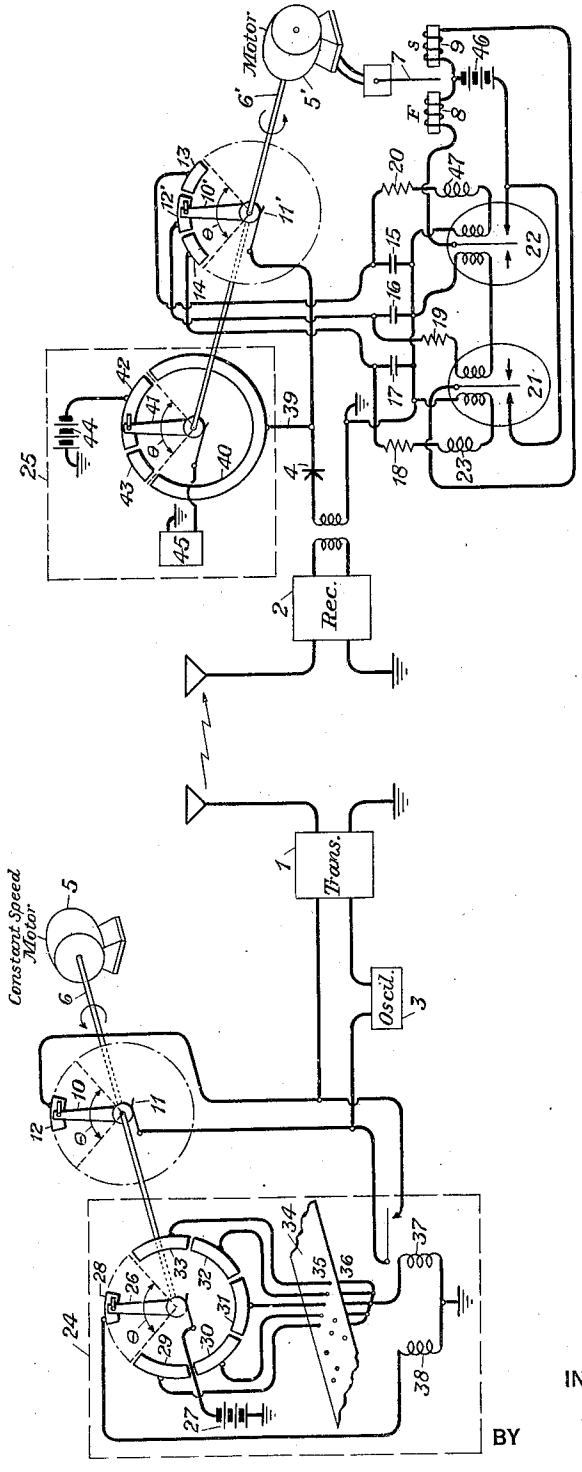
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SYNCHRONIZING SYSTEM

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## SYNCHRONIZING SYSTEM

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This invention relates to radio communication or land transmission systems, to the transmission of pulses for synchronizing and to synchronizing means for use on such systems. More particularly it relates to means for synchronizing two or more periodic elements, one at the transmitter and one or more at receivers in a radio communication or signaling system as may be required for machine telegraphy, television and the like. The invention may also be employed in connection with wire transmission or transmission by guided electric waves but is particularly suited to radio transmission by virtue of its ability to overcome the deleterious effects of static interference and fading of signals.

In the operation of ordinary start-stop printing telegraph instruments over radio transmission systems it is necessary to transmit over the system a signal or pulse at the beginning of each character of the message, the purpose of this pulse being to start the receiving mechanism, which operates automatically thereupon for the number of signal pulses required to transmit a single character and then is stopped by a final pulse and remains stopped until another start impulse is received. It has been found by experiment that a considerable part of the errors in received copy is caused by failure to receive start or stop impulses due to static or fading and by receipt of false start impulses due to static. One purpose of the present invention is to provide a means for synchronizing two rotating shafts, one at a transmitting station and one at a receiving station, whereby the transmitting and receiving elements of printing telegraph or other apparatus may be operated in unison. The synchronizing system which is the subject of this invention operates by virtue of a continuous series of spaced pulses but is independent of any individual synchronizing impulse and is dependent only upon the average effect of a large number of pulses whereby the effect of static and fading may be much reduced.

The invention may be understood in detail from the following description read in connection with the accompanying illustration showing one form of the invention. While but one receiving station is illustrated in the drawing, it will be understood that any number of such stations may simultaneously receive from and be synchronized with a single transmitter.

