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SYNCHRONIZING SYSTEM

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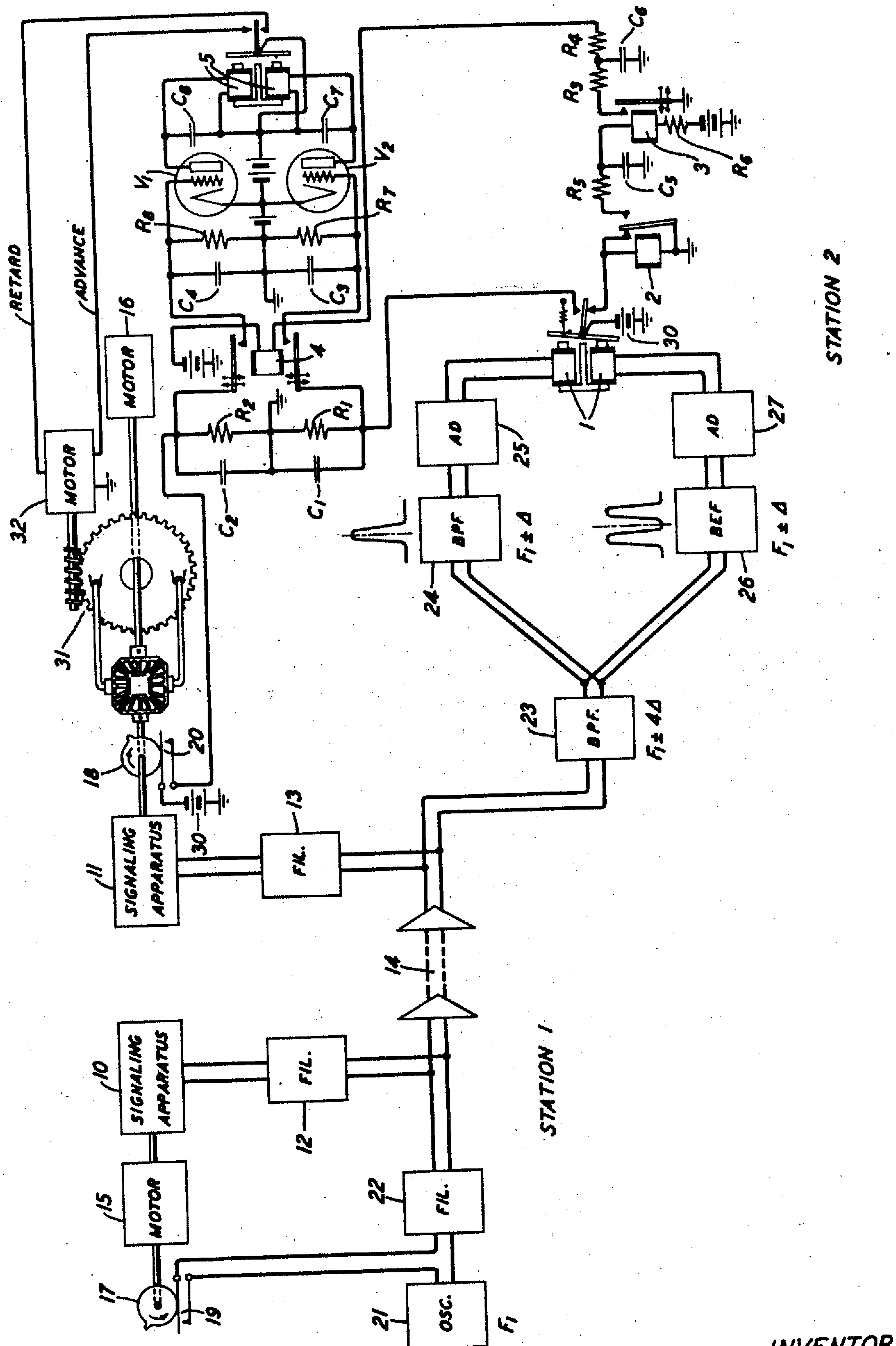

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SYNCHRONIZING SYSTEM

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The present invention relates to a system for synchronizing the movements of separated devices such as may be used, for example, at different terminals of a signaling system.

