April 16, 1940. A. McL. NICOLSON 2,197,005

TWO WAY TELEVISION SYSTEM

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Fig. 1

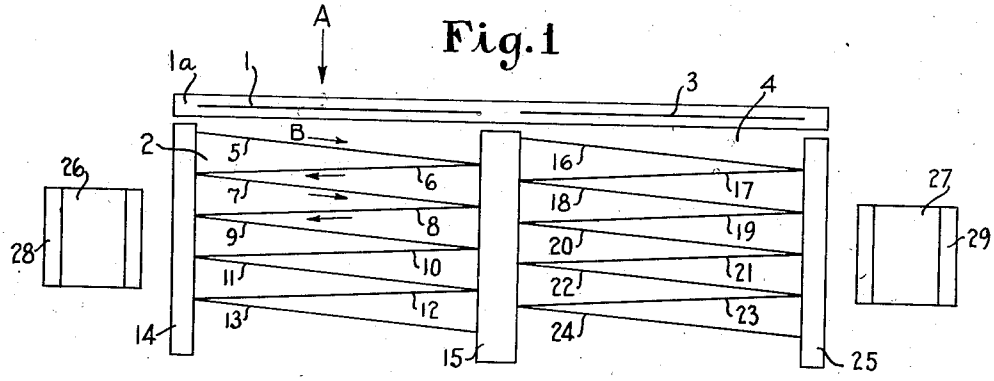


Fig. 2

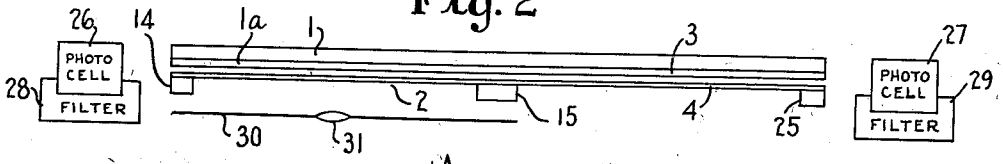


Fig. 3

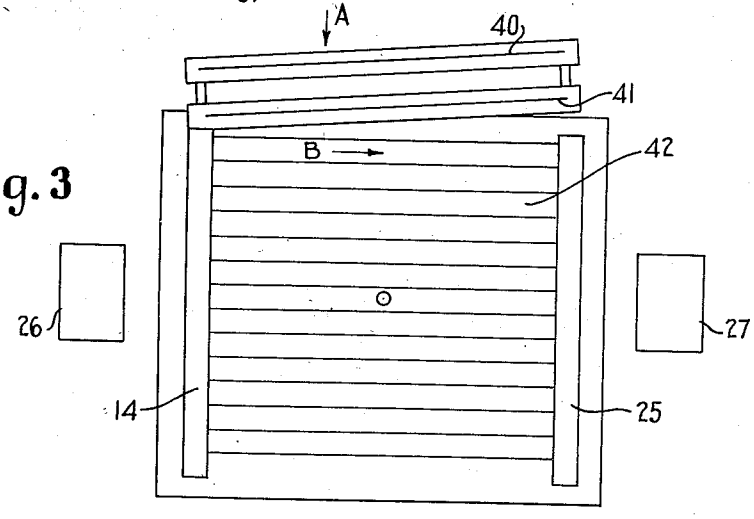
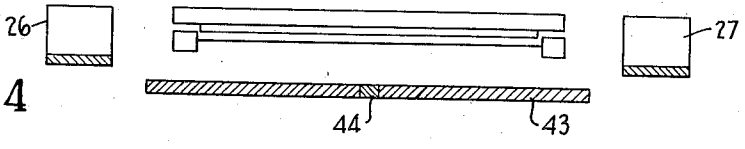
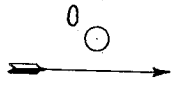


Fig. 4





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Fig.5

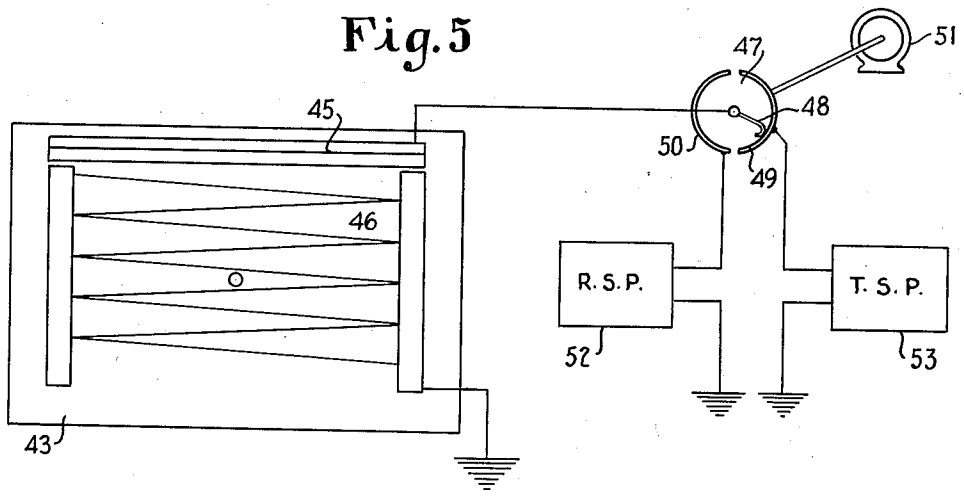
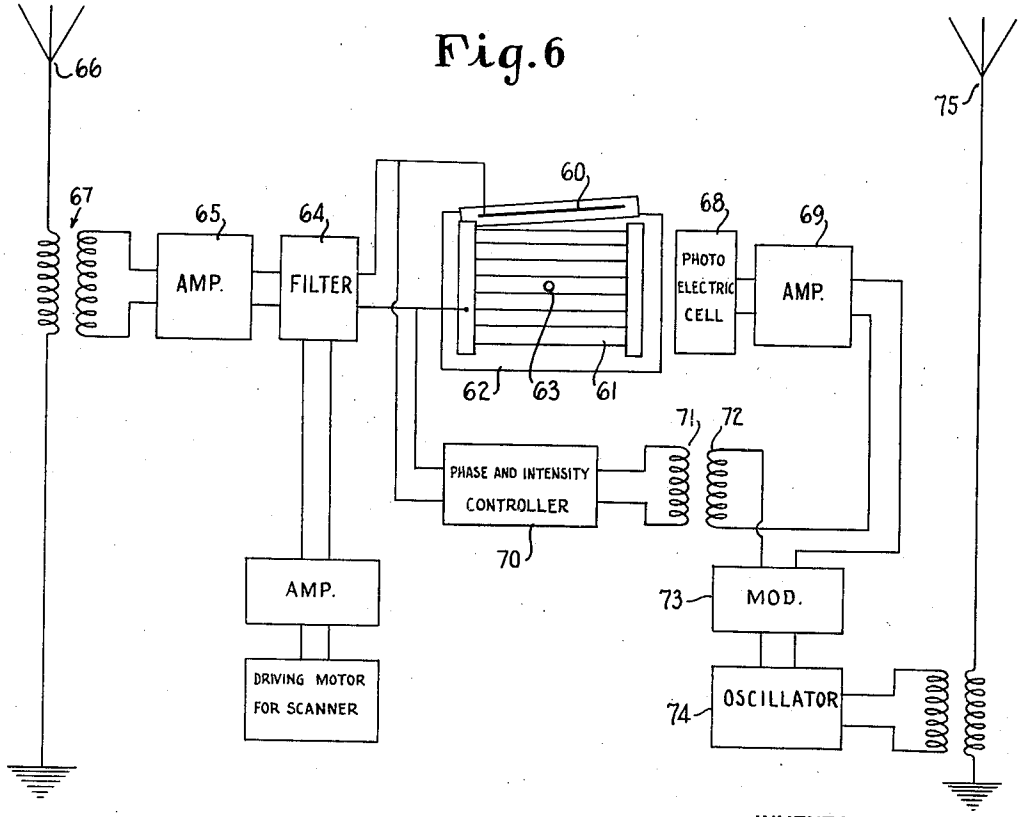


