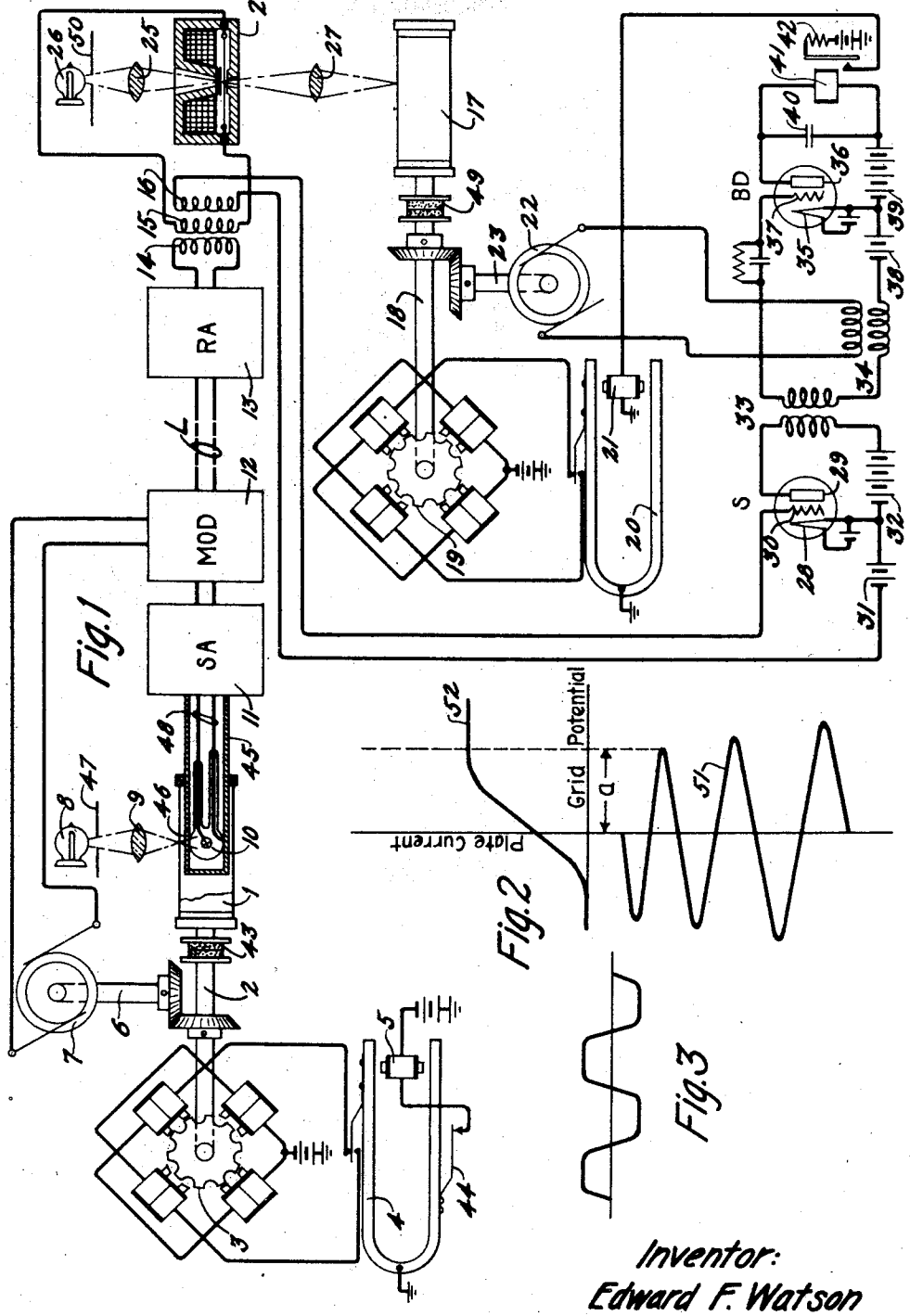
June 29, 1926. 1,590,270

E. F. WATSON

METHOD AND APPARATUS FOR SYNCHRONIZING IN PICTURE TRANSMISSION SYSTEMS

Filed Nov. 25, 1925



Inventor:
Edward F. Watson
by G. E. Folk Atty.

Patented June 29, 1926. 1,590,270

UNITED STATES PATENT OFFICE.

EDWARD F. WATSON, OF LARCHMONT, NEW YORK, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

METHOD AND APPARATUS FOR SYNCHRONIZING IN PICTURE-TRANSMISSION SYSTEMS.

Application filed November 25, 1925. Serial No. 71,342.

This invention relates to synchronizing and particularly to methods and means of securing synchronism in systems for the transmission of pictures and images by electricity.