The invention is particularly suited to cases in which independent drives are provided for the devices at separated stations which are capable of running for short times in sufficiently close synchronism and phase agreement and in which impulses are sent over the system from time to time to correct any accumulated error in the speed of one of the devices to restore synchronism and phase agreement.

An object of the invention is to provide for accurate and reliable speed control of a distant device, including those cases in which the transmission path over which the control is exerted is subject to noise, fading or other difficulties.

In accordance with the specific embodiment of the invention to be disclosed herein, the corrective means at a receiving station is biased to non-operative condition and this bias is, if anything, increased by presence of noise or during fading so as to guard against false operation. The corrective means remains unoperated except when positively throught into action by receipt of a synchronizing pulse, being at all other times protected against the effects of spurious energy.

Specifically, a relay is operated, through a noise protection circuit, to throw its armature away from a normal contact to an operate contact to initiate operation of the correcting means. If the relay only partially operates or operates too briefly, the correcting mechanism is not actuated. Full operation of the relay for the duration of the control impulse results in a comparison between the phase position of the controlled machine and that of the distant machine as determined by the time of receipt of the pulse, and in either no correction or in an advance or a retardation of the phase position of the controlled machine according as the controlled machine is in correct phase or behind or ahead of the distant machine.

A more complete understanding of the invention will be had from the following detailed description when read in connection with the accompanying drawing, the single figure of which is a simplified schematic circuit diagram of a complete system embodying the invention.

Referring to the drawing, stations 1 and 2 are arranged for the transmission of signals between the terminal signal apparatus indicated at 10 and 11, which may be of any desired type, such as telegraph, picture transmission, privacy systems or other types of signaling which require the synchronous movement of devices or machines incorporated in or accompanying the signaling apparatus. These signals may employ a band of frequencies passed by the band-pass filters 12 and 13. The line 14 is illustrative of any type of transmission path or channel and may be a radio link, if desired. These sets of apparatus 10 and 11 are driven by respective motors or other driving means indicated at 15 and 16, respectively. On the same shaft with the signaling apparatus at each station is a cam 17 or 18 adapted once each revolution to close corresponding contacts 19 or 20 for a brief instant. These are for purposes of synchronizing the apparatus 10, 11 as will be described presently.

At station 1 an oscillator 21 is provided for generating a wave of frequency F_1 outside the range employed for signaling. A short impulse of this frequency is transmitted over the system each time the springs 19 are closed by rotation of the cam 17 and this impulse is selectively transmitted through the narrow band-pass filter 22.

At the receiving end, this pulse is sent through the first band-pass filter 23 which is arranged to pass a fairly sizable band each side of F_1. The output of this filter is then divided, part going through a much narrower filter 24 which passes only about one-fourth the band width of the original filter. The output of this narrow filter is fed to the upper amplifier detector 25, and the output of the original filter 23, is fed through a band elimination filter 26, to the lower amplifier detector 27. The outputs of these two detectors are then fed to the differential relay 1, as indicated. When no energy of frequency F_1 is present, the output of the amplifier detector 27 will always be greater than that of 25 if any noise is present. This is because the lower amplifier receives about three times the band width of the upper. Thus, at such times, the differential relay 1 will operate in the down direction. This relay is also biased sufficiently to hold its armature down if no input is present.

When a pulse of frequency F_1 is received, however, it will put a comparativelgy large amount of energy in the upper branch of this circuit and almost none in the lower (a slight amount due to transients). Thus, the relay 1 will operate in the upper direction due to the presence of the pulse. Operation of relay 1 in the up direction does two things. It releases relay 2 and immediately charges condenser C_1 to the full value of the battery 30. Release of relay 2 causes condenser C_5 to discharge to ground and thus operates relay 3. This discharge is purposely made a little slow so that occasional very brief false operation of relay 1 does not cause relay 3 to operate.

