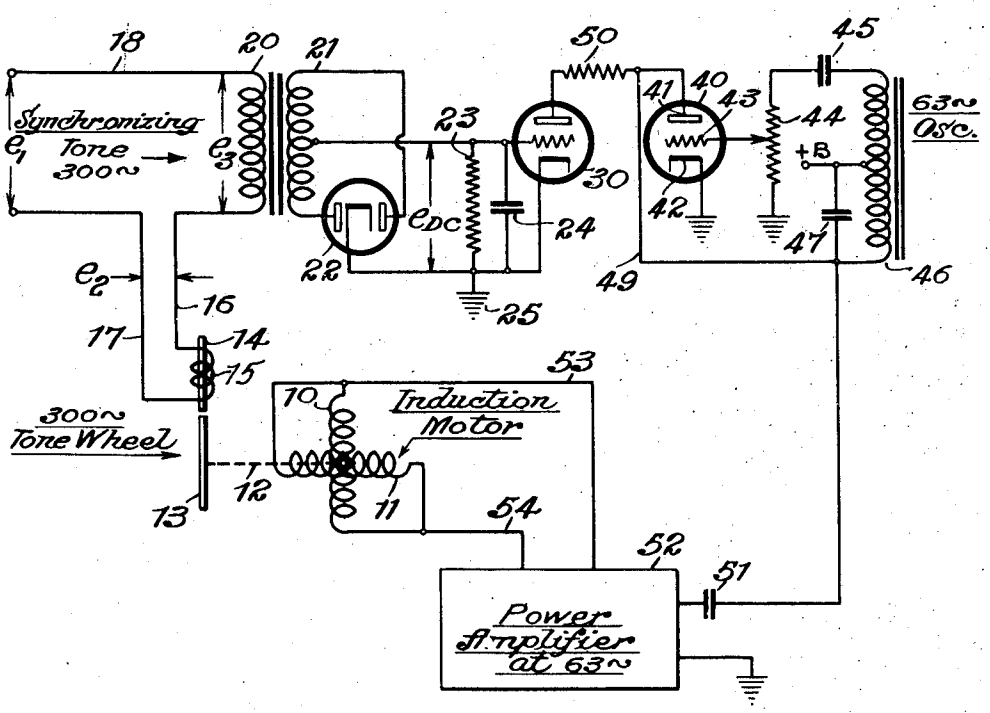
April 30, 1946. M. ARTZT 2,399,421

SYNCHRONIZING DEVICE

Filed Nov. 26, 1941

Fig. 1.



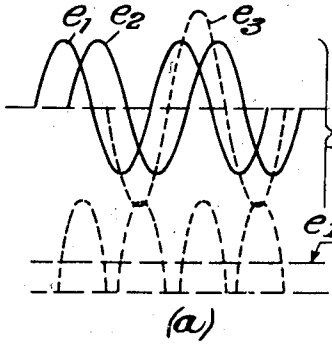


Fig. 2.

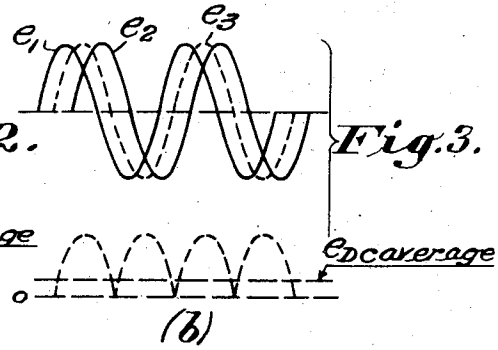


Fig. 3.

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SYNCHRONIZING DEVICE

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Application November 26, 1941, Serial No. 420,583

9 Claims. (Cl. 178—69.5)

My invention relates, in general, to systems for synchronizing the operation of two devices, and more particularly to synchronizing systems for facsimile transmission and reception apparatus.

In the art of facsimile transmission and reception signals are developed at the transmitter usually by the linear scansion of an optical image which is to be transmitted. Since in the majority of such arrangements there must be a relative movement between the scansion apparatus and the page to be scanned, and further, since at the reproducer this scansion must be exactly duplicated, it is generally customary to transmit synchronizing signals which are indicative of the position of the scansion apparatus. Accordingly, it is one of the objects of my invention to provide an apparatus for controlling the speed of such a device in accordance with the time of receipt of the synchronizing signals.

It has been found that an induction motor may be used preferably with apparatus of this nature. Accordingly, it is another of the objects of my invention to provide a device for controlling the speed of an induction motor in accordance with the time of receipt of synchronizing signals.

In order to give an indication of the speed and phase of the scansion at the transmitter in a facsimile system, there is usually provided means for developing and transmitting a synchronizing signal which may be in the form of a steady tone indicating the speed of the scanner motor. Also, signals may be developed at the receiver which will give an indication of the speed and phase of the receiving and reproducing means. Accordingly, it is another of the objects of my invention to provide a device for comparing locally generated signals with signals received from an external source.

