the form shown, this may comprise conducting disk 13 provided on its periphery with a coating of insulating material except at point 15. Engaging the periphery of disk 13, I may provide a contact finger or brush 16.

It will be seen that in the operation of this arrangement, coil 18 is momentarily traversed by high frequency oscillations at the instant that conducting point 15 passes under contact 16, and this may be arranged to take place at the instant that the scanning apparatus, driven from the shaft 12, is operating on the first element of the image.

In the particular arrangement shown, therefore, high or fine frequency oscillations will pass through coil 18 every time the scanning apparatus passes through initial position with reference to the image. It will be understood, however, that the contact may be closed to permit oscillations to pass through coil 18 with greater or less frequency, by the interposition of suitable gearing for driving the disk 13, or by other arrangements, as will be understood. A second coil 19 is provided, which may be shunted across the power line connecting the generator 10 and motor 11 to pass relatively low or coarse frequency oscillations; and a third coil 20 is provided, in which currents are flowing from the output of the photo cell amplifier. The coils 18, 19 and 20, are all coupled to coil 21, which feeds a suitable modulator and oscillator 22, diagrammatically shown, in such manner that the carrier frequency transmitted is modulated by the currents flowing in coils 18, 19 and 20.

The arrangement of said coils, modulator and oscillator, is shown only in diagram, as this arrangement per se forms no part of my invention, and is well known in the art. The modulated carrier frequency oscillations are passed through coil 23, and thence to coil 26 inductively coupled thereto, which is connected in circuit with antenna 24, and if desired, a tuning condenser 27

may be associated therewith. It will be understood that all of the modulating currents may be amplified, if desired, to a greater or less extent, and that in case it is desired, one or more of these modulated currents may be impressed as modulations upon separate carrier frequency oscillations which in turn may be used to modulate the carrier frequency of the station. Since the particular apparatus for modulating carrier oscillations, which modulated oscillations are in turn used to modulate another carrier, is well known in the art, it is not described in detail.

It will be understood that the signal radiated from the antenna 24 comprises three components: (1) the component indicating the value of light intensity at a particular time at the transmitter; (2) the currents representing the frequency of the motor generator system 10 and 11; and, (3) signals representing the passage of the transmitting scanning apparatus over a particular point of the frame of reference, and while I have indicated a method and apparatus for transmitting all of these signals of a similar carrier wave, it will be apparent that difficulties of modulation and separation may be avoided if desired, by transmitting each of these signals as modulations of separate carrier waves, each transmitted from a separate antenna or radiating system.

Referring now more particularly to Figure 2, I have shown diagrammatically one form of receiving apparatus, which I term a "synchro-nome," adapted to operate in response to signals transmitted from a system operating as just described. In this arrangement, 30 represents an antenna provided with inductance 31, shunted if desired, by a tuning condenser 32; the inductance 31 is suitably coupled to a second inductance 33, which feeds the input circuit of a suitable receiver and filter 34, which may comprise as many stages of radio frequency amplification as desired, together with detection and the necessary filtering circuits separating the various signal components from each other and from the received carrier.

The photocell currents are passed to the light control apparatus, as shown diagrammatically by leads designated "to light control," and it will be understood that these currents may be amplified to the extent desired. The currents representing the relatively low or coarse frequency of the motor-generator system 10 and 11, may be amplified by suitable amplifier 36, and may be converted, if desired, by means of a converter 37, to currents of the phase desired. In the arrangement shown, I have illustrated the output of converter 37 as being supplied to a suitable three phase motor 38; in this connection, it is desired to point out that preferably motor 11 and motor 38 should have as near as possible, the same operating characteristics, so that these two motors, under normal conditions, will operate at substantially the same speed or in coarse or approximate synchrony.

To obtain fine synchrony operation of the motor 38 and the motor-generator system 10, 11 I provide the rotor of motor 38 with a series of coils 44, herein diagrammatically shown for purposes of simplicity, as a single coil, preferably mounted on a pivot at one end so as to be free to align themselves radially under the action of centrifugal force when the motor is operating at substantially synchronous speed. I also provide a series of stationary coils 45, adapted to coact with coils 44 and connected in series therewith through a circuit comprising contact 40

bearing on slip ring 39 of the shaft 38a of motor 38, and also by means of contact 42 bearing on slip ring 41 insulated from the shaft of motor 38.