Fig.6

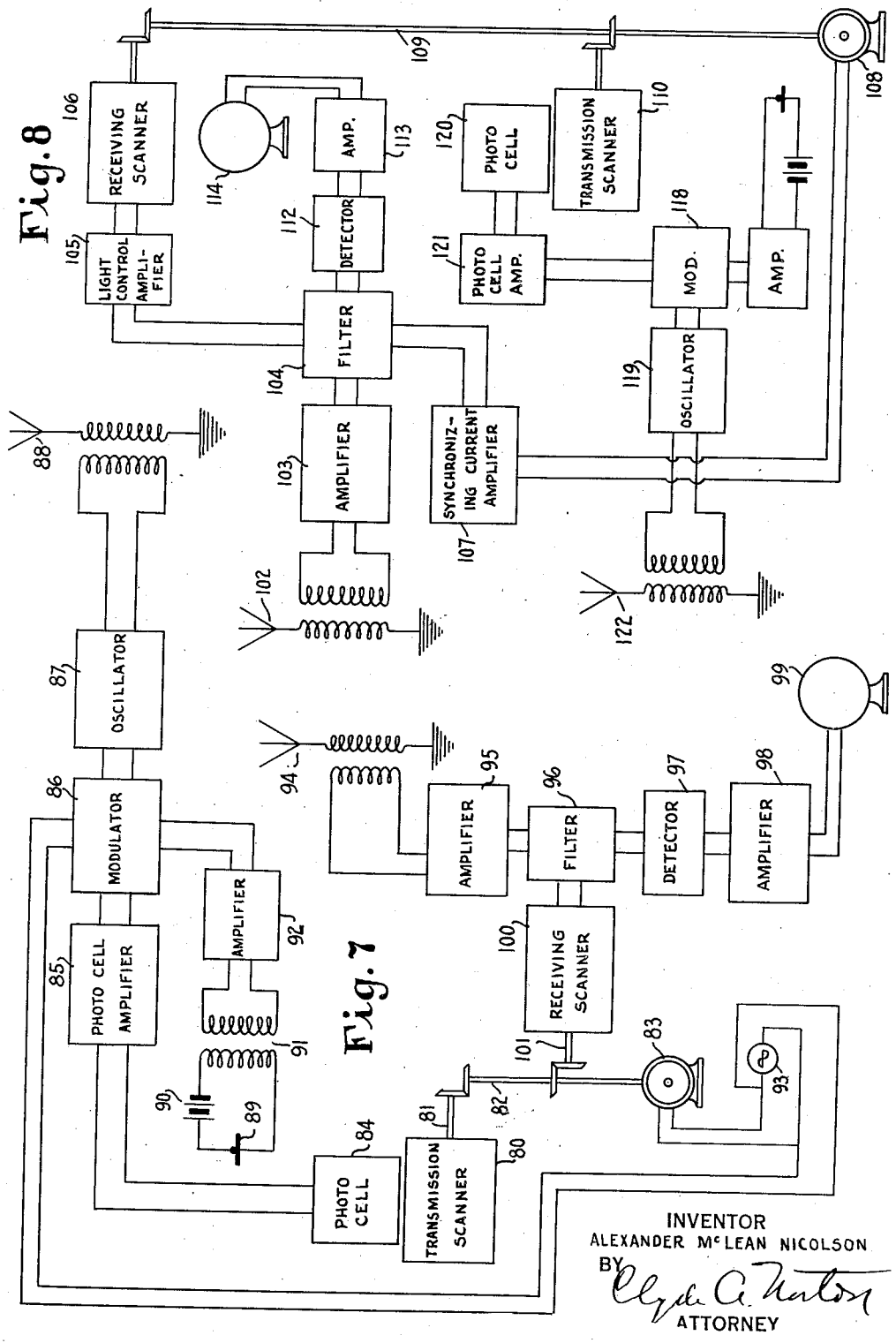


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Fig. 9

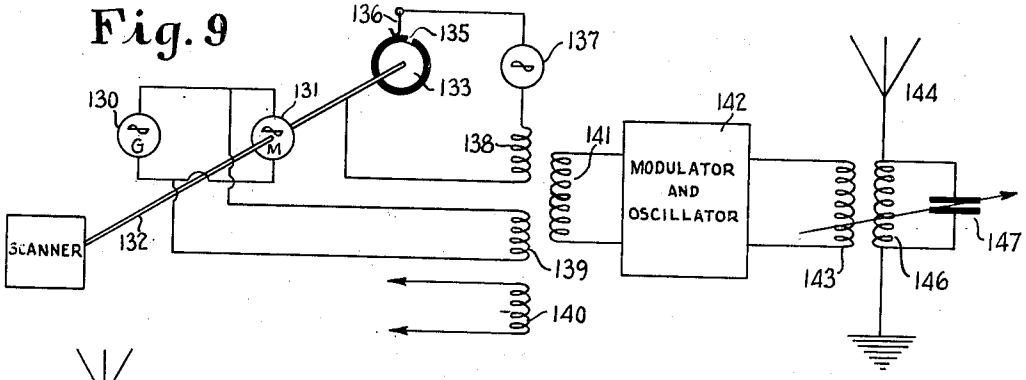


Fig. 10

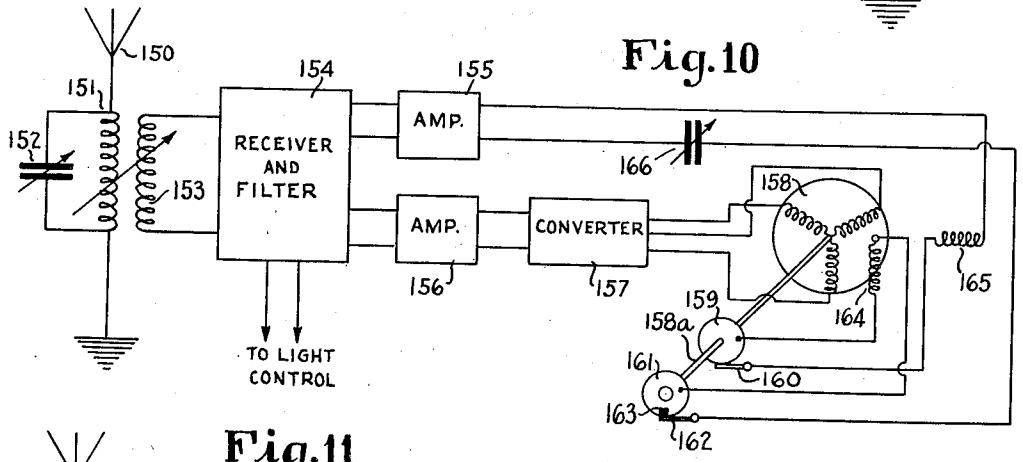
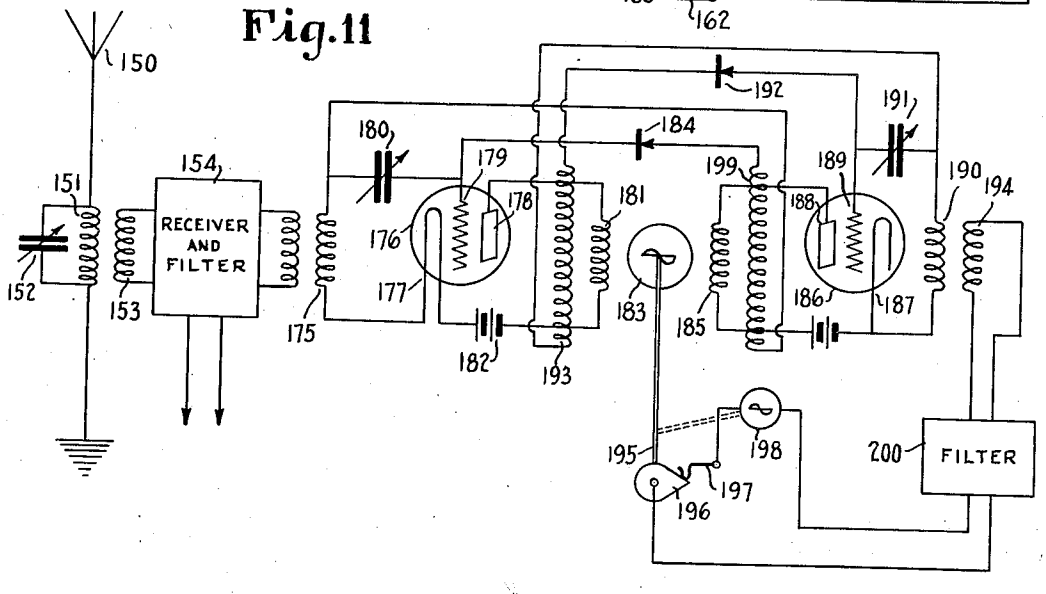


Fig. 11



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Fig. 12

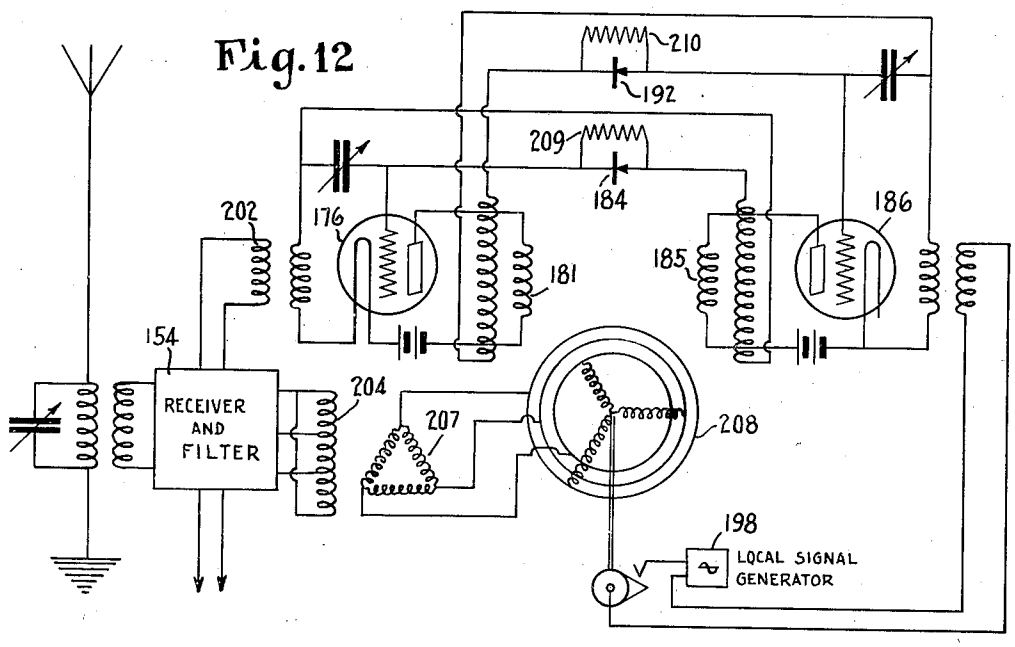
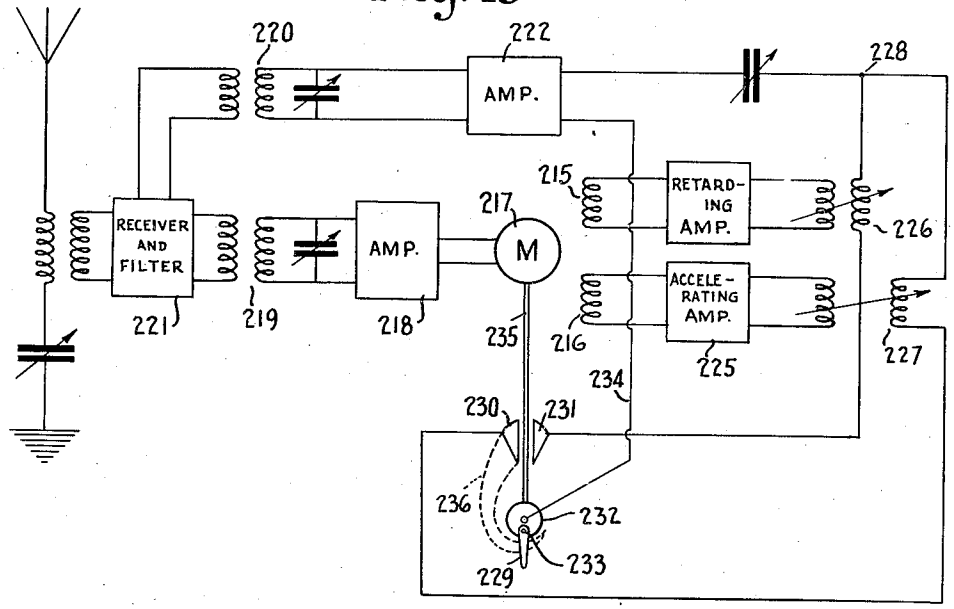


Fig. 13



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Patented Apr. 16, 1940 2,197,005

UNITED STATES PATENT OFFICE

2,197,005

TWO-WAY TELEVISION SYSTEM

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

Application May 7, 1928, Serial No. 275,672

4 Claims. (Cl. 178—6)

This invention relates to a method and apparatus for facsimile transmission or television and more particularly to a method and apparatus for providing two-way television between two relative separated stations, together with telephone communication, if desired, either over wire lines or through radio channels.

