

June 21, 1960

P. K. ECKHARDT ET AL
REMOTE CONTROL SYSTEMS

2,942,238

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2 Sheets-Sheet 1

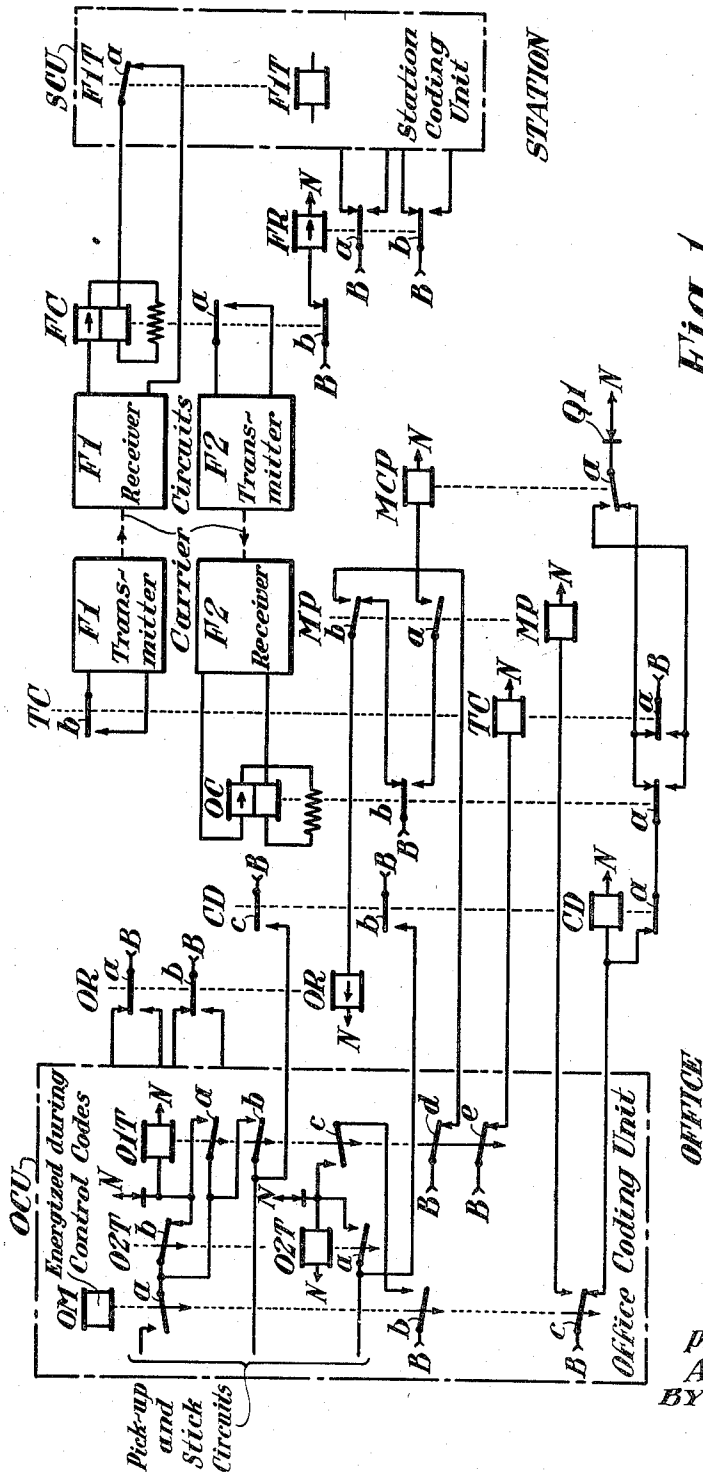


Fig. 1.

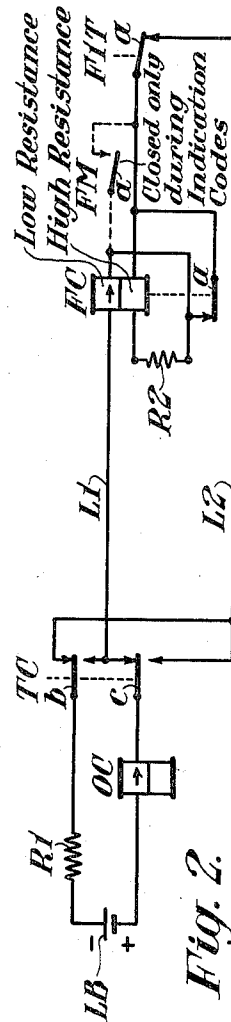


Fig. 2.