The comparison values which are developed by comparing the signal from an external source with the locally generated signal may be utilized to control the frequency of a wave generated at the receiver and which in turn controls the speed at which the induction motor may be operated. Accordingly, it is another of the objects of my invention to provide a device for controlling the frequency of the wave impressed on a driving motor in accordance with the difference in phase between a locally generated wave and a received wave.

My invention in general comprises providing an induction motor to drive a facsimile receiving apparatus, and also coupled to the driving element of the induction motor is a means for developing electrical waves in accordance with the position of the rotor of the motor. The phase of the signals developed in this fashion are compared with the phase of a received tone such as a synchronizing tone and the resultant comparison wave is utilized to affect the frequency of an oscillator, the wave developed by the oscillator being utilized to drive the induction motor.

My invention will best be understood by reference to the drawing, in which:

Fig. 1 shows a preferred embodiment thereof.

Figs. 2 and 3 are explanatory diagrammatic curves.

Referring to Fig. 1, there is shown a preferred embodiment of my invention. In this figure the induction motor is labeled, and is shown schematically by the windings 10 and 11. The shaft of the induction motor is indicated by the dashed line 12. Connected to the shaft is a tone wheel 13 which is positioned adjacent a magnet 14, the latter having wound thereabout a coil 15. The actual apparatus driven by the induction motor has not been shown here since such apparatus is well known per se, and does not of itself comprise the essence of this invention.

It will be appreciated that the passage of the teeth in the tone wheel through the magnetic field in the neighborhood of the magnet 14 will cause the development of a pulse each time a tooth passes therethrough. These pulses are indicated by a voltage e_2 which is shown as occurring between the conductors 16 and 17. A 300 cycle tone has been illustrated purely for illustrative purposes.

If it be assumed that the synchronizing signal or tone received is a 300 cycle tone, it will be apparent that if the apparatus remains in synchronism with the transmitting apparatus which generates a 300 cycle synchronizing tone, there will be a constant phase relationship between the two waves. The synchronizing tone has been indicated as being impressed across conductors 17 and 18, and is shown schematically as the voltage e_1. The voltage e_1 and the voltage e_2 are impressed onto the primary 20 of a transformer having secondary 21, and the combined voltages are illustrated by the symbol e_3. Apparatus for receiving and segregating the synchronizing tone are well known per se and have not been shown here.

The voltage set-up across the secondary 21 of the transformer is impressed onto a full wave rectifier 22, this rectifier having in the output circuit thereof a time constant circuit compris-

ing resistance **23** and condenser **24**, the cathode side of the tube **22** being grounded at **25**. It will be appreciated, therefore, that there is provided in the output circuit of the tube **22** a direct current voltage that varies in amplitude with the phase relationship between the two tones e_1 and e_2. This variable direct current potential is illustrated schematically as e_{DC}, and is impressed onto the control electrode-cathode path of a thermionic tube **30** having an anode, cathode, and at least one control electrode.

An oscillating arrangement is provided comprising a thermionic tube **40** having anode **41**, cathode **42** and control electrode **43**. The control electrode **43** is connected to the sliding arm of a potentiometer **44** having one terminal thereof grounded and the other terminal thereof connected to a condenser **45**, the latter in turn being serially connected with an inductive member **46** which has connected across a part of the windings thereof a condenser **47**. The anode of the tube **30** is connected to the anode of the tube **40** through a resistor **50**. The anode of the tube **40** is also connected to a common terminal of inductance **46** and condenser **47**, which is remote from the terminal of inductance **46** which is connected to the condenser **45**. This connection is accomplished through the conductor **49**, and the anode supply is indicated schematically as +B and is connected to the common terminal of inductance **46** and condenser **47** which is nearest the connection of the inductance **46** to the condenser **45**. It will be appreciated, however, that this forms merely one form of oscillator and that I am not limited to the specific form of oscillator shown.

It will be appreciated that the load on the oscillator will vary in accordance with the plate current of tube **30** and hence since the load will vary, the frequency of the oscillator will vary. A portion of the output of the oscillator is impressed through condenser **51** onto a power amplifier illustrated schematically at **52**. The output of the power amplifier is impressed onto the induction motor through leads **53** and **54**.

Referring to Fig. 2, there is shown a diagrammatic set of waves which illustrates the operation of the device when running synchronously. Since, for synchronous operation, the waves e_1 and e_2 will have the same frequency and hence will remain in constant phase relationship, e_3 will be an unvariable wave. If this is true, then e_{DC} will remain at a constant amplitude, and the average value of e_{DC} will not change, and hence the induction motor speed will not change.