It is an object of this invention to provide a method and apparatus whereby the subject, at one station, which I term the "home station", is scanned, and a series of signals representing the image of the subject is transmitted to what I term the "distant station", while simultaneously at the distant station the image received from the home station is projected or exposed to the view of the subject at the distant station, and simultaneously the subject at the distant station is scanned and a series of signals transmitted from the distant station to the home station are projected as the image of the subject at the distant station in view of the subject at the home station.

It is a further object of this invention to provide a method and apparatus by which a subject may be scanned, while simultaneously there is projected or exposed to his view an image of the subject at the distant station, without interference by the received image with transmission scanning.

It is a further object of this invention to provide a method and apparatus whereby the same source of illumination may be utilized to produce an image of a distant object in view of the home subject whose image is to be transmitted, and simultaneously to scan the home subject.

It is a further object of this invention to provide a system of the class described in which the synchronizing at all of the stations is controlled by a master source of synchronizing currents at one station, and in which the receiving and transmitting scanning apparatus at any particular station is operated by a single prime mover synchronized with said master source of synchronizing currents.

It is a further object of this invention to provide a system of the class described in which scanning elements at different stations may be caused to operate at the same or synchronous speed, and to take and maintain the same relative position with reference to the image, 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 such a system in which any station may be set into operation and synchronized with the scanning elements in the same relative position in each station without the necessity of manual adjustments.

It is a further object of my invention to provide what I may term a complete television telephone broadcasting system, in which a master transmitter station may transmit both sounds and images to any desired number of receiving stations under the complete control of the transmitting station, so that if any observer wishes to receive the broadcast matter, he may simply close a switch, and the receiver will be put into operation, the receiving scanner synchronized with the transmitting scanner, as to speed of travel, and adjusted thereto as to space position on the image, and this condition maintained indefinitely under control of the transmitter and without requiring further attention from the observer.

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

The features of novelty which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its fundamental principles and as to its particular embodiments will best be understood by reference to the specification and accompanying drawing, in which:

Figure 1 is a front elevation of one form of transmitting and receiving scanning apparatus according to my invention, showing the focussing screen and lens removed from the transmitting scanning apparatus;

Figure 2 is a top plan view of the apparatus shown in Figure 1, with the focussing screen in place;

Figure 3 is a front elevation view of one form of apparatus according to my invention, in which one set of electrodes is utilized in both the transmitting and receiving scanning apparatus;

Figure 4 is a top plan view of the apparatus shown in Figure 3;

Figure 5 is a diagrammatic view of apparatus in which the same electrodes are used alternately for transmitting and receiving scanning;

Figure 6 is a diagrammatic view of a complete station in which reception and transmission is carried on simultaneously, and in which the subject is scanned for transmission and simultaneously the received image is exposed to his view;

Figures 7 and 8 are diagrammatic views of a complete system comprising a home station and a distant station between which two-way telephony and television may be carried on, Figure 7 repre-

senting the home station and Figure 8 the distant station;

Figure 9 is a circuit diagram of a transmitter for transmitting signals controlling light intensity, speed and position of a receiving scanner;

Figure 10 is a circuit diagram of a receiver adapted for operation on signals received from apparatus such as shown in Figure 9;

Figure 11 is a circuit diagram of a receiver utilizing vacuum tubes for speed and position control;

Figure 12 is a circuit diagram of a slightly modified form of apparatus such as shown in Figure 11; and

Figure 13 is a circuit diagram of receiving apparatus utilizing the phenomenon of resonance for speed and position control.

It is known that in order to transmit images, a signal must be sent which successively indicates the light intensity at each elemental section of area of the image, and at the receiving apparatus a source of light must be controlled so that it corresponds not only in intensity but also in position to each particular element of the area of the image to be transmitted. Some form of apparatus must be utilized at the transmitter whereby the light sensitive element, such as a photo electric cell, is successively subjected to light reflected from successive elements of the area of the subject, and simultaneously at the receiver similar apparatus must be used, which causes a light to play over a surface in the same pattern which is followed as a result of the functioning of the transmitting apparatus. This apparatus is termed the "scanning apparatus", that used at the transmitter being designated as the "transmitting scanning apparatus", and that at the receiver being designated as the "receiving scanning apparatus".

The transmitting scanning apparatus is driven by a suitable prime mover, preferably a synchronous motor energized from currents of predetermined frequency, and the receiving scanning apparatus is driven by a similar prime mover energized by currents of the same frequency, which may be, and preferably are, transmitted to the receiving apparatus over the same or different channel from that used for the transmission of light controlling signals.

In order to make possible two-way television, it is necessary to provide at the home station and at the distant station or stations, apparatus by which the subject is scanned for transmission to the other stations, and also on apparatus for exposing in view of the subject the image reconstructed from the signals received from the other station.

In accordance with my invention, I provide a single apparatus which I may term a "duplex scanning apparatus" which simultaneously scans the subject whose image is to be transmitted and produces in view of the subject the image received.

In its preferred form, the duplex scanning apparatus, according to my invention, consists of apparatus arranged to scan the subject and to reconstruct the received image, driven from a single prime mover, such as a synchronous motor, which, in turn, is driven by a source of alternating current of predetermined and fixed frequency.

In accordance with one form of the duplex scanning apparatus, there may be provided separate sources of illumination arranged side by side, and operating simultaneously and in synchronism.

In accordance with another form, I may utilize a single source of illumination, which operates successively at predetermined intervals to scan the subject for transmission and to produce the received image.

In accordance with still another form of my invention, I may utilize a single source of illumination which simultaneously scans the subject for transmission and produces the received image, together with arrangements for preventing fluctuations of illumination due to the received signal from appearing in the transmitted signal.

In all of these forms of apparatus, a single prime mover is utilized for driving the moving parts of the apparatus in both the transmission and receiving arrangements at the same station.

While I have shown a single home station and a single distant station, it will be understood that as many stations as desired may be utilized, by providing the appropriate apparatus: but in any case, I prefer to utilize a master source of synchronizing current at one station, which controls the prime movers in all of the stations, thus eliminating the necessity for transmitting synchronizing signals in both directions between the home station and the distant station, and preferably the apparatus in all other stations is arranged as will hereinafter be described in detail, so that all speed control at stations other than the master station is operated by apparatus controlled by the master station, so that no manual adjustment is required at any station other than the master station, either in starting or maintaining operation.

In order to prevent the illumination of the subject, due to the received image, from affecting the transmission scanning, I prefer to scan the subject for transmission by means of radiant energy outside the range of visible light, preferably by infra-red radiation or ultra-violet radiation; and the photo electric cells or other apparatus for converting the radiation energy reflected back from the subject, into current or potential variations, are preferably protected by a suitable energy filter to prevent undesired response of the apparatus to visible light radiation.