The coils 44 and 45 are arranged to be energized by the incoming metronome signals, which may be amplified to the extent desired by the amplifier 35. It will be noted that I provide an insulating segment 43 on the periphery of the disk or slip ring 41, so that the circuit through coils 44 and 45 is periodically interrupted at one point during the revolution of slip ring 41; at all other times, the output circuit of amplifier 35 passes through coil 45 to contact 40, thence to slip ring 39, thence through coil 44 to slip ring 41 to contact 42, and thence through a suitable tuning condenser 46 to amplifier 35.

The coils 44 should be arranged so that at speeds substantially less than synchronous speeds, the coils 44 will not be extended radially outward, and will have very little effect; however, as the motor 38 reaches synchronous speed, these coils will swing into position with their axes extending radially in position to coact with stationary coil 45; the insulating section 43 is so positioned on the slip ring 41, that it interrupts the output circuit of amplifier 35 when the position of the receiving scanning apparatus operated by motor 38 corresponds to the position desired; that is to say, in case the transmitter sends out a metronome signal at the instant the scanning apparatus passes across the first element of the image, then the insulating segment 43 will be so positioned with respect to the scanning apparatus driven by motor 38, that insulating segment 43 passes under the contact 42 at the instant that the receiving scanning apparatus driven by the motor 38, passes across the first element of the receiving screen.

If it be assumed that the motor 38 is operating at the same speed as the motor 11 and the instantaneous position of the transmitting and receiving scanning apparatus with respect to the frame of reference, is the same, then the circuit of coils 44 and 45 will be open at the instant the metronome signal is received, and these coils will have no effect. If, on the other hand, as will usually be the case in starting, this condition does not obtain, then the circuit through these coils will be closed, and upon receipt of the metronome signal and during the duration thereof, coils 44 and 45 will operate to attract or repel each other, as the case may be, it being understood that the polarity of all of the coils is so chosen as to obtain maximum action.

For the purpose of discussion, it may be assumed that the coils are so wound, that upon the passage of current therethrough, they are attracted. It will then be apparent that if the motor 38 is operated at less than synchronous speed or is out of proper position with respect to the frame of reference, then every time a metronome signal is received, an impulse will be delivered to the motor 38 tending to speed it up, provided the space relation of the coils 44 and 45 is properly chosen. On the other hand, if the motor 38 is operating at greater than synchronous speed, it is apparent that the position of the coils 44 will be such that it will be retarded by the action of the currents corresponding to the received metronome signal.

In order to prevent a condition of more or less continuous hunting by the motor 38, it may be desirable to arrange the said motor so that it will normally operate at a speed relatively a little slower than synchronous speed, so that correcting

or accelerating impulses are supplied thereto periodically, so as to maintain synchronous speed.

It will also be observed that with such an arrangement, regardless of the space position of the receiving scanner with respect to the frame of reference, the driving motor cannot operate at synchronous speed until the correct position with respect to the frame of reference has been reached, and this makes it possible to provide a single master switch, operable for example by remote control, if desired, which master switch may be arranged to close all the necessary circuits to set the receiving apparatus in operation.

Therefore, it becomes possible to operate a television broadcasting system, requiring no skill on the part of the operator at the various receiving stations, since if the transmitting station is in operation and it is desired to receive from it, the receiving operator need only push a single start-stop switch to starting position, whereupon the receiving apparatus will be set into operation, as already described, and will continue to function under the complete control of the transmitting station as long as the master switch is kept closed, no attention being required on the part of the receiving operator.

Referring now more particularly to Figure 3, I have shown diagrammatically another form of synchronome or synchronous receiver for exactly keeping step with the master metronome at the transmitting station. In this arrangement, I have shown the same receiving antenna and frequency filter as indicated in Figure 2, but utilizing thermionic vacuum tubes as controlling devices to differentiate between periodically generated master and local signals.

