

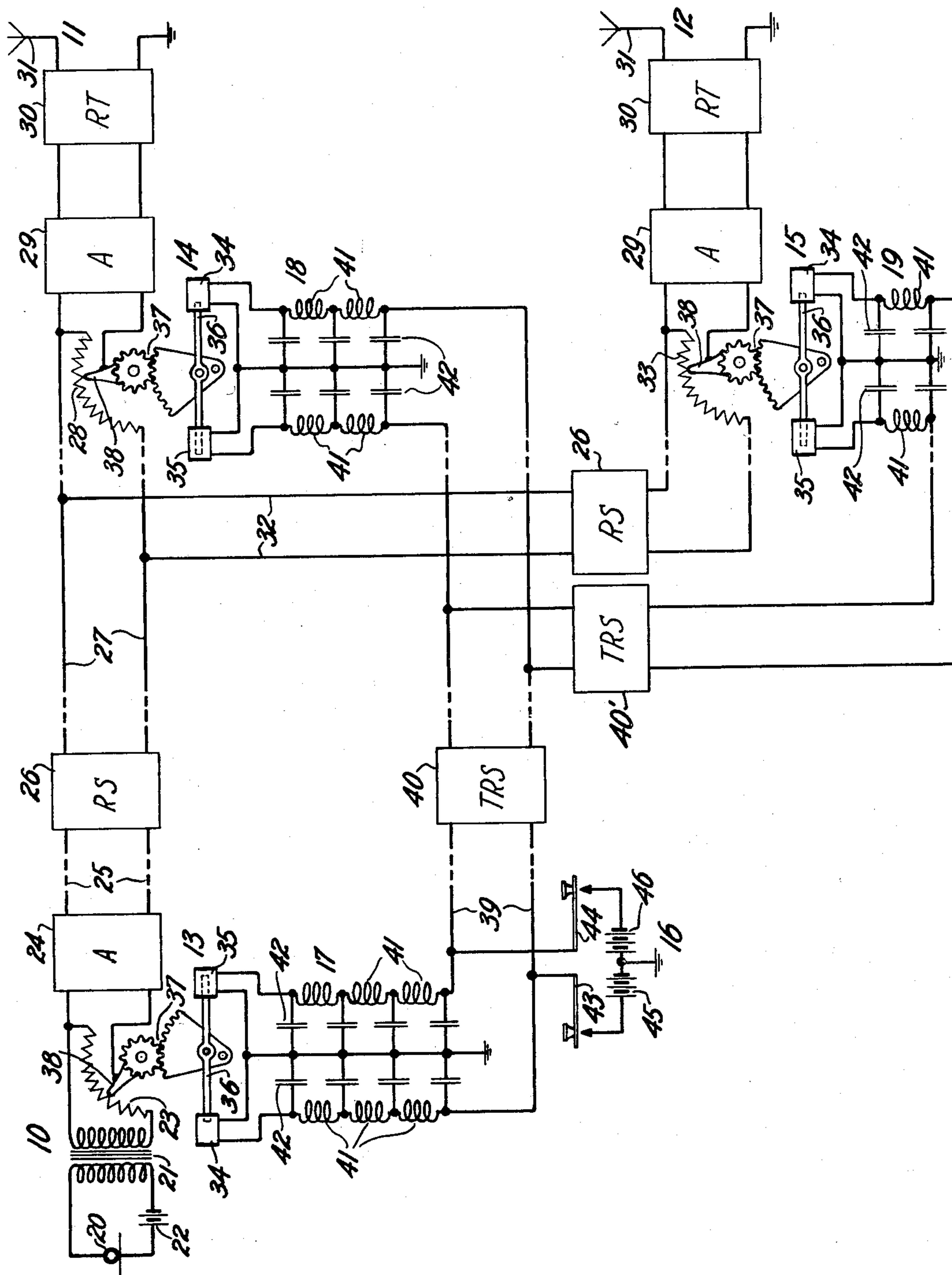
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CONTROL SYSTEM

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UNITED STATES PATENT OFFICE

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CONTROL SYSTEM

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This invention relates to control systems, and more particularly to systems for synchronizing the movement of controlled devices.

5 The radio broadcasting art has now developed to the stage that signals picked up at a studio or pick-up station may be supplied over a network of wire lines to a large number of radio stations, at which the
10 signals are caused to modulate high frequency carrier waves to be broadcast. It has been found necessary, in connection with broadcasting systems involving the transmission of signals, such as speech or music, over
15 wire lines from a pick-up point to one or more broadcasting transmitters, to provide control means adapted to adjust the volume of signals at the transmitting and receiving ends of the line. The necessity for this is
20 quite generally known to arise from the fact that the wire lines and associated amplifiers and repeaters have a limited volume capacity, and the signal volume at times may respectively exceed or fall below the maxi-
25 mum or minimum volume level limits necessary for optimum transmission.