Referring now more particularly to Figure 1, I have shown an intercept scanning apparatus of the type described and claimed in my copending application, entitled "Scanning system for television", filed October 26, 1927, Serial Number 228,712, comprising a relatively movable electrode 1 adapted to sweep by a stationary electrode system 2 in close proximity thereto, but without making actual contact. The electrode 1 may be a knife edge or wire provided with points, projections or serrations, and the stationary electrode 2 may comprise similar knife edges, wires or the like, provided with similar points or serrations, and may be made up of a plurality of electrodes 5, 6, 7, 8, 9, 10, 11, 12 and 13 disposed adjacent to each other and at a slight angle with respect to each other.

The electrodes 5, 6, 7 . . . 13, are mounted between support rods 14 and 15, and are preferably connected together and to one terminal of a suitable source of potential, the other terminal of which is connected to the electrode 1. The source of potential may be an alternating current source, such as a vacuum tube oscillator or the like, of any desired frequency, or a plurality of sources may be utilized of different frequencies,

and in addition, if desired, there may be provided a source of direct current, as more particularly shown and described in the application above referred to.

The electrode 1 may be mounted upon a carrier rod 1a and is preferably arranged to be moved at constant speed past the electrodes 5, 6 . . . 13 in a direction, for example, as shown by the arrow A. As the electrode 1 moves, a discharge is produced between it and the electrodes 5, 6 . . . 13 successively, which discharge moves laterally across these electrodes, in the direction shown by the arrows B, at a relatively high rate of speed. If the source of potential energizing the said electrodes is maintained constant and the spacing of the electrodes properly chosen, and the magnitude and frequency of the potentials properly chosen, the intensity of the discharge will be constant.

As pointed out in the applications herein referred to, the discharge may operate in the atmosphere, or one or both of the electrode may be enclosed within a chamber containing atmosphere or any suitable gas or mixture of gases, at a pressure greater or less than atmospheric pressure; and if desired, vaporizable substances, such as mercury, salts and the like, may be enclosed in the said chamber; gases, such as neon, at a pressure of a few millimeters of mercury, are found to be satisfactory.

In this instance, an opaque screen 30 may be provided interposed between the electrode system 1 and 2 and the subject to be scanned. This screen may be provided with a small opening at its center, such as a pin hole, or a larger opening may be provided fitted with a lens 31 of any suitable type for the radiation employed. Suitable radiation responsive devices, such for example as photo electric cells 26 and 27 may be placed in such position as to receive the radiation reflected back from the subject; and in case it is desired to scan the subject by infra-red radiation or ultra-violet radiation, the light sensitive cells will be protected by a filter such as 28 and 29 chosen, to pass only the desired radiation to the cells. The output of the cells may be amplified by suitable apparatus, such for example as a multi-stage vacuum tube amplifier system, to the desired strength.

If the carrier rod 1a be mounted upon a chain, as shown in the application above referred to, so as to pass successively across the electrode system 2, and if a series of similar electrodes 1 be mounted upon a chain at the proper interval, and if the correct number and spacing of the electrodes 5, 6, 7, be chosen in accordance with the size of the image which it is desired to transmit and the amount of detail to be transmitted, then it will be understood that as the electrodes 1 pass across the electrode system 2, a discharge will be produced which successively illuminates all elemental areas of the image. Reflection from these elemental areas to the photo electric cells, produces in the output of these cells an electro-motive force or current proportional to the light intensity of the elemental areas of the subject, which electro-motive force or current may be utilized to control a transmitter of any suitable type.

If now, it be assumed that signals of a similar type are being received from the distant station, these incoming signals may be caused to reproduce the image at the distant station by impressing a potential corresponding thereto upon a similar electrode system comprising movable electrode 3 and stationary electrode system 4 made up of cross electrodes 16, 17, 18, 19, 20, 21, 22, 23 and 24 mounted upon support bars or rods 15 and 25. This electrode system, I designate as the "receiving electrode system" and it will be noted that the construction of the receiving electrode system is substantially identical with that of the transmitting electrode system, the electrode 3 being carried upon the same carrier rod 1a, and operating in synchronism therewith. It will now be apparent that if the subject stands in position to be scanned by a transmitting electrode system 1 and 2, he will observe the image produced by the receiving electrode systems 3 and 4; if the illumination produced by the receiving system is not sufficient to affect the photo electric cells, it will not be necessary to utilize a different type of radiation to scan the subject for transmission, and the lens 31 may be of the ordinary type, and the protective filters 28 and 29 may be omitted. If however, the illumination produced by the receiving screen is sufficient to affect the response in the photo electric cells 26 and 27, the lens 31 may be of any suitable substance which absorbs visible light but passes ultra-violet or infra-red, and filters of corresponding material will be employed to protect the photo electric cells 28 and 29.

Referring now more particularly to Figure 3, I have shown an arrangement in which a single set of stationary electrodes is utilized both for transmission and reception scanning. In this instance, 40 designates an electrode similar to the electrode 1, which may be utilized to produce the transmission scanning discharge, and 41 a similar electrode spaced therefrom, which may be utilized to produce the receiving scanning discharge. The stationary electrode system 42 may be made up of a plurality of parallel knife edge or wire electrodes, mounted upon carrier rods 14 and 25, and the electrodes 40 and 41 are mounted upon the frame so as to move together as in the case of the apparatus shown in Figure 1.

The source or sources of potential for producing the transmitting scanning discharge are connected between the electrodes 40 and 42. The source or sources of potential for producing the receiving scanning discharge are connected between the electrodes 41 and 42, and it will be understood that as the electrodes 40 and 41 move downward in the direction shown by the arrow A, they pass at an angle over the stationary electrodes of the system 42, and a series of discharges are produced travelling in the direction shown by the arrow B. It will be noted that in this instance, the electrodes 40 and 41 are shown as mounted at a slight angle with respect to the electrodes of the system 42: the angle will preferably be so chosen that the trailing edge of the electrodes 40 and 41 passes off one electrode at the instant the leading edge passes over the next electrode.

In order to prevent interference between the reception and transmission scanning, a screen 43, transparent to visible light but opaque to ultra-violet and infra-red, is positioned in front of the electrode system: the screen 43 may be provided with a pin hole at the center or with a lens 44, transparent to infra-red or ultra-violet, or both. As a result of this construction, it will be seen that an object O positioned in front of the screen, will be successively scanned by the transmission scanning discharge, whereas the

screen 43 will not interfere with the perception of the image produced by the receiving electrodes. The nature of the electrodes 40 and 41 and of the potentials supplied thereto will preferably be so chosen that the transmission discharge is relatively rich in radiation of the desired nature, and relatively weak in visible radiation, in order to prevent loss of detail of the received image.

Referring now more particularly to Figure 5, I have shown an arrangement in which the same electrodes are utilized alternately for transmission and reception scanning. In this instance, movable electrode 45 and stationary electrode system 46 may be arranged as shown in Figure 1, and provided with a screen 43 as in Figure 4. A suitable commutator device 47 may be arranged to periodically connect the electrode 45 to the transmitting source of potential and to the receiving source of potential. For example, 52 and 53 may designate respectively the receiving source of potential and the transmitting source of potential, the transmitting source of potential being constant and the receiving source of potential being controlled by the incoming signals. A rotating contact 48 may be provided, connected to electrode 45 and adapted to pass successively over segments 49 and 50, segment 49 being connected to one terminal of the transmitting source of potential 53 and the other terminal of which may be connected to ground or to a common return. The segment 50 is connected to one terminal of the receiving source of potential, the other terminal of which is connected to ground or a common return. The electrode system 46 is likewise connected to ground or to the common return. The rotating contact 48 may be driven through suitable connection with the prime mover 51, which drives the scanning apparatus. The speed of operation of the commutator 47 may be so chosen that any part of one, or one, or more single images, is scanned for transmission and then for reception, but it will be understood that it is undesirable to scan for transmission or reception for a period longer than $\frac{1}{32}$ of a second, as to do this, would cause the image to flicker.