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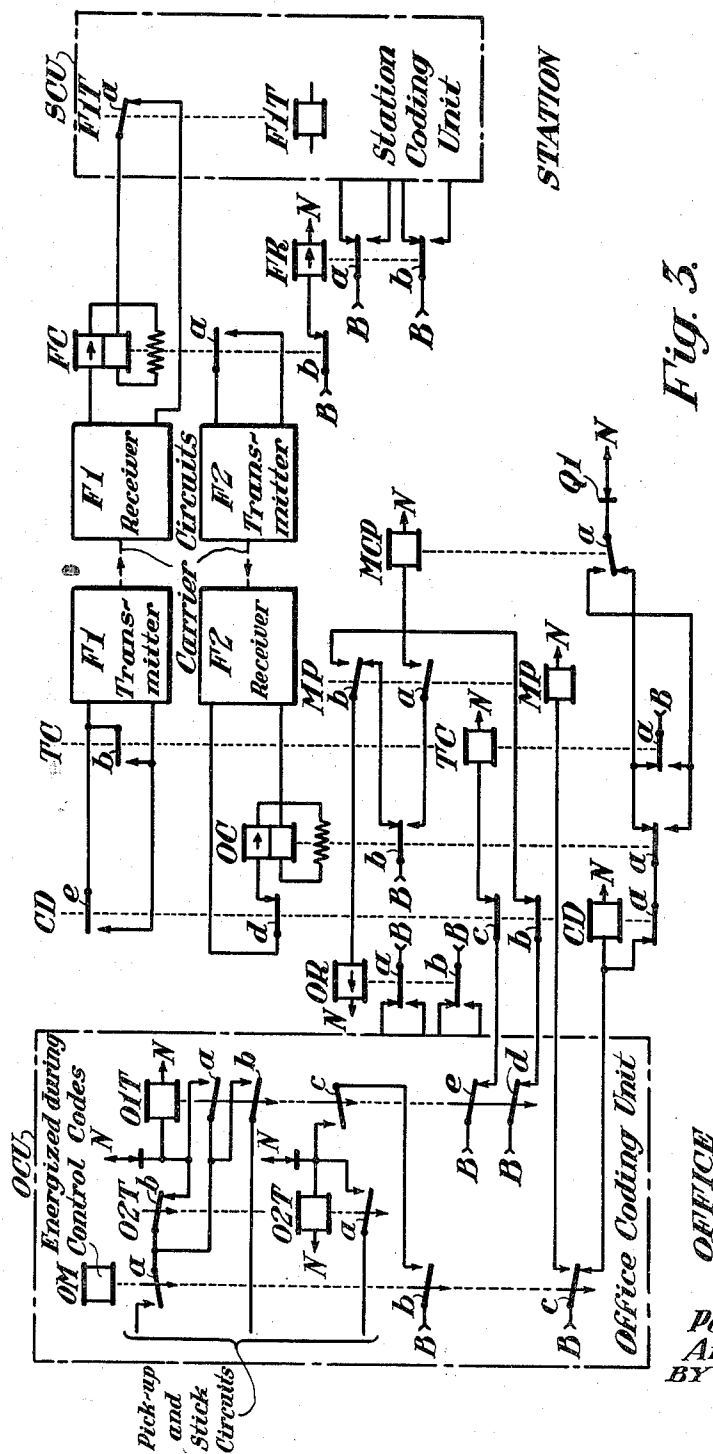
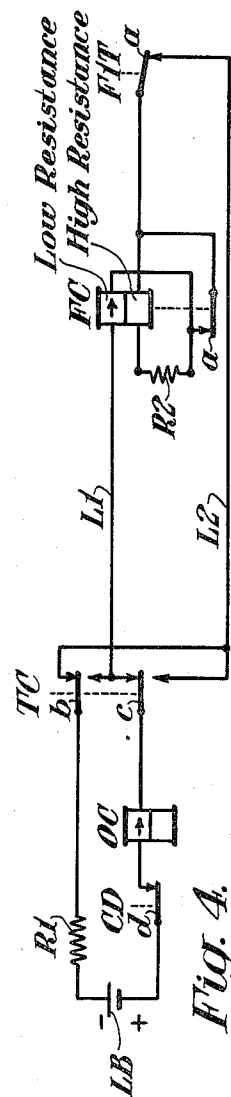
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REMOTE CONTROL SYSTEMS

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5 Claims. (Cl. 340-163)

Our invention relates to a remote control system. More particularly, our invention relates to a remote control system in which the proper transmission of control functions is checked at the office.