The method of control, now generally used, consists in compressing the volume of signals at the pick-up station and reexpanding
30 ing the volume of the signals in the same degree at the broadcasting station, with the result that the signals supplied to the modulator have the same characteristics as the original signal. The volume control devices at the respective stations are gener-
35 ally operated in accordance with electric impulses transmitted over control lines separate from the signal lines. The control lines may include mechanical relays or re-
40 peaters requiring a considerable time for operation, and hence the control impulses may be delayed more or less depending upon the number of repeaters and the length of the lines. For this reason the
45 control impulses may reach the several controlled stations at different instants.

The signals, however, because repeated by space discharge devices, are ordinarily propagated without material delay. As a
50 result the delay of the control impulses may

cause objectionable volume changes in the broadcast signal. For example, at a given instant, the volume of the signals at the pick-up station may be increased by the volume control device and because of the speed
55 with which signal waves are transmitted, this increase becomes effective immediately at the broadcasting station. The control impulses will not ordinarily immediately effect a compensating reduction in the signal
60 volume supplied to the broadcasting transmitter, hence a volume peak, not actually characteristic of the original signal is produced in the broadcast wave. In the present invention, means is provided to delay
65 the volume control action at the pick-up station sufficiently to enable a compensating action to be effected at the broadcasting station at the proper instant, namely at the instant that the signal volume change would
70 otherwise become effective at the latter station.

It is an object of this invention to adjust the time of propagation of impulses from a source over paths normally of different elec-
75 trical length.

A specific object is to synchronize the operation of a plurality of devices controlled from a single station.

A more specific object is to compensate
80 for the differences in the time of transmission of control impulses over different paths from a source to distant control devices, so that any desired time interval between the operation of these devices may be secured.
85

A related object is to adjust the interval between a plurality of control actions, effective at separate points with respect to a signal wave, to the time of propagation of the wave between the respective points.
90

The invention provides, as a feature, a control system including controlled and controlling devices and interconnecting lines, with suitable delay circuits or elements for effecting the several objects above enumer-
95 ated.

The invention broadly may be explained as a control system, wherein electromagnetic or other devices are located at separate points and are connected by a network of
100

lines to a common control device, by means of which, impulses are supplied to the lines for operating the controlled devices. The impulses may be similar to telegraph impulses and may be relayed and repeated by telegraph or similar relays. Such relays, however, have a time delay in operation, so that impulses supplied to one controlled device may be delayed more or less than those supplied to another device at a different location, depending upon the number of relays included in the respective control paths.

Other factors also may affect the time of propagation of the control impulses from the control station to the different controlled devices. To enable the action of the controlled devices to be effective at the proper instants, at the several desired points, this invention provides delay circuits to enable the time of propagation of control impulses to the several controlled devices to be adjusted. As a result, the interval between the control actions may be suitably adjusted.

The invention may be applied, in practice, to a volume control system, wherein it is desired to adjust the interval between signal volume adjustments made respectively at a pick-up station and at one or several broadcasting stations, to the time required for the propagation of a signal volume change between these stations.

The invention is illustrated in the figure of the drawings in connection with a volume control circuit associated with a chain of radio broadcasting stations.

Referring to the drawings, the system therein shown comprises a pick-up station 10 and a plurality of radio broadcasting stations 11 and 12. The pick-up station and the several broadcasting stations are provided with volume control devices 13, 14 and 15, respectively, which are connected by a wire network to a control station 16. The wire network has included, in the individual branches extending to the controlled devices 13, 14 and 15, the delay circuits 17, 18 and 19, respectively.

At the station 10 a pick-up transmitter 20 is connected to the primary winding of a signal transformer 21, in series with a source of current represented as a battery 22. The secondary winding of the transformer is connected to a volume control potentiometer comprising a resistance 23 and a control arm 38, which is in turn connected to the input terminals of an amplifier 24. This amplifier may be any one of many well-known forms, but preferably includes space discharge tubes. The output terminals of this amplifier are connected to a wire line 25, which includes a repeater station 26, at which there may be provided space discharge amplifiers and repeaters of any desired type, preferably employing space discharge tubes. The output terminals of the repeater station

26 are connected to a second wire line 27 which extends to a control potentiometer comprising a resistance 28 and a control arm 38, at the broadcasting station 11. This potentiometer is connected to a suitable space discharge amplifier 29, which is adapted to supply amplified signal waves to the radio transmitter 30, connected to the antenna 31.