Referring now more particularly to Figure 6, I have shown a system in which the same discharge is utilized simultaneously for transmission and receiving scanning: in this case, 60 designates a movable electrode adapted to sweep at an angle over the stationary electrode system 61. A screen 62, transparent to visible light but opaque to infra-red and ultra-violet, is provided having a pin hole or lens 63 transparent to infra-red or ultra-violet. The electrode 60 is connected to one terminal of the output of a filter 64, which is used in case the synchronizing currents are generated at the transmitting station, the other terminal of the filter being connected to the electrode system 61. The filter 64 is in turn connected to the output of the amplifier 65, which is fed through transformer 67 from the receiving antenna 66. The filter serves to separate the synchronizing currents from the light controlling currents. The synchronizing currents derived from the filter may be passed through suitable amplifiers and utilized to operate the prime mover or driving motor, which moves the electrode 60. The light reflected from the subject is allowed to fall upon the photo electric cell 68, the output of which is amplified by a suitable amplifier 69.

It will be understood that fluctuation in the light intensity of the discharge will produce an undesired component, which represents the incoming signal, and the signal, as transmitted, should be free of any such fluctuation. For this purpose, a portion of the voltage or current supplied to the electrodes may be utilized to eliminate the undesired component from the output of the photo cells. The voltage drawn from the output of the filter 64 may be passed through a phase and intensity controller 70, which may comprise a vacuum tube amplifier affording a variable amplification ratio and also including a phase shifter.

The output of the phase and intensity controller 70 is impressed upon the output of the amplifier 69, in such a direction as to neutralize the undesired current fluctuations due to fluctuation of the illumination on the subject. The cancellation may be effected by means of coils 71 and 72 suitably coupled. The output of the amplifier 69, after cancellation of the undesired component, is impressed on a suitable modulator 73 controlling the output of suitable oscillator 74, which may be a vacuum tube oscillator of the type well known in the art, the output of which is impressed upon the transmitting antenna 75. It may be pointed out in this connection that to prevent oscillation of the entire system through reception upon antenna 66 of signals transmitted from the antenna 75, it is desired to operate the transmitter at a frequency sufficiently different from the receiver to permit of ready exclusion from the receiver of signals transmitted from the same station, and in addition geographical separation of the transmitting and receiving antennae may be employed.

Referring now more particularly to Figures 7 and 8, these two figures show diagrammatically a complete two-way telephone-television system, utilizing a home station and a distant station, Figure 7 being arbitrarily termed the "home station" and Figure 8 the "distant station".

Referring now more particularly to Figure 7, 80 designates transmitting scanning apparatus, which may, and preferably will be, one of the arrangements shown and described herein, but it is to be understood, that insofar as the operation of the system is concerned, other forms of scanning apparatus may be utilized, as for example those shown and described in my copending applications, entitled "Scanning system for television", Serial Number 228,712, filed October 26, 1927, "Method and apparatus for television and the like", Serial Number 218,425, filed September 9, 1927, "High speed television system" Serial Number 222,417, filed September 28, 1927, and "Pilot television system", Serial Number 225,415, filed October 11, 1927, or any other suitable form of scanning apparatus, such for example, as those well known in the art. The scanning apparatus is driven from a suitable prime mover 83, which may, and preferably will be, a synchronous motor operating on currents, for example having a frequency in excess of 2,000 cycles. A mechanical connection such as coupled shafts 81 and 82 may be utilized for driving the scanning apparatus. The prime mover 83 may be energized by a source of alternating current, such for example as alternator 93 generating currents of the proper frequency. A photoelectric cell or cells are provided as at 84 adapted to receive the radiation reflected from the subject, and the output of the photoelectric cells is amplified by a suitable amplifier 85, which may comprise the necessary number of stages of thermionic amplifiers. The output of the amplifier 85 is supplied to a modulator 86 of any suitable type known in the art, which serves to modulate the

output of the oscillator 87, likewise of any suitable type known in the art.

The output of the oscillator 87 may be amplified if not of the desired intensity, or if of sufficient intensity, may be applied directly to the transmitting antenna 88 or to a carrier circuit leading to the distant station. The output of the source of synchronizing currents 93, which I may term a "master source", is also supplied to the modulator 86, and may be impressed upon the transmission frequency oscillations as a separate tone modulation. In addition, there may be provided a microphone 89 of any suitable type, as for example, the well-known carbon button type, energized by a local battery 90, and coupled through transformer 91 to a suitable amplifier 92. The output of the amplifier 92 may be supplied to modulator 86 and for the purpose of modulating the output of the modulator 87 in accordance with speech.

In case the frequency of the currents to be transmitted interferes with the transmission of the synchronizing currents, the synchronizing frequency may be raised to a point where such interference is overcome, or as an alternative, the amplified microphone currents may be utilized to modulate a second oscillator, of a frequency outside the range of speed frequency, and this modulated oscillation may itself be impressed upon the transmitted oscillations as a modulation.

It will now be seen that as the subject is scanned for transmission, signals representing his image will be transmitted from the antenna 88, and if the subject speaks, his voice will be picked up by the microphone and similarly transmitted. The transmitted signals are received at the distant apparatus upon the antenna 102 and impressed upon amplifier 103, where they are amplified to the extent desired. The amplified currents are then passed through a suitable filter 104, which serves to separate the currents of the various channels: for example, the amplifier 107 may receive the synchronizing currents which are amplified to the extent desired and passed on to synchronous motor 108, which is preferably similar to the synchronous motor 83, and operates at the same speed on currents of the same frequency.

The motor 108 comprises a suitable shaft 109, which serves to operate the transmitting scanning apparatus 110. Photoelectric cell or cells 120 are provided upon which the reflected radiation from the subject at the distant station falls. The output of the photoelectric cell is impressed upon the amplifier 121, and there amplified to the extent desired, after which it is supplied to modulator 118 serving to modulate the output of oscillator 119, which energizes the transmitting antenna 122.

In this connection, it should be noted that the frequency of the oscillator 119 should be chosen sufficiently far removed from that of oscillator 87, so that ready separation of the two frequencies may be obtained. The incoming signals at the distant apparatus, corresponding to speech frequency, are separated by the filter 104 and supplied to the detector 112: after detection, the speech currents are amplified to the extent desired by the amplifier 113, and impressed upon the loud speaker 114. The light controlling signals are separated by the filter and impressed upon the amplifier 105, the output of which is supplied to the receiving scanning apparatus 106, which may be, and preferably will be, of the type herein shown, or may be any of the arrangements shown and described in my copending applications above referred to, or alternatively, any of the well known types of scanning apparatus.