In the illustration radio transmitter 1 and receiver 2 are of any type suitable to transmit and receive pulses or telegraph signals. In the illustration it is assumed that voice-frequency tone pulses are employed, the source of tone being the oscillator 3. At the output of the receiver 2 the voice-frequency pulses pass through the rectifier 4, thereby becoming unidirectional pulses in their effect upon the apparatus connected beyond the rectifier. Motor 5 is of any known type capable of producing a high degree of constancy in the rate of rotation of shaft 6. At the receiving station the motor 5' may be of any type capable of rotating shaft 6' at the same speed as shaft 6 but provided with a speed control lever or switch 7 which may be operated electrically to retard or advance the speed of motor 5' slightly by energizing magnet 9 or 8 respectively.

At the transmitting end shaft 6 carries brush 10 which through slip ring 11 is connected to oscillator 3. During the course of each rotation brush 10 passes over segment 12 completing the connection of oscillator 3 to transmitter 1 and sending out a short pulse of tone at each revolution.

At the receiving end these short pulses are rectified as above mentioned by rectifier 4 and applied to slip ring 11' connected to brush 10', which during each rotation passes over segments 13, 12', 14 in the order named. These segments are connected respectively to equal condensers 15, 16, 17. The condensers will obviously be charged by whatever impulses of signal or static may flow into them from the receiver through the rectifier 4 during the successive intervals when the brush 10' is in contact with their corresponding segments. Bridged across condenser 16 is a leak resistance 19 and one winding of each of the two polar relays 21 and 22. Across condenser 17 is bridged leak resistance 18, dummy relay winding 23 and one of the windings of relay 21. The bridge across condenser 15 is similar, containing resistance 20, dummy winding 47 and one winding of relay 22. The resistances 18, 19 and 20 are all alike as are all the relay windings. The dummy windings have the same electrical characteristics, particularly resistance, as do the real relay windings. Thus the three condensers are of equal capacity and the three leak or discharge paths are of equal resistance and have similar electrical characteristics. It will be evident that this equality is not essential to the functioning of the invention but is convenient for explanatory purposes. The tongues of the two polar relays are assumed to be free of bias and therefore will move to right or left as the current in the right-hand or left-hand coil of the relay may be the stronger. When the current in the discharge circuit of

condenser 16 is stronger than that in the discharge circuits of the other two condensers, the relay tongues will be held on inactive contacts, the right-hand contact in relay 21 and the left-hand contact in relay 22. This will be the case when shafts 6 and 6' are running in exact synchronism and brush 10' passes over segment 12' during the interval in which is received the synchronizing pulse sent out by the passage of brush 10 over segment 12 as already described. To be sure current will flow in the discharge circuits of condensers 15 and 17 due to their being charged by static and other interference. However, relay 16 will receive on the average a like share of such charge due to interference. If the condensers are of sufficient capacity, any momentary inequality in the charging effects due to the random occurrence in time of static pulses will be ironed out and the currents through the discharge windings due to interference will be substantially equal and will be of no effect in operating the relay tongues.

As noted above when the synchronizing pulse is received entirely during the period of contact of brush 10' and segment 12' no live contact is made by relays 21 and 22 and no current flows through magnets 8 and 9. Let it now be assumed that motor 5' begins to run slightly too slow. Brush 10' will then fall behind its proper position and will not arrive at segment 12' as soon as the synchronizing pulse is received. On this account some of the synchronizing pulse will be received when brush 10' is on segment 13. This will cause additional charge on condenser 15 and additional current through the right-hand winding of relay 22. Meanwhile the amount of pulse received on segment 12' is decreased and consequently there is less current in the left-hand winding of relay 22. When brush 10' falls behind to the extent that more of the synchronizing pulse is received on segment 13 than on segment 12', it is evident that the right-hand winding of relay 22 will predominate and the tongue will be drawn to the right-hand or live contact, thereby completing the circuit from battery 46 through magnet 8 which draws speed control lever 7 toward the position causing an increase in the speed of motor 5'. The increased speed of motor 5' will gradually bring the brush 10' back into contact with segment 12' during the interval in which the synchronizing pulse is received and relay 22 and speed control arm 7 will be returned to the non-operated condition by the increased charge to and discharge current from condenser 16 and the decreased currents to and from condenser 15.

If the speed of shaft 6' should tend to become too fast, it will be evident from the above description, by analogy, that segment 14 will finally receive more of the synchronizing pulse than segment 12', whereat condenser 17 will have a greater discharge current than condenser 16, and the tongue of relay 21 will be brought to the left, closing the circuit from battery 46 through magnet 9, which moves lever 7 to cause a corrective decrease in the speed of motor 5'.