An object of the invention is to maintain synchronism between two widely separated movable elements such as the sending and receiving drums of a picture transmission system.

A feature of the invention relates to a synchronizing method wherein a picture carrier current is generated at the sending station having a frequency exactly proportional to the sending drum, and at the receiving station a portion of such carrier is combined with a current generated at said receiving station having a frequency exactly proportional to the receiving drum speed but slightly different from said carrier frequency and utilizing the beat frequency current to control the speed of the receiving drum.

Another feature consists in the provision of means whereby a single carrier wave is used both for intelligence transmission and synchronism, a portion of the carrier current of uniform amplitude being selected and caused to beat with a locally generated current at the receiving station for maintaining synchronism.

Other features and advantages of the invention will appear from the following description and also from the appended claims.

In the drawing Figure 1 illustrates a picture transmission system including a sending and a receiving station and an interconnecting transmission line.

Fig. 2 illustrates the potential-current characteristic of one of the thermionic devices.

Fig. 3 illustrates the wave shape of the output current of one of the thermionic devices under one condition.

The equipment at the transmitting station, shown at the left in Fig. 1, comprises a transmitting member or cylindrical drum 1 which is suitably mounted for rotation and also for movement laterally with respect to its axis. The drum is driven by a shaft 2 through a friction clutch 43. By suitable mechanical arrangements, which have not been shown but which are well known in the art, the drum 1 is caused to move slowly in the direction of its axis during rotation.

The shaft 2 is driven by a motor 3 of the phonic wheel type, the motor 3 being governed by a tuning fork 4. The fork 4 has a definite natural period of vibration and is maintained at this frequency by a driving magnet 5 which has its circuit interrupted at the contact 44 carried by one of the fork tines. The other tine of the fork 4 carries contacts for completing circuits through the magnets of the phonic wheel motor 3.

The member 1, hereinafter called a drum, is preferably a skeleton framework for carrying the film to enable the passage of light. Within the drum 1 is located an opaque stationary shield 45 having an aperture 46 therein. Within the shield 45 is a photoelectric cell 10 so arranged that light passing through the aperture 46 impinges upon the cathode of said cell. A source of light 8 is positioned at some convenient point and produces a beam the size of which may be regulated by an aperture in the shield 47. This beam is directed and focused by the lens 9 at a point which lies substantially within the surface of the sending film. The beam of light passes through the film and the aperture 46, and impinges upon the cathode of the cell 10.

Thus, by wrapping a transparency of a picture around the drum 1, such transparency may be scanned over its entire area in a helical trace determined by the rotational and longitudinal movement of the drum 1. During the scanning period, the beam of light reaching the cathode of the photoelectric cell will vary in intensity in exact accordance with the tone values of the succeeding elemental areas of the picture transparency. The variable light shining on the cell 10 causes, in the well known manner, a variable electric current to flow in the circuit 48. This current may be amplified by the amplifier 11 before it is used to modulate a carrier current for transmission over the line L.

The carrier current is generated by means of an alternating current generator 7 which is geared by means of the shaft 6 directly to the shaft 2 of the phonic wheel motor 3. Thus, the current generated by the generator

7 will have a frequency which varies directly as the speed of the motor 3. The current from the machine 7 is applied to the input circuit of a modulator 12 together with the amplified picture current from the amplifier 11. Thus, the picture current serves to modulate the amplitude of the carrier wave in accordance with the tone values of the picture. The modulated carrier is then applied to the line L and transmitted to the receiving station.

At the receiving station there is provided a receiving drum 17 arranged in a manner similar to the drum 1 for rotation and transverse movement. The drum 17 is driven through a clutch 49 by the shaft 18, to which is connected a phonic wheel motor 19. The phonic wheel motor 19 is driven by a tuning fork 20 which has a natural period the same as that of the tuning fork 4. The frequency of the fork 20 is maintained and regulated by means of the driving magnet 21.

For translating the received picture currents into light variations, there is provided at the receiving station a light valve 24 of the string galvanometer type, well known in the art. A source of light 26 produces a beam the size of which may be regulated by the aperture in a screen 50. This beam is then directed by the lens 25 and focused at the string of the light valve 24. The aperture in the light valve 24 is in turn focused, by means of the lens 27, at a point lying substantially within the surface of the receiving drum 17. Therefore, if a light sensitive film is wrapped about the drum 17, and the string of the light valve is vibrated to vary the intensity of the beam of light passing from the source 26 to the surface of the sensitive film, the film may be exposed in accordance with the tone values of the picture at the transmitting end.