The received metronome signal, picked up by the coil 50, is applied to the control electrode 54 of the thermionic tube 51. This signal is amplified sufficiently to energize the coil 56, controlling the speed of the synchronome motor 58. It will be observed that the tube is provided with the usual cathode 52 and anode 53, which is energized by the battery 57, and the input circuit may include a tuning condenser 55. When the output coil 56 is energized, part of the amplified signal is transferred to the coil 68 to control or block the activity of a similar thermionic tube 61, having a cathode 62, anode 63 and control electrode 64. The current induced in the coil 68 may be rectified by rectifier 67 of any suitable type. The rectifier when it is energized, passes negative charges, corresponding to the rectified metronome signal, to the control electrode 64 of the thermionic tube 61. This vacuum tube amplifier normally is energized by a local signal, similar to the master metronome signal generated by oscillator 73 and supplied periodically by a contact device 71 attached to the shaft 70 of the synchronome motor. The local or synchronome signal may be produced by a high frequency generator 73, coupled to the synchronome motor 58, when the spring 72 feeds the local signal, which passes through filter 75 to the amplifier 61 and through the coils 69 and 65; and a tuning condenser 66 may be provided to strengthen the input signals which pass the filter. Both metronome and synchronome signals should comprise, near synchrony, high frequency oscillations of, preferably, similar periodicity.

When the output coil 60 is energized, a portion of the energy is carried by the associated coil 74 and is rectified by the rectifier 59 so as to pass negative blocking charges to the amplifier 51 from generator 73. The coils 56 and 60 operate

to accelerate or retard the synchronome motor 58, except that at speeds much below synchrony, the accelerating coil 56 alone functions. When the motor speeds up sufficiently to cause the generator to pass energy of approximately speed frequency through the filter, then the retarding coil 60 will be able to function in arresting the speed of the synchronome motor.

Which coil operates to control the motor, depends on the advent of distant or local signal. When the metronome energizes the amplifier 51, it establishes a negative blocking potential on the control electrode 64 of the amplifier 61, and consequently suppresses energy flow in the coil 60. When the synchronome signal energizes the amplifier 61, it establishes a negative blocking potential on the control electrode 54 of the amplifier 51, and likewise suppresses energy flow in the coil 56.

Accordingly, if the synchronome is running below metronome speed, it is accelerated, and if above it is retarded; in fact, it is maintained at synchrony. The currents in coils 56 and 60 are amplified sufficiently to produce the energy required to control the motor 58. If the frequency of the currents is low, as for example representing the direct current fluctuations of the tubes 51 and 61, then ordinary field coils with magnetic material for reinforcement of the flux may be used. On the other hand, high frequency currents may be applied to these coils with the design of the motor modified to respond to fluctuating currents of higher order.

Moreover, the motor 58 may be driven by local power to approximate synchrony and the load on the coils 56 and 60 may be reduced to values sufficient to exert the required speed variations to maintain synchrony.

Referring now more particularly to Figure 4, in which I indicate again the thermionic controlling system described in Figure 3; I show a polyphase motor synchronome 83 driven synchronously with and by the master metronome 10 described in Figure 1. The receiver 34 filters and amplifies and supplies to output coil 80 the synchronome signals, described in Figure 3, and to coil 81 the polyphase currents necessary to energize the network system 82 and motor 83 of the synchronome. If the speed developed by the motor 83 is approximately synchronous with the transmitting system 10, 11, and the time-phase sufficient to cover a complete scanning element or reference frame as described, then the speed controlling coils 56 and 60 will take care of speed variations within the time and space represented by a single phasing of the motor system. Of course, the speed controlling coil 60 may, at lower speeds than synchrony, have its action cut out by causing, as in Figure 3, the synchronome motor 83 to drive the generator 73 and to suppress its oscillating currents by a filter until the correct frequency is generated and passed to the coil 60, as aforesaid.

On the other hand, the local signal generator 73 may, as shown in Figure 4, be a self-sustaining oscillator whose energy is periodically tapped and transmitted, as indicated, to the retarding coil 60.

The rectifiers 59 or 67, if of the gaseous tube type, may be shunted with suitable impedances 84 and 95, in order to maintain at high frequency rectifications, the tubes 51 and 61 sufficiently discharged at the conclusion of the master or local time signals, so as not to block and interfere with the desired operation.