At the home station, the signals transmitted from the antenna 122, are received upon antenna 94 and impressed upon amplifier 95, where they are amplified to the extent desired. The output of the amplifier 95 may be supplied to the filter 96, which serves to separate the speech currents and the light control currents. The speech currents are transmitted to the detector 97, thence to the amplifier 98 and thence to the loud speaker or similar receiver 99. The light control currents are impressed upon the receiving scanning apparatus 100, and driven from the prime mover 83 by means of shaft 101 coupled to shaft 82.

In this connection, it should be noted, that the transmission of synchronizing currents takes place only from the home station to the distant station, and not from the distant station to the home station. It will be clear that the transmission of synchronizing currents from the distant station to the home station is not necessary, since in the home station the transmitting and receiving scanning apparatus is driven in synchronism by the motor 83 operating from master synchronizing source 93. In the distant station, the received signals carry as one component the synchronizing currents, which are amplified and utilized to operate a second prime mover 108, which operates in synchronism with the prime mover 83: and the prime mover 108 drives the receiving and transmission scanning apparatus at the distant station, from which it will be seen that merely by the transmission of synchronizing currents from the home station to the distant station, all four scanners are operated in synchronism. However, it will be understood that in case it is desired, the synchronizing currents received at the distant apparatus, may be transmitted back to the home station for the purpose of comparison or regulation, but this is not essential.

While I have shown and described by way of example, a single home station and a single distant station, it is to be understood that several distant stations may be provided and that a specific frequency band may be selected for transmission in each direction between the various stations. For example, if we indicate the home station as A and the distant stations B, C, and D, one band of frequencies may be selected for transmission from A to B and a second band for transmission from B to A: similarly, a third band may be selected for transmission from A to C, and a fourth band from C to A, a fifth band from A to D, and a sixth band from D to A: also, in the event that broadcasting is desired, the station A may transmit always on the same frequency, and the various distant stations may be tuned to receive that frequency.

In the foregoing, the method of and apparatus for synchronizing the operating stations has been described only in a general way to establish its relation to the remainder of the system. The particular arrangement and operation of apparatus for exactly synchronizing the various stations will now be described in more detail.

In order for such a system as is here discussed 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".

Therefore, if the master or transmitter station sends a signal periodically and repeatedly whenever the transmitting scanner passes a predetermined point of reference, this signal may be used to bring the receiving scanner into step, and it follows that if this signal be repeated with sufficient rapidity, the receiver will be kept in step at all times during operation. In other words, such a signal may serve the double purpose of maintaining synchronous speed of the driving motor and space position of the scanner.

To this end 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.

Referring now more particularly to Figure 9, **130** designates diagrammatically a generator driven by any suitable prime mover, and generating currents of the desired frequency for operating motor **131**, 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 **137**, from one terminal of which a connection passes to coil **138**, thence to the shaft **132**, which drives the scanning apparatus. Mounted on shaft **132** I provide a suitable device for periodically closing a circuit through source **137** and coil **138**. In the form shown, this may comprise conducting disk **133** provided on its periphery with a coating of insulating material except at point **135**. Engaging the periphery of disk **133**, I may provide a contact finger or brush **136**.

It will be seen that in the operation of this arrangement, coil **138** is momentarily traversed by high frequency oscillations at the instant that conducting point **135** passes under contact **136**, and this may be arranged to take place at the instant that the scanning apparatus, driven from the shaft **132**, is operating on the first element of the image.

In the particular arrangement shown, therefore, high frequency oscillations will pass through coil **138** 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 **138** with greater or less frequency, by the interposition of suitable gearing for driving the disk **133**, or by other arrangements, as will be understood. A second coil **139** is provided, which may be shunted across the power line connecting the generator **130** and motor **131**: and a third coil **140** is provided, in which currents are flowing from the output of the photo cell amplifier. The coils **138**, **139** and **140**, are all coupled to coil **141**, which feeds a suitable modulator and oscillator **142**, diagrammatically shown, in such manner that the carrier frequency transmitted is modulated by the currents flowing in coils **138**, **139** and **140**.

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 **143**, and thence to coil **146** inductively coupled thereto, which is connected in circuit with antenna **144**, and if desired, a tuning condenser **147** 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 144 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 130 and 131; 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 10, I have shown diagrammatically one form of receiving apparatus, which I term a "synchronome", adapted to operate in response to signals transmitted from a system operating as just described. In this arrangement, 150 represents an antenna provided with inductance 151, shunted if desired, by a tuning condenser 152: the inductance 151 is suitably coupled to a second inductance 153, which feeds the input circuit of a suitable receiver and filter 154, 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 photo cell currents are passed to the light control apparatus, as shown diagrammatically by leads disignated "to light control", and it will be understood that these currents may be amplified to the extent desired. The currents representing the frequency of motor-generator system 130 and 131, may be amplified by suitable amplifier 156, and may be converted, if desired, by means of a converter 157, to currents of the phase desired. In the arrangement shown, I have illustrated the output of converter 157 as being supplied to a suitable three phase motor 158: in this connection, it is desired to point out that preferably motor 131 and motor 158 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. Mounted on the rotor of motor 158, I may provide a series of coils 164, herein diagrammatically shown for purposes of simplicity, as a single coil, preferably mounted on a pivot 164A 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 165, adapted to co-act with coils 164 and connected in series therewith through a circuit comprising contact 160 bearing on slip ring 159 of the shaft 158a of motor 158, and also by means of contact 162 bearing on slip ring 161 insulated from the shaft of motor 158.

The coils 164 and 165 are arranged to be energized by the incoming metronome signals, which may be amplified to the extent desired by the amplifier 155. It will be noted that I provide an insulating segment 163 on the periphery of the disk or slip ring 161, so that the circuit through coils 164 and 165 is periodically interrupted at one point during the revolution of slip ring 161: at all other times, the output circuit of amplifier 155 passes through coil 165 to contact 160, thence to slip ring 159, thence through coil 164 to slip ring 161 to contact 162, and thence through a suitable tuning condenser 166 to amplifier 155.

The coils 164 should be arranged so that at speeds substantially less than synchronous speeds, the coils 164 will not be extended radially outward, and will have very little effect: however, as the motor 158 reaches synchronous speed, these coils will swing into position with their axes extending radially in position to co-act with stationary coil 165: the insulating section 163 is so positioned on the slip ring 161, that it interrupts the output circuit of amplifier 155 when the position of the receiving scanning apparatus operated by motor 158 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 163 will be so positioned with respect to the scanning apparatus driven by motor 158, that insulating segment 163 passes under the contact 162 at the instant that the receiving scanning apparatus driven by the motor 158, passes across the first element of the receiving screen.