The transmission line 27 has connected to it a branch 32 extending through a second repeater station 26 to a control potentiometer, including a resistance 33 and a control arm 38, at the other broadcasting station 12; this station also including an amplifier 29 and a radio transmitter 30 associated with an antenna 31. The transmitting apparatus at station 12 may be identical with the corresponding apparatus at station 11.

The control arms 38, of the potentiometers at the respective stations, are adapted to be adjusted by driving means 13, 14 and 15, which may be of any desired type. The potentiometers 23—38, 28—38 and 33—38 constitute the controlled devices hereinbefore and hereinafter mentioned. The driving means includes solenoids 34 and 35 having an armature 36 connected to a gear 37, which is adapted to operate the arms 38. The respective solenoids may have one terminal connected to ground and the opposite terminal connected to one side of the control line 39, which may include the several telegraph repeater stations 40. The line 39 also includes, at the several stations 10, 11 and 12, delay circuits 17, 18 and 19 respectively which may be any one of various forms, but which are illustrated as including series inductance elements 41 and shunt capacity elements 42.

The control station 16 includes keys 43 and 44, adapted to connect the batteries 45 and 46 between ground and the respective sides of the control line 39.

The system just described operates as follows: Sound waves such as speech or music are supplied to the pick-up transmitter 20 which produces corresponding electrical waves that are supplied through transformer 21 and the associated potentiometer 23—38 to the amplifier 24. The volume of signals may be controlled by adjustment of the arm 38, which varies the voltage of the signal waves supplied to the input circuit of the amplifier 24. The signal waves from amplifier 24 are supplied to the wire line 25 and are repeated at the repeating station 26 to the line 27, over which they are transmitted through the potentiometer 28—38 and amplifier 29 to the radio broadcasting transmitter 30 at station 11. They are here caused to modulate radio frequency carrier waves and the resulting modulated waves are supplied to the antenna 31.

Signal waves are also supplied over the

line 32 in like manner to the radio transmitter 30 which supplies similar modulated waves to the antenna 31 at station 12.

The volume of signals supplied to the line 25, the repeater station 26 and the lines 27 and 32 may be controlled by means of the keys 43, and 44 at the control point 16. When key 43 is depressed all of the solenoids 34 at the several stations 10, 11 and 12 are energized. Likewise, when the key 44 is depressed all of the solenoids 35 are energized.

Solenoids 34 cause a movement of their associated potentiometer arms 38 in one direction, whereas solenoids 35 cause a movement of these arms in an opposite direction. Thus, by energizing the solenoids 34 and 35, any desired movement of the switch arms 38 relative to the resistances of potentiometers 23, 28 and 33 may be produced.

When solenoid 35 at station 10 is energized the switch arm 38 is rotated to the left, and accordingly the amplitude level of the signal current supplied to lines 27 and 32 is increased. When the solenoids 35 at stations 11 and 12 are energized, they cause the switch arms 38, associated with resistances 28 and 33, respectively, to be rotated to the right and hence produce a change in the amplitude level of the signal currents supplied to the radio transmitters, which change is equal and opposite to the increase in level caused by the adjustment of the potentiometer at station 10. The amplitude level of the signal current supplied to the lines 27 and 32 at station 10 is consequently increased, whereas the amplitude level of the signal current supplied to the radio transmitters at stations 11 and 12 is decreased to the same extent. On the other hand when the solenoids 34 are energized, the amplitude level of the signal current supplied to the lines from the station 10, is decreased, whereas the amplitude level of the signal currents supplied to the transmitters at the broadcasting stations is correspondingly increased.

By this method of control, the amplitude level of the signal currents, supplied to the radio transmitters at the broadcasting stations 11 and 12, may be adjusted to have any desired relation to the amplitude level of the signal currents supplied at the pick-up station 10. Consequently, the volume of the signal, although changed at station 10, may be restored at stations 11 and 12 to a value bearing a definite relation to that produced at the pick-up station, for example it may be restored to the same value.

By virtue of the action of the delay networks 17, 18 and 19, the volume control adjustments at the several stations are effected at desired predetermined intervals. The keys 43 and 44 will ordinarily be located at

the same place as the pick-up transmitter 20, although they may be located elsewhere. Accordingly, the circuit connecting the keys and the potentiometer 23—38 will generally be short and no repeating devices will be included between the keys and the device 13. Hence little or no delay will be interposed to the control impulses traversing this path.