In Figure 5, I show a modified synchronome for attuning by the principle of resonance the local apparatus to the incoming master metronome signals. The receiver 96 delivers the coarse and fine synchronizing signals to coils 94 and 95, respectively, for driving and controlling the synchronome motor 92. By means of shaft 108, the motor drives the wheel 105, which carries peripherally the suspended metallic plate 102 pivoted at 106. This plate is designed near synchronous speed, to engage capacitively corresponding conducting sectors or areas 103 and 104, whose separation apart and distance from the fly plate 102 is adjustable.

The condensive couples 102 and 103, and 102 and 104, when in conjunction near synchronous speed with the master metronome, energize one or other of the two resonant circuits 99 and 100, provided the metronome signal is being sent and received through coil 95, amplifier 97 and the lines 101 and 107.

The mode of operation of the resonance synchronizer is as follows: the synchronome 92 is driven from the receiver 96 through the amplifier 93 at approximate or coarse synchrony, at which, also, the movable condenser plate 102 will fly out sufficiently far, centrifugally, to close, electrostatically, one or other of the resonant circuits containing respectively coils 99 and 100.

For example, if the plates 102 and 103 meet in capacitative conjunction, then high frequency current from amplifier 97 will pass through the momentarily established electric condenser, thus formed, and will energize the coil 100 and amplifier 98; and coil or coils 91 will be strongly energized and may, for example, thus accelerate the speed of the motor 92. Similarly, the coil or coils 90 may retard the motor when the capacitative currents flow through the moving condenser system 102 and 104. Now, when the metronome signal occurs during conjunction of the plates, the synchronome is either expedited or retarded, and at synchrony of the synchronome the fly plate will be passing just between the plates 103 and 104.

In order to assist rapid acceleration of the synchronome motor 92, the condenser plate 103 taking part in the process may have its functioning area tail off as shown in dotted lines at 109.

In high speed television and synchronization, the wheel 105 should be geared to relatively high speed with the shaft 108 of the motor 92; the separation between plates 103 and 104 and the width of the fly plate 102 should be reduced to a minimum compatible with sharp tuning.

While I have shown and described certain preferred embodiments of my invention, modifications and changes may be made without departing from the spirit and scope of my invention as will be understood by those skilled in the art.

I claim:

1. In a system for synchronizing the operation of a pair of current controlled devices, a source of frequency current to drive the first of said devices, means associated with said first device to generate metronome signals in accordance with the operation of said first device, means to transmit to the second of said devices said metronome signals and signals characteristic of said frequency current, means responsive to the last mentioned signals to cause said second device to operate in at least coarse synchrony with said first device, means associated with said second device to generate synchronome signals

in accordance with the operation of said second device, and means responsive to said metronome and synchronome signals to cause said second device to operate in fine synchrony with said first device.

2. In a system for synchronizing the operation of a pair of current controlled devices, a source of relatively low frequency current to drive the first of said devices, means associated with said first device to generate a relatively high frequency current in accordance with the operation of said first device, means to transmit to the second of said devices signals having the low and high frequency characteristics of the aforementioned currents, means responsive to the low frequency characteristic of said signals to cause said second device to operate in at least coarse synchrony with said first device, means associated with said second device to generate relatively high frequency current in accordance with the operation of said second device, and means responsive to the high frequency currents to cause said second device to operate in fine synchrony with said first device.

3. In a system for synchronizing the operation of a pair of current controlled devices, a source of frequency current to drive the first of said devices, means associated with said first device to generate impulses at a frequency characteristic of the operation of said first device, means to transmit signals having the frequency characteristics of said current and said impulses, means associated with the second of said devices to receive and filter said signals, means responsive to the portion of the signals corresponding to said current to cause said second device to operate in at least coarse synchrony with said first device, means associated with said second device to generate impulses at a frequency characteristic of the operation of said second device, and means for comparing the impulses generated by said pair of devices to cause said second device to operate in fine synchrony with said first device.