If it be assumed that the motor 158 is operating at the same speed as the motor 131 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 164 and 165 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 164 and 165 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 158 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 158 tending to speed it up, provided the space relation of the coils 164 and 165 is properly chosen. On the other hand, if the motor 158 is operating at greater than synchronous speed, it is apparent that the position of the coil 164 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 158, 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 11, 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 10, 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 175, is applied to the control electrode 179 of the thermionic tube 176. This signal is amplified sufficiently to energize the coil 181, controlling the speed of the synchronome motor 183. It will be observed that the tube is provided with the usual cathode 177 and anode 178, which is energized by the battery 182, and the input circuit may include a tuning condenser 180. When the output coil 181 is energized, part of the amplified signal is transferred to the coil 193 to control or block the activity of a similar thermionic tube 186, having a cathode 187, anode 188 and control electrode 189. The current induced in the coil 193 may be rectified by rectifier 192 of any suitable type. The rectifier when it is energized, passes negative charges, corresponding to the rectified metronome signal, to the control electrode 189 of the thermionic tube 186. This vacuum tube amplifier normally is energized by a local signal, similar to the master metronome signal generated by oscillator 198 and supplied periodically by a contact device 196 attached to the shaft 195 of the synchronome motor. The local or synchronome signal may be produced by a high frequency generator 198, coupled to the synchronome motor 183, whence the spring 197 feeds the local signal, which passes through filter 200 to the amplifier 186 and through the coils 194 and 190; and a tuning condenser 191 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 185 is energized, a portion of the energy is carried by the associated coil 199 and is rectified by the rectifier 184 so as to pass negative blocking charges to the amplifier 186 from generator 198. The coils 181 and 185 operate to accelerate or retard the synchronome motor 183, except that at speeds much below synchrony, the accelerating coil 181 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 185 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 signal energizes the amplifier 176, it establishes a negative blocking potential on the control electrode 189 of the amplifier 186, and consequently suppresses energy flow in the coil 185. When the synchronome signal energizes the amplifier 186, it establishes a negative blocking potential on the control electrode 179 of the amplifier 176, and likewise suppresses energy flow in the coil 181.

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 181 and 185 are amplified sufficiently to produce the energy required to control the motor 183. If the frequency of the currents is low, as for example representing the direct current fluctuations of the tubes 176 and 186, 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 183 may be driven by local power to approximate synchrony and the load on the coils 181 and 185 may be reduced to values sufficient to exert the required speed variations to maintain synchrony.

Referring now more particularly to Figure 12, in which I indicate again the thermionic controlling system described in Figure 11; I show here a polyphase motor synchronome 208 driven synchronously with and by the master metronome 130 described in Figure 9. The received 154 filters and amplifies and supplies to output coil 202 the synchronome signals, described in Figure 11, and to coil 204 the polyphase currents necessary to energize the network system 207 and motor 208 of the synchronome. If the speed developed by the motor 208 is approximately synchronous with the transmitting system 130, 131, and the time-phase sufficient to cover a complete scanning element or reference frame as described, then the speed controlling coils 181 and 185 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 may, at lower speeds than synchrony, have its action cut out by causing, as in Figure 11, the synchronome motor 208 to drive the generator 198 and to suppress its oscillating currents by filter until the correct frequency is generated and passed to the coil 185, as aforesaid.

On the other hand, the local signal generator 198 may, as shown in Figure 12, be a self-sustaining oscillator whose energy is periodically tapped and transmitted, as indicated, to the retarding coil 185.

The rectifiers 184 or 192, if of the gaseous tube type, may be shunted with suitable impedances 209 and 210, in order to maintain at high frequency rectifications, the tubes 176 and 186 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 13, I show a modified synchronome for attuning by the principle of resonance the local apparatus to the incoming master metronome signals. The receiver 221 delivers coarse and fine synchronizing signals to coils 219 and 220 respectively, for driving and controlling the synchronome motor 217. By means of shaft 235,

the motor drives the wheel 232, which carries peripherally the suspended metallic plate 229 pivoted at 233. This plate is designed near synchronous speed, to engage capacitively corresponding conducting sectors or areas 230 and 231, whose separation apart and distance from the fly plate 229 is adjustable.

The condensive couples 229 and 230, and 229 and 231, when in conjunction near synchronous speed with the master metronome, energize one or other of the two resonant circuits 226 and 227, provided the metronome signal is being sent and received through coil 220, amplifier 222 and the lines 228 and 234.

The mode of operation of the resonance synchronizer is as follows: the synchronome 217 is driven from the receiver 218 at approximate synchrony, at which, also, the movable condenser plate 229 will fly out sufficiently far, centrifugally, to close, electrostatically, one or other of the resonant circuits containing respectively coils 226 and 227.

For example, if the plates 229 and 230 meet in capacitative conjunction, then high frequency current from amplifier 222 will pass through the momentarily established electric condenser, thus formed, and will energize the coil 227 and amplifier 225: and coil or coils 216 will be strongly energized and may, for example, thus accelerate the speed of the motor 217. Similarly, the coil or coils 215 may retard the motor when the capacitative currents flow through the moving condenser system 229 and 231. 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 230 and 231.

In order to assist rapid acceleration of the synchronome motor 217, the condenser plate 230 taking part in the process may have its functioning area tail off as shown in dotted lines at 236.

In high speed television and synchronization, the wheel 232 should be geared to relatively high speed with the shaft 235 of the motor 217: the separation between plates 230 and 231 and the width of the fly plate 229 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. A two-way television system for simultaneous television reception and scanning comprising a home and a distant station each including an extended fixed electrode, a movable electrode which passes over the fixed electrode, and means to supply current for creating an arc between said electrodes to produce a two dimensional illuminated surface, means for producing a synchronizing current of predetermined frequency, means controlled by said synchronizing current for moving said movable electrode to scan a subject, means for transmitting signals representing the subject scanned and the frequency of the synchronizing current to the distant station along a single channel, means for moving the movable electrode at the distant station controlled by said signals for scanning a subject at the distant station, means controlled by said signals for varying the current supplied to the electrodes to vary the intensity of the arc, means for transmitting to the home station signals representing the subject at the distant station, and means at the home station controlled by signals transmitted from the distant station for varying the current supplied to the electrodes to vary the intensity of the arc and reproduce the image of the subject at the distant station.

2. A simultaneous two-way television transmission and reception system comprising a home and a distant station, an extended fixed electrode forming a portion of a two dimensional surface and a movable electrode at each station, means for supplying electrical energy to said electrodes to create an arc between said fixed and moving electrodes, means for moving said movable electrodes rapidly and in synchronism to cause the arc to travel over the fixed electrode and to create, visually, at each station, a two dimensional illuminated surface and means at each of the stations for controlling the electrical energy supplied to said electrodes at the other station to vary the intensity of the arcs.

3. A simultaneous two-way television transmission and reception system comprising a home and a distant station, an extended fixed electrode forming a portion of a two dimensional surface and a movable electrode at each station, means for supplying electrical energy to said electrodes to create an arc between the fixed and movable electrodes, means for moving said movable electrodes in synchronism to cause the arc to travel over the fixed electrode and create visually at each station a two dimensional illuminated surface and means at each station responsive to the light cast by said arc and reflected from a subject to be transmitted to the other station for controlling the electrical energy supplied to the electrodes at said other station and thereby vary the intensity of the arc at said other station.

4. The television system set forth in the preceding claim, comprising means for varying the amount of electrical energy supplied to the electrodes to compensate for variations in illumination of the subject due to production of an image on said two dimensional surface.

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