To operate the light valve, the incoming modulated carrier wave is applied to the proper amplifying devices 13 and the output current of these amplifiers is applied to the primary winding 14 of the transformer. The current induced in the secondary winding 15 of the transformer is applied to the string of the light valve 24. Due to the magnetic field surrounding the light valve string, this string will vibrate at an amplitude which is directly proportional to the strength of the current flowing therethrough. During the vibration of the string of valve 24, the drum 17 is caused to rotate and move axially so that the beam of light of varying intensity transverses the entire area of the film in a helical trace.

In order that no distortion can occur in the received picture, it is necessary that the drum 17 be driven in exact synchronism with the drum 1 at the transmitting station. It is to the accomplishment of this end that the present invention is especially directed.

At the receiving station there is provided an alternating current generator 22 which, through the shaft 23, is directly geared to the shaft 18. Thus, the speed of the generator 22 varies directly as the speed of the phonic wheel motor 19 and the shaft 18. Accordingly, the frequency of the current produced by the generator 22 is a rectilinear function of the speed of the shaft 18. The generator 22 is so designed that when the drums 1 and 17 are rotating in exact synchronism, the frequency of the current produced by said generator is a given definite amount less than the frequency of the current produced by the generator 7. For example, the frequencies may differ from each other by a matter of 100 cycles per second.

There is also provided at the receiving station a selector S and a beat detector BD, each in the form of a thermionic vacuum tube. The selector S has its input circuit, including the filament 28 and grid electrode 30, connected to the terminals of the tertiary winding 16 of the transformer. A battery 31 maintains the grid 30 at a desired negative potential. The output circuit of the selector S, including the filament 28 and anode or plate 29, includes the space current source 32 and is connected to the primary winding of a transformer 33.

The component circuit elements of the selector S are so selected and proportioned that the tube S is overloaded for all values of the incoming carrier current greater than the minimum value. This may best be seen by consulting Fig. 2. In this figure, the curve 51 represents the incoming modulated carrier wave. The amplitude of this carrier wave will vary between a minimum and a maximum value depending upon the range between the darkest element of the transmitted picture and the lightest element thereof. Assume that for the range of intensity of picture elements, the amplitude of the carrier wave never becomes less than the value *a*.

Referring now to the curve 52, this represents the grid potential-plate current characteristic of the tube S. It will be noted that for all variations of grid potential between a given positive value and a given negative value, the plate current varies along the steep portion of the curve 52. For all values, however, of grid potential greater than a given amount, the tube becomes saturated and no further change in plate current takes place. As previously mentioned, the elements of the circuit may be so taken that this overloading is present for all amplitudes of the incoming wave greater than the minimum amplitude. Accordingly, for an average amplitude the wave shape of the current in the plate circuit of the selector S will be somewhat simi-

lar to that shown in Fig. 3. This means that regardless of how the amplitude of the carrier wave may vary, due to the modulation by the picture currents, the portion selected by the tube S will be converted into a current having an approximately uniform amplitude.

The alternating current generator 22 has its output circuit connected to the primary of a transformer 34, the secondary of which is included in the input circuit of the beat detector BD. Also, the secondary of the transformer 33 is included in the input circuit of the beat detector. This input circuit includes the biasing battery 38 and the filament 35 and grid 37 of the tube. The output circuit of the tube BD, including the plate 36 and filament 35, is connected to the windings of a relay 41. A space current source 39 is included in series with the output circuit, and a condenser 40 is placed in shunt of the relay 41.

Since the current flowing in the secondary of the transformer 33 has a frequency which differs from that of the current flowing in the secondary of transformer 34, a resultant beat frequency potential will be set up causing the current in the output circuit of the detector to have a similiar frequency. Thus, the relay 41 will operate at a rate determined by the beat frequency of the two currents impressed upon the input circuit of the beat detector. Should the receiving drum 17 vary in speed from that of the sending drum 1, the frequency of the current produced by the generator 22 would vary by the same law and accordingly the frequency of the beat frequency current would vary. For example, if the speed of drum 17 falls off, the difference between the beating frequencies increases and accordingly the rate of operation of relay 41 increases. An increase in the speed of operation of relay 41 increases the speed of fork 20, whereby the drum is accelerated and brought back into synchronism with drum 1. Similarly, if drum 17 tends to run faster than drum 1, the beat frequency decreases in value and the frequency of relay 41 decreases. This acts to slow down the drum 17 to bring it back into synchronism with drum 1. In this manner, the relay 41 may be made to control the tuning fork 20 so as to exactly compensate or correct any tendency of speed variation.

What is claimed is:

1. The method of maintaining synchronism between sending and receiving members which consists in generating an alternating current having a frequency directly related to the speed of the sending member, generating a second alternating current having a frequency directly related to the speed of said receiving member but different from the frequency of said first current, transmitting said first current from the sending member to the receiving member, combining said currents to produce a beat frequency current, and utilizing said beat frequency current to govern the speed of the receiving member.