4. In a system for synchronizing the operation of a pair of current controlled devices, a source of frequency current to drive the first of said devices, means associated with said first device to generate metronome impulses in accordance with the operation of said first device, means to transmit signals to the second of said devices which signals include impulses having the characteristics of said current and the metronome impulses, means associated with said second device to receive and filter said signals, means to amplify the metronome impulses to and cause said second device to operate in at least coarse synchrony with said first device, means associated with said second device to generate synchronome impulses in accordance with the operation of said second device, and means responsive to said metronome and synchronome impulses to cause said devices to operate in fine synchrony.

5. In a system for synchronizing the operation of a pair of current controlled devices, a source of frequency current to drive the first of said devices, means associated with said first device to generate metronome signals in accordance with the operation of said first device, means including modulator and oscillator circuits to broadcast said metronome signals and signals characteristic of said frequency current, means associated with the second of said devices to receive and filter the signals, means responsive to the signals characteristic of said frequency

current to drive said second device in at least coarse synchrony with said first device, means associated with said second device to generate synchronome signals in accordance with the operation of said second device, and means responsive to said metronome and synchronome signals to cause said devices to operate in fine synchrony.

6. In a system for synchronizing the operation of a pair of current controlled devices, a source of frequency current to drive the first of said devices, means associated with said first device to generate metronome signals in accordance with the operation of said first device, means to transmit said metronome signals and signals characteristic of said frequency current, means associated with the second of said devices to receive and filter said signals, power means for said second device, means including an amplifier responsive to the signals characteristic of said frequency current to cause said power means to drive said second device in at least coarse synchrony with said first device, means operated by said power means to generate synchronome signals in accordance with the operation of said second device, and means responsive to said metronome and synchronome signals to cause said power means to operate said second device in fine synchrony with said first device.

7. In a system for synchronizing the operation of a pair of current controlled devices, a source of frequency current to drive the first of said devices, means associated with said first device to generate metronome signals in accordance with the operation of said first device, means to transmit said metronome signals and signals characteristic of said frequency current, means associated with the second of said devices to receive and filter said signals, a three-phase motor for said second device, means including an amplifier and a converter responsive to the signals characteristic of said frequency current to cause said motor to drive said second device in at least coarse synchrony with said first device, means operated by said motor to generate synchronome signals in accordance with the operation of said second device, and means associated with said motor responsive to said metronome and synchronome signals to cause said motor to drive said second device in fine synchrony with said first device.

8. In a system for synchronizing the operation of a pair of current controlled devices, a source of frequency current to drive the first of said devices, means associated with said first device to generate metronome signals in accordance with the operation of said first device, means to transmit said metronome signals and signals characteristic of said frequency current, means associated with the second of said devices to receive and filter said signals, power means for said second device, means including an amplifier responsive to the signals characteristic of said frequency current to cause said power means to drive said second device in at least coarse synchrony with said first device, means operated by said power means to generate synchronome signals in accordance with the operation of said second device, accelerating and retarding circuits for said power means, the accelerating circuit being adapted to receive metronome signals and the retarding circuit being adapted to receive synchronome signals, and said circuits being electrically associated to affect said power means one way or the other whenever the metronome

and synchronome signals vary from synchronous timed relation.

9. In a system for synchronizing the operation of a pair of current controlled devices, a source of frequency current to drive the first of said devices, means associated with said first device to generate metronome signals in accordance with the operation of said first device, means to transmit said metronome signals and signals characteristic of said frequency current, means associated with the second of said devices to receive and filter said signals, means including an amplifier responsive to the signals characteristic of said frequency current to cause said second device to operate in at least coarse synchrony with said first device, means associated with said second device to generate synchronome signals in accordance with the operation of said second device, accelerating and retarding circuits for said second device, and means to compare the timing of the metronome and synchronome signals to selectively energize said circuits in accordance with any deviation in the synchronous timing relation of such signals.