It will be evident from a consideration of the working of the apparatus illustrated, as described above, that the characteristics of the device are subject to control and wide alteration by design. The speed of the shafts, the angular space occupied by the segments, the inherent stability of the motors, the values of condensers and discharge leaks, the sensitivity of the speed control device, etc., all are subject to variation and may be so proportioned as to obtain desired characteristics.

As has been explained above, any disturbance such as static, interfering signals and the like which is as likely, on the average, to fall on one segment as another, i. e., is random in time, will not materially affect the synchronizing action since its effect is balanced out as already described. The differential effect introduced by adding the signal in greater degree to one condenser charge than to another is relied upon for the synchronizing action. Since there is no differential effect of this character when no synchronizing signal is received, the device remains in status quo and no regulation of the speed of motor 5' is made. On this account the device is relatively immune to the effects of radio fading; disappearance of the signal for a short interval does no harm and the speed correcting action is resumed with the reappearance of the signal.

This synchronizing system utilizes only a fraction of the time of the transmission channel, a fraction represented by the ratio of the angle $\theta$ to 360°. The angle $\theta$ can, of course, be made larger or smaller by design as long as the other elements of the system are suitably proportioned. If a separate channel were to be devoted to synchronizing, the angle $\theta$ might be increased to 360° if desired and the desired exactness of synchronism obtained by using a large ratio of speed between shafts 6, 6' and the working shafts of the apparatus to be synchronized. On the other hand, where one channel must be used both for synchronizing and for communication, the time interval not included in the period when the brushes 10, 10' are within the region encompassed by angle $\theta$, may be employed for sending intelligence. An example of one way this may be carried out for printing telegraph communication is illustrated in the accompanying drawing. The apparatus included within the dotted enclosure 24 comprises the telegraph transmitter and that within enclosure 25 the telegraph receiving equipment.

In 24 a brush 26 connected to ground through battery 27 is carried on an extension of shaft 6 and contacts, as it rotates, segments 28, 29, 30, 31, 32 and 33. Of these, segment 28 is traversed while brush 10 is within angle $\theta$ and the others are traversed without that interval. Below is a tape transmitter of well known type which may be of the kind shown in patent to Benjamin, No. 1,298,440. A perforated tape 36 bearing a message punched in five-unit code passes under the five fingers 35 which are connected one to each of the segments 29 to 33, inclusive, as shown. Where a hole is punched the contact finger slips through the tape and contacts with the lower fingers 36 thereby establishing a connection from the corresponding segment through the contact fingers, the relay 37 and to ground. Stepping magnet 38 is connected from segment 28 to ground. When brush 26 rests on segment 28 as shown, current from battery 27 flows through magnet 38 which performs the function of moving the tape so as to bring the punchings representing the next character between fingers 35 and 36. At this same time a synchronizing pulse is sent out due to the contact of segment 12 and brush 10. As the brushes pass outside the angle $\theta$ and brush 26 passes consecutively over segments 29, 30, 31, 32, 33 current passes from battery 27

through the winding of relay 37 when brush 26 is in contact with a segment whose corresponding contact finger finds a hole in the tape. No current flows when the brush 26 is in contact with segments whose corresponding upper contact finger is prevented from contacting its lower contact finger by the unpunched tape. In this way a series of five units, any one of which may be mark or space elements, is impressed on relay 37. Operation of the relay contacts by the direct-current marking pulses causes pulses of tone to be sent from oscillator 3 while for spacing units no tone is sent. Since relay 37 is not operated by contact between brush 26 and contact 28, it will be evident that telegraph signals will be sent only when synchronizing signals are not being sent and vice versa.

At the receiving end the synchronizing signals are utilized as already described in segments 14, 12' and 13. The telegraph signals cannot be utilized by the synchronizing brush and segments since the brush is not in contact with these segments during the time of receipt of the telegraph signals. The telegraph signals can, however, flow over conductor 39 to segment 40 of the telegraph receiver illustrated in enclosure 25. In this device brush 41 carried on an extension of shaft 6' passes in rotation over segments 40, 42 and 43 of which the latter two lie within the angle $\theta$ and the former without that angle. The brush 41 is connected through an ordinary start-stop printer 45 of well known type to ground. Between segment 42 and ground is connected a battery 44. The operation is as follows: When brush 41 passes from segment 42 to segment 43, the circuit is opened, thereby producing the standard start signal required at the initiation of each character signal by the printer. As the brush 41 passes over segment 40 the five-code units of the telegraph character are received over conductor 39 and flow to printer 45. As brush 41 leaves segment 40 and contacts segment 42, the battery 44 puts potential on the printer 45, thereby producing the standard stop signal. The synchronizing signals cannot pass into the printer since brush 41 is not in contact with segment 40 when these signals are received.