2. The method of maintaining synchronism between the picture drums at the sending and receiving stations of a picture transmission system which consists in generating an alternating carrier current for transmitting the picture characteristics which has a frequency determined directly by the speed of the sending drum, generating a second alternating current at the receiving station which has a frequency determined directly by the speed of the receiving drum and differing from the frequency of said carrier current, transmitting the carrier current to the receiving station, selecting from said carrier current a portion having a uniform amplitude regardless of the wave shape of the carrier current, combining the selected current with said second mentioned current to produce a beat frequency current, and employing said beat frequency current to govern the speed of the receiving drum.

3. In a picture transmission system, sending and receiving members located respectively at sending and receiving stations, separate shafts for driving said members generators driven directly from said shafts for producing alternating currents which differ from each other in frequency, means for transmitting the current generated at the sending station to the receiving station, means for combining the transmitted current with the current generated at the receiving station to produce a beat frequency current, and means responsive to said beat frequency current for governing the speed of said receiving member.

4. In a picture transmission system, sending and receiving members located respectively at sending and receiving stations, generators at said sending and receiving stations, mechanical connections for maintaining a definite relation between the speeds of said generators and said sending and receiving members, said generators producing alternating currents respectively having frequencies which differ from each other, means for transmitting the current generated at the sending station to the receiving station, means for combining the transmitted current with the current generated at the receiving station to produce a beat frequency current, and means responsive to said beat frequency current for governing the speed of said receiving member.

5. In a picture transmission system, sending and receiving members located respectively at corresponding stations, separate shafts for driving said members, a generator at the sending station geared directly to the shaft thereat for producing an alternating

current, means for transmitting said current to the receiving station, a generator at the receiving station geared directly to the shaft thereat for producing an alternating current having a frequency differing from that of said first mentioned current, means at the receiving station for combining said currents to produce a beat frequency current, and means responsive to said beat frequency current for regulating the speed of said receiving member.

6. In a picture transmission system, sending and receiving members located respectively at corresponding stations, separate shafts for driving said members, generators driven directly from said shafts for producing alternating currents which differ from each other in frequency, means for transmitting the current generated at the sending station to the receiving station, means at the receiving station for selecting a portion of the transmitted current, the selected current having a uniform amplitude regardless of the variations in the wave shape or amplitude of the transmitted current, means for combining the selected current with the current generated at the receiving station to produce a beat frequency current, and means responsive to said beat frequency current for governing the speed of said receiving member.

7. In a picture transmission system, sending and receiving members located respectively at corresponding stations, shafts for driving said members, generators driven directly from said shafts for producing alternating currents which differ from each other in frequency, means for transmitting the current generated at the sending station to the receiving station, a thermionic discharge device responsive to the transmitted current and arranged to be overloaded at all values of said transmitted current for producing a current of uniform amplitude, means for combining the current produced by said device with the current generated by said generator at the receiving station to produce a resultant current, and means controlled by said resultant current for governing the speed of the receiving member.

8. The combination in a picture transmission system, of sending and receiving members located at respective stations, driving means for said members, generators mechanically connected to said driving means for generating alternating currents differing from each other in frequency, means for modulating the current generated at the transmitting station in accordance with the characteristics of a picture, means for transmitting the modulated current to the receiving station, means for combining a portion of the transmitted current with the current generated at the receiving station to produce a resultant current, and means controlled by the resultant current for controlling the speed of the receiving member.

9. The combination in a picture transmission system, of sending and receiving members located at respective stations, driving means for said members, generators mechanically connected respectively to said driving means for producing alternating currents differing from each other in frequency, means for modulating the current produced at the sending station in accordance with the characteristics of a picture, a transmission line for transmitting the modulated current to the receiving station, a light sensitive element mounted on the receiving member, means controlled by the modulated current for regulating the amount of light passing to said light sensitive element, means for combining a portion of the transmitted current with the current generated at the receiving station to produce a resultant current, and means responsive to said resultant current for governing the speed of said receiving member.

10. In a picture transmission system, sending and receiving members located respectively at sending and receiving stations, separate shafts for driving said members, a generator driven from the shaft at the sending station for producing an alternating current of a given frequency, means for transmitting said current to the receiving station, a generator driven from the shaft at the receiving station for generating an alternating current having a frequency lower than that of said first-mentioned current, means for combining the transmitted current with the current generated at the receiving station to produce a beat frequency current, and means responsive to said beat frequency current for governing the speed of said receiving member.

In testimony whereof, I have signed my name to this specification this 24th day of November 1925.

EDWARD F. WATSON.