When relay 3 operates, however, it will remain operated after relay 2 again operates during the time required to charge up C_5 through R_6. This time is made equal to a little more than half the time for one rotation of cam 17.

When relay 3 operates, it initiates the operation of relay 4. The latter relay is made both slow operate and slow release. This is done by making both resistances R_3 and R_4 comparatively large. Thus, the relay does not operate until C_6 has discharged to a fairly low value through R_3 but it then remains operated after release of relay 3 until C_6 has been charged up through R_4. Thus, relay 4 is made to operate for a brief interval at a time one-half a revolution after the pulse is received from cam 17.

Relay 4, as may be seen, connects the differential detector consisting of tubes V_1 and V_2, relay 5 and their associated circuits to the two condensers C_1 and C_2. It was pointed out previously that C_1 is charged to its full value every time a pulse is received from the far end. As soon as this pulse ceases, C_1 starts discharging through R_1. C_2, however, is also charged to the full value of the same battery through cam 18 every revolution of the main drive 16 at this station, and similarly, it starts to discharge through R_2 as soon as cam 18 breaks.

If the pulse from the far end occurs at the same instant as the pulse from cam 18, it is apparent that the voltages across R_2 and R_1 will be equal at all times. Thus, when relay 4 operates for a brief interval, one-half a revolution after the pulse from cam 17, part of the charge from C_2 will be transferred to C_4 and a small and equal part of the charge from C_1 is transferred to C_3. Since the charge on C_1 was equal to that on C_2, the charge on C_3 will be equal to that on C_4. Thus the plate currents produced in V_1 and V_2 will be equal and differential relay 5 will stay at its mid-position. Thus, the phase of cam 18 will not be changed since the differential drive 31 is not actuated.

Let us now assume, however, that the pulse from cam 17 arrives ahead of the pulse from cam 18. In this case condenser C_1 starts to discharge ahead of the time that C_2 starts to discharge and thus through the whole cycle the voltage across R_1 will be less than that across R_2. When relay 4 operates, C_4 will be charged to a higher voltage than C_3 and the amount by which this voltage exceeds that of C_3 will be determined by the amount of time by which the pulse from cam 17 is ahead of the pulse from cam 18.

Thus, the current in the plate circuit of V_1 will exceed that in V_2 during the time in which C_4 and C_3 are discharging through R_7 and R_8, respectively. Thus, relay 5 will be operated in the up direction for a time dependent on the amount by which the charge in C_4 exceeds the charge in C_3. There will, of course, be some low value of current for which relay 5 will not operate in either direction and thus if the difference in voltage on C_3 and C_4 is rather small, the difference currents in the two windings of relay 5 will soon drop to a value too small to operate the relay. On the other hand, if the difference in the voltages on C_3 and C_4 is large, the difference current in relay 5 will remain large enough to operate it for a longer period.

Since the pulse from cam 17 came too soon, the voltage in C_2 is greater during the remainder of the cycle than that in C_1 and thus relay 5 is operated in the up direction for a time dependent on this difference in the time of the two pulses. This operates the motor 32 to move the differential gear 31 in the direction to advance the shaft connected to cam 18. This drive is so adjusted that when relay 5 is held operated for a time determined by the difference in arrival of the pulse, operation of the drive for that amount of time changes the phase of cam 18 by very nearly the correct amount to bring cam 18 into the right position. If it is not in the correct position when the next pulse comes along, a similar adjustment will, of course, be made to bring it into more exact synchronism.

The above describes what happens when the pulse from cam 17 arrives too soon. If it arrives too late, a similar series of events takes place, except that now the voltage on C_1 will be greater than that on C_2 during the discharge cycle and thus relay 5 will be operated in the down direction and the motor 32 will be rotated in the reverse direction so that the phase of cam 18 will be retarded.