What is claimed is:

1. A synchronizing system comprising a first periodic element and in association therewith means for sending consecutive electric pulses, means for transmitting said pulses, a second periodic element, means for receiving said pulses and in association therewith means for selecting and means for individually storing impulses received during each of a plurality of consecutive recurrent time intervals, means for balancing against each other said individually stored impulses and means responsive thereto to change the rate of occurrence of said recurrent time intervals.

2. A synchronizing system comprising a first periodic element and in association therewith means for sending consecutive electric pulses, means for transmitting said pulses, a second periodic element, means for receiving said pulses and in association therewith means for selecting and means for individually storing impulses received during each of three consecutive recurrent time intervals, means for balancing against each other said stored impulses and means responsive thereto to control the speed of said second periodic element.

3. A synchronizing system comprising a first periodic element and in association therewith means for sending consecutive electric pulses, means for transmitting said pulses, a second periodic element, means for receiving said pulses and in association therewith means for selecting and means for individually storing impulses received during each of three consecutive recurrent time intervals, means for balancing stored impulses received during the first occurring of said three time intervals against those received during the second occurring time interval and means responsive thereto to increase the speed of said second periodic element, means for balancing stored impulses received during the second occurring interval against those received during the third time interval and means responsive thereto to decrease the speed of said second periodic element.

4. In a synchronizing system, means for sending periodically an electrical impulse, a transmitting medium, means for receiving, in association therewith a distributor, means for driving said distributor, said distributor comprising means for delivering the output of said receiving means consecutively and repetitively to each of a plurality of storage circuits, means for comparing the stored energies in said storage circuits and means responsive thereto controlling the speed of said driving means.

5. In a synchronizing system, means for sending periodically an electrical impulse, a transmitting medium, means for receiving, in association therewith a distributor, means for driving said distributor, said distributor comprising means for delivering the output of said receiving means consecutively and repetitively to each of a plurality of storage circuits, means for comparing the energy of one of said storage circuits, with that of a second storage circuit and responsive thereto means to increase the speed of said driving means, means for comparing the energy of said first mentioned storage circuit with that of a third storage circuit and means responsive thereto to decrease the speed of said driving means.

6. A synchronized system including a sending station comprising means for sending consecutive equally spaced impulses, a transmitting medium, a receiving station comprising means for receiving said impulses, connected thereto a brush driven by a motor having a speed control, said brush contacting in rotation three segments connected respectively to three condensers and three leak circuits, means for balancing the currents in said leak circuits against each other and means responsive thereto to operate said speed control.

7. A synchronized system including a sending station comprising means for sending consecutive equally spaced impulses, a transmitting medium, a receiving station comprising means for receiving said impulses, connected thereto a brush driven by a motor having a speed control, said brush contacting in rotation three segments connected respectively to three condensers and three leak circuits, means for balancing the current in one of said leak circuits against each of the other two leak circuit currents independently and means responsive thereto to operate said speed control.

8. In a synchronized communication system, means for transmitting periodically consecutive equally spaced synchronizing pulses, means for sending these between communication signals, a transmitting medium, a receiver for receiving said pulses and said signals, periodic distributor

means for separating said pulses and said signals and for conducting them into separate circuits, means to synchronize said distributor with said pulses comprising means for individually storing impulses received during each of a plurality of consecutive recurrent time intervals, means for balancing against each other said individually stored impulses and means responsive thereto to correct the speed of said distributor.

9. In a self-synchronizing receiver means to receive electric effects, a periodic distributor for distributing said electric effects in time sequence to a plurality of storage circuits, means for discharging said storage circuits in respective distinct circuits and means responsive to the strongest discharge to control the periodicity of said distributor.

10. In a self-synchronizing receiver means to receive synchronizing impulses and communication signals, periodic distributor means for separating said impulses and said signals and conducting them into separate circuits, means to synchronize said distributor with said impulses comprising a plurality of impulse receiving circuits associated with said distributor, each such circuit including an impulse storage circuit and a discharge circuit, means for putting in opposition the effects of two of said discharge circuits and means responsive thereto to modify the speed of said distributor.

11. The method of nullifying the effect of interference in receiving recurrent signals which includes receiving and individually storing interference effects impinging during each of a plurality of consecutive recurrent time intervals, receiving and individually storing normal signal effects during less than the full plurality of intervals, opposing one set of stored effects against another such set, and utilizing the differential effect.

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