On the other hand, since the branches of line 39 between the station 16 and the stations 11 and 12 will in general be longer, and may include the repeater stations 40 and 40', respectively, as illustrated, the transmission of the control impulses to these stations will be considerably delayed. The impulses supplied to station 12 will ordinarily be delayed to a greater extent than those supplied to station 11, because of the greater number of repeater stations included in this path, and the impulses supplied to both of these stations will in general be delayed to a greater extent than those supplied to the station 10.

The delay circuits 17, 18 and 19 are therefore designed to change the electrical length of the paths to the respective stations, so that the difference in time of propagation of the control impulses over the several paths is equal to the time of propagation of a signal volume change from the pick-up station to the respective broadcasting stations. As a result, control actions will be effective at the several broadcasting stations at the instant when a volume change produced by the potentiometer 23—38 arrives. Undesired volume peaks, which tend to introduce distortion in the broadcast signals, will accordingly be prevented.

Although this invention has been described in connection with a particular embodiment, it is susceptible of general application. For example, any suitable delay circuits may be employed, and the use of mechanical as well as electrical devices is contemplated. The devices shown in the drawings merely serve to illustrate a convenient type. The volume control devices and the impulse sending devices may be modified, for example, to include a chain of relays. Likewise, the number of broadcasting stations may be almost indefinitely increased, and the signal and control networks correspondingly extended. It is also evident that any one of the delay circuits may be omitted, the other delay circuits being designed so that the control impulses are effective at all stations at the proper instant.

The invention is therefore to be limited only as indicated by the scope of the appended claims.

What is claimed is:

1. In a control system, a plurality of devices to be controlled, a control station therefor, a network of lines interconnecting said devices with said station, said lines having different impulse propagation char-

acteristics, and supplementary circuits for adjusting the propagation characteristics of said lines.

2. In a control system, a plurality of adjustable devices, a control station, circuits having different characteristics, interconnecting said adjustable devices with said control station, over which impulses are transmitted, for varying the adjustment of said devices, and means included in said circuits for delaying the transmission of said impulses over certain of said circuits, whereby the relative time of operation of said devices may be adjusted.

3. In a broadcasting system, a pick-up station, a plurality of broadcasting stations, means for controlling the volume of signals at said pick-up station in one sense and at said broadcasting stations in an opposite sense, said means including elements inherently tending to delay the control operations at certain of said stations, and means for adjusting the delay, whereby control actions at all of said stations may be effected in a predetermined time order.

4. The method of volume control of signals which comprises, simultaneously transmitting control impulses from the common control station over paths requiring different intervals for the propagation of said impulses, and interposing delay in the propagation of impulses in certain of said paths.

5. In a broadcasting system including a pick-up station and a plurality of broadcasting stations and a control station, the method of volume control of signals which comprises, transmitting control impulses from the control station to the signal pick-up and broadcasting stations, to vary the volume of signals at said pick-up station in one sense and at said broadcasting stations in an opposite sense, in accordance with said impulses, and adjusting the time of propagation of said impulses to all of said stations, whereby a desired difference in time of effecting volume variations at the several stations may be obtained.

6. In a volume control system, a plurality of volume control devices at a plurality of separated stations, means for transmitting impulses, controlling all of said devices over circuits inherently requiring different intervals for propagating said impulses, and means in said circuits for adjusting said intervals.

7. In combination, a control station, a plurality of devices to be controlled, a plurality of paths having different time factors for the transmission of impulses connecting said control station and said devices, and means for substantially equalizing the time of propagation of said impulses over all of said paths.

8. In combination, a source of impulses, a

plurality of electromechanical devices, a wire line connected to said source and including separate branches connected to individual devices, and, included in said branches, delay circuits for equalizing the time of propagation of said impulses to all of said devices.

9. In combination, a source of signals, a radio transmitter, a line connecting said source and said transmitter, a signal volume control means at said source and a volume control means at said transmitter, and means for causing operation of said control means at predetermined instants comprising a source of control impulses, a line having branches connecting said source of impulses with each of said control means, and a delay circuit associated with at least one of said branches.

10. In a control system, the method of effecting control of a plurality of devices which comprises, adjusting the interval between a plurality of control actions effective at separate points with respect to a signal wave, to the time of propagation of said wave between said respective points.

In witness whereof, I hereunto subscribe my name this 5th day of April, A. D., 1926.

JOHN H. BELL.