As noted above, the time actions in relay 3 and relay 4 are so arranged that relay 4 operates for a brief interval one-half a revolution after the operation of relay 1. It is the difference between voltages on C_1 and C_2 at the end of this brief interval that determines what happens to relay 5. If cam 18 operates any time from just after the release of relay 4 to just before the operation of relay 1, the voltage in C_2 will be lower than that in C_1 the next time relay 4 is operated. This, of course, means that relay 5 will be operated in the down direction, thus causing cam 18 to be retarded by an amount dependent on the difference in these voltages.

If cam 18 operates any time from slightly after the operation of relay 1 to just before the release of relay 4, the voltage in C_2 will be greater than that in C_1 before relay 4 releases, and thus relay 5 will be operated in the up direction for a time dependent on the difference in this voltage and cam 18 will thus be advanced correspondingly.

It is apparent that in the above arrangement no correction is made in the speed at the receiving end unless a pulse gets through to operate relay 1. Thus the device is able to, in effect, ignore any period during which no pulse gets through and to maintain its synchronism within the capabilities of its own main drive during that time. As soon as pulses come through, however, it will immediately pull into synchronism.

What is claimed is:

1. In a system for synchronizing the motions of distantly located devices, means for periodically sending impulses under the control of the first device, means controlled by the receipt of said impulses for placing a charge of definite value on a condenser, means controlled by the second device for placing an equal charge on a similar condenser, similiar leakage paths for said condensers, a speed corrector for said second device, means for actuating said corrector in accordance with the difference exsiting between the charges on said two condensers, and means actuated by the receipt of said impluses for placing said last means under control of the charges on said condensers.

2. In a system for synchronizing the movements of separated devices, means in each devise to produce pulses at periodic times, a circuit for translating the time difference between said

pulses into a voltage difference, speed corrective means for the second device, means normally preventing said voltage difference from reaching said speed corrective means, and means controlled by an impulse produced by the first device and operating only after a delay interval for causing said voltage difference to exert a controlling effect on said corrective means.

3. In a system for controlling the movement of a body by impulses sent over a communication channel, means controlled by the body for periodically charging a condenser, means for periodically charging another condenser in response to each of said impulses, a circuit for taking off the voltage across both of said condensers, a speed correcting circuit for said body, a slow operate relay also controlled by each of said impulses but unresponsive to momentary currents short in comparison to the duration of one of said impluses, and means controlled by said relay when operated for momentarily connecting said speed correcting circuit across the terminals of said first-mentioned circuit.

4. In a system for controlling the speed of a local mechanism to agree with the speed of a mechanism located at a distance, a transmission path leading from the distant mechanism to the local mechanism, means to send periodic control impulses over said path from the distant mechanism, said path being subject to noise, a narrow band filter and a relatively broad band filter having their inputs connected in parallel to said

path, a differential relay having an actuating winding connected to the output of said narrow band filter and a restoring winding connected to the output of said other filter, said relay when operated in response to one of said control impulses closing a circuit for placing a charge of definite value on a first condenser, means controlled by the movement of the local mechanism for periodically placing a charge of definite value on a second condenser, resistive paths around said condensers for dissipating their charges at a given rate, a speed correcting circuit adapted to be connected across said condensers to receive the difference in voltage across them, and a delayed action relay operated from said differential relay in response to one of said impulses for momentarily connecting said speed correcting circuit across said condensers after both of said condensers have had the mentioned charges placed on them.

5. A system according to claim 4 in which said speed correcting circuit includes condenser means for storing a charge and resistive circuit means for dissipating the stored charge at a given rate, said delayed action relay in operating transferring the differential voltage existing across said first and second condensers to said condenser means to enable actuation of said correcting means to continue after said delayed action relay has disconnected said correcting circuit from across said first and second condensers.

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