Referring to Fig. 3, there is shown schematically the wave arrangement of the device when the motor slows down, for instance, and it will be seen that e_1 and e_2 pull apart in phase relationship and hence e_3 varies. Since e_3 varies, then e_{DC} will vary and the average value of e_{DC} will lower. This causes the tube **30** to draw more current and hence the oscillator load is changed and it will raise the oscillator frequency. When the tube **30** draws less current, as will be the case when the induction motor speeds up and e_1 and e_2 pull closer into a co-phasal relationship, e_{DC} will be greater in value and the tube **30** will draw less current, and the oscillator frequency will be lowered.

It is usually arranged that when the motor is running synchronously with the motor at the transmitter, e_{DC} averages about half value and the oscillator frequency is at the center of its range. Taking, for example, the increasing frequency of the oscillator which takes place when the motor has slowed down, the increased frequency of the supply allows the induction motor to run at a higher slip to carry an increased load, but the higher slip is furnished electrically rather than mechanically in the form of reduced speed.

This method of synchronism also completely separates the synchronous tone from the motor frequency, and they do not have to be the same or even bear any direct relationship to each other. In actual tests the system has been shown to be very good, and is almost completely free from hunting tendencies.

It will be apparent that there may be departures from the particular showing which has been illustrated hereinbefore, but which will not depart from the spirit and scope of my invention, and accordingly I claim all such departures as may fall fairly within the spirit and scope of my invention as identified in the hereinafter appended claims. One example thereof is, for instance, the fact that a synchronous motor may be used in place of the induction motor, but the hunting characteristic is not quite as good as that of the induction motor.

What I claim is:

1. The method of synchronizing the operation of a plurality of prime movers which comprises the steps of developing a signal representative of a phase of the cycle of operation of each of said prime movers, comparing the developed signals, developing a signal representative of the comparison of the signals, and utilizing at least a portion of the signal representative of the comparison of the waves to control the speed of operation of at least one of said prime movers.

2. In an apparatus for synchronizing the movement of a prime mover with that of another prime mover, and wherein a signal is received indicative of the phase and speed of one of said prime movers, means for generating an electrical signal representative of the phase of the prime mover to be synchronized, means for combining the locally generated signal and the received signal, energy storage means, means for impressing onto said energy storage means energy proportional to the instantaneous combined values of the received wave and the locally generated wave, and means for utilizing at least a portion of the stored energy to affect the speed of the prime mover to be synchronized.

3. In an apparatus for synchronizing the movement of a prime mover with that of another prime mover, and wherein a signal is received indicative of the phase and speed of one of said prime movers, means for locally generating a signal representative of the speed and phase of the prime mover to be synchronized, means for combining the received signal with the locally generated signal, rectifying means, means for impressing said combined signals onto said rectifying means, energy storage means electrically associated with said rectifying means whereby energy of a value proportional to the value of the combined received signal and locally generated signal is stored, oscillating means, and means for controlling frequency of oscillation of said oscillator in accordance with the value of the stored energy.

4. Apparatus in accordance with claim 3, wherein means are provided for impressing energy of a frequency dependent upon the frequency of oscillation of said oscillator onto said prime mover to be synchronized to control the speed and phase thereof.

5. Apparatus in accordance with claim 3, wherein said locally generated signal is generated by a tone wheel, and means for driving said tone wheel by said prime mover to be synchronized.

6. Apparatus in accordance with claim 3, where said prime mover comprises an induction motor.

7. In facsimile apparatus wherein scansion signals representative of the optical values of a transmitted image are received as recurring trains of signals, and wherein synchronizing signals interspersed between said recurring trains of signals are received, means for locally generating signals indicative of the speed and phase of the driving motor of said facsimile apparatus, means for developing a control potential representative of the instantaneous value and phase relationship of the combined synchronizing and locally generating signals, and means for utilizing said developed control potential to control the speed of the driving motor of said facsimile apparatus.

8. The method of comparing the relative phase relationship of two alternating current waves of substantially identical frequency and of substantially constant amplitude, which comprises the steps of combining the two waves to produce a resultant alternating current wave having a variable amplitude determined by the phase displacement of the two waves, developing a uni-directional pulsating current of varying intensity from the resultant wave, and storing energy in accordance with the varying intensity of the developed pulsating current.

9. An apparatus for comparing the relative phase relationship of two alternating current waves of substantially identical frequency and of substantially constant amplitude, comprising means for combining the two alternating current waves to produce a resultant alternating current wave having a variable amplitude determined by the phase displacement of the two waves, a rectifier, means for applying the resultant alternating current wave to the rectifier to generate a uni-directional pulsating potential of varying intensity, and filter means for filtering the generated uni-directional pulsating potential to produce a direct current potential that varies in intensity in accordance with the phase relationship of the two original alternating current waves.

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