10. In a system for synchronizing the operation of a pair of current controlled devices, a source of frequency current to drive the first of said devices, means associated with said first device to generate metronome signals in accordance with the operation of said first device, means to transmit said metronome signals and signals characteristic of said frequency current, means associated with the second of said devices to receive and filter said signals, means including an amplifier responsive to the signals characteristic of said frequency current to cause said second device to operate in at least coarse synchrony with said first device, accelerating and retarding resonance circuits for said second device, means to apply said metronome signals on said circuits, and means operated by said second device to establish resonance in one or the other or both of the circuits by closing on one side or the other or at synchrony one or the other or both of the circuits, as the case may be, whereby the operation of said second device is maintained in fine synchrony with said first device.

11. In a system for synchronizing the operation of a pair of current controlled devices, a source of frequency current to drive the first of said devices, means associated with said first device to generate metronome signals in accordance with the operation of said first device, means to transmit said metronome signals and signals characteristic of said frequency current, means associated with the second of said devices to receive and filter said signals, power means for said second device, means responsive to the signals characteristic of said frequency current to cause said power means to start and accelerate said second device to at least coarse synchrony with said first device, means operated by said power means to generate synchronome signals in accordance with the operation of said second device, and means associated with said power means responsive to the establishment of synchrony or near synchrony of the metronome and synchronome signals to cause said second device to operate in fine synchrony with said first device.

12. In a system for synchronizing the operation of a pair of current controlled devices, a source of frequency current to drive the first of said devices, means associated with said first device to generate metronome signals in accord-

ance with the operation of said first device, means to transmit to the second of said devices said metronome signals and signals characteristic of said frequency current, means responsive to the last mentioned signals to cause said second device to start and accelerate to at least coarse synchrony with said first device, means associated with said second device to generate synchronome signals in accordance with the operation of said second device, and means responsive to said metronome and synchronome signals to cause said second device to operate in fine synchrony with said first device.

13. In a system for synchronizing the operation of a pair of current controlled devices, a source of power to drive the first of said devices, means associated with said first device to generate a frequency current in accordance with the operation of said first device, means to transmit to the second of said devices signals having the frequency characteristics of said current, means responsive to the signals to start and accelerate said second device, means associated with said second device to generate a current, the frequency of which is adapted to be the same as the frequency current generated by said first device when the devices are in synchrony, and means to compare the frequency of the current generated by said second device with the frequency characteristics of said signals to cause said second device when it reaches synchrony speed to be maintained in synchrony.

14. In a system for synchronizing the operation of a pair of current controlled devices, a source of power to drive the first of said devices, means associated with said first device to generate a frequency current in accordance with the operation of said first device, means to transmit to the second of said devices signals having the frequency characteristics of said current, means responsive to said frequency characteristics of said signals to start and accelerate said second device to the speed of said first device, means associated with said second device to generate a frequency current, means responsive to said last mentioned current to retard said second device, and means to filter said current for passage of frequency currents of the character generated at and beyond synchronous speeds to cause said second device when it reaches synchronous speed to be maintained in synchrony.

15. In a system for synchronizing the operation of a pair of current controlled devices, a source of frequency current to drive the first of said devices, means associated with said first device to generate metronome signals in accordance with the operation of said first device, means to transmit said metronome signals and signals characteristic of said frequency current, means associated with said second device responsive to the signals characteristic of said frequency current to start and accelerate said second device to approximate synchronous speed, accelerating and retarding circuits for said second device, means associated with said second device to generate synchronome signals in accordance with the operation of said second device, and means to compare the timing of said metronome and synchronome signals to determine the energization of said circuits so as to cause said second device when it reaches synchrony speed to be maintained in synchrony.

16. In a system for synchronizing the operation of a pair of current controlled devices, a source of frequency current to drive the first of said devices,

means associated with said first device to generate metronome signals in accordance with the operation of said first device, means to transmit said metronome signals and signals characteristic of said frequency current, means associated with said second device responsive to the signals characteristic of said frequency current to start and accelerate said second device to approximate synchronous speed, accelerating and retarding resonance circuits for said second device, means to 10

apply said metronome signals on said circuits, and means associated with said second device to establish resonance in one or the other or both of the circuits by closing on one side or the other or at synchrony one or the other or both of the circuits, as the case may be, so as to cause said second device when it reaches synchrony speed to be maintained in synchrony.

ALEXANDER McLEAN NICOLSON.