The general system of the present invention is of the time code type employing codes of long and short elements which are transmitted over a communication channel. For example, the general system of this invention may be that disclosed in Letters Patent of the United States No. 2,442,603, issued June 1, 1948 to Arthur P. Jackel, for a Remote Control System.

In applying remote control systems of this type to varied kinds of installations, special problems frequently arise. One such problem is to assure that each control step is received properly at the station before the control functions are registered and act to accomplish the corresponding operation of the apparatus at that station. In other words, a check must be made, at the office or control location, that no line interruptions or erroneous pulses have distorted the code. Since the communication channel between the office and the station or stations may be a direct current line circuit or a carrier channel of any well known type, these interruptions or erroneous pulses are a matter of some concern. Such erroneous action may cause the registry of false controls or at least improper controls which result in actions at the station which are, at a minimum, not those designated and which may be very undesirable. Thus the check provided at the office to assure that the control functions are properly received at the station must be capable of halting the code or at least preventing its registry at the selected station. Since remote control systems of this general type may have progressive registry of the control functions, an instantaneous check as to the correct reception of the control code and provisions for immediately preventing the registry of false control functions are necessary.

Accordingly, an object of our invention is to provide, in a remote control system of this type, means to check the transmission of control codes to assure their proper reception at the stations.

Another object of our invention is to provide, in a remote control system, answer-back facilities from stations to the control office which indicate the proper reception of control codes during the progress of the code.

It is also an object of our invention to provide means at the control location in such a system to prevent the registry of improper control functions at the stations.

Still another object of our invention is to provide means at the office of remote control system, responsive to answer-back indications of the improper reception of a control code at a station, to halt that control code during its transmission.

A further object of our invention is to provide an arrangement in a remote control system to prevent the registry of improper control functions if a control code

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is distorted by interruptions on the communication channel.

Other objects and features of our invention will be obvious as the specification progresses when taken with respect to the accompanying drawings.

In practicing our invention, we provide means at each station in a remote control system to retransmit back to the control or office location each control code step as it is received. This retransmitted code step may be a regular code step transmitted over the indication channel if such a separate channel is in use, or the retransmitted code step may be a code pulse on the simplex communication channel superimposed upon the corresponding control pulse or code step. This retransmitted or answer-back pulse is received at the office nearly simultaneously with the transmission of the corresponding control step. The proper reception of this answer-back pulse holds energized a code disagreement relay to allow the control code transmission to continue. If no answer-back pulse or an out-of-synchronism pulse is received at the office, this code disagreement relay is released and immediately causes the coding action to halt. Depending upon the details of the system involved, the control code may be halted immediately, that is, upon the existing code step and the system reset to normal. In other cases, the code may be halted only on an odd numbered code step and the system reset then to normal. In either case, the registry of improper control functions at the selected station is prevented and the effect on the system of communication channel interruptions or extraneous pulses is minimized.

We shall now describe two forms of apparatus embodying our invention and thereafter point out the novel features thereof in the appended claims.

Referring now to the drawings,

Fig. 1 shows one form of apparatus embodying our invention as applied to a remote control system in which carrier communication channels are used.

In Fig. 2, the form of our invention of Fig. 1 is shown applied to a remote control installation using a direct current line circuit.

In Fig. 3 of the drawings, a second form of the apparatus embodying our invention is shown which may be used under certain specialized operating conditions. In this drawing, the remote control system as shown utilizes a carrier communication channel.

Fig. 4 of the drawings shows the application of the second form of our invention to a remote control system using a direct current line circuit.

In each of the drawings, similar reference characters refer to similar parts of the apparatus.

It is to be pointed out at this time that a suitable local source of direct current energy is provided at each office and station location shown in the drawings, this power source being preferably a battery of proper voltage and capacity. However, for the sake of simplicity, these power sources are not shown in the drawings, their positive and negative terminals being identified by the conventional reference characters B and N, respectively. In all figures of the drawings, the movable portion of each neutral relay contact is conventionally illustrated to move up when the corresponding relay winding is energized. In other words, regardless of whether the contact is above or below the winding symbol in the drawing, the upper stationary contact point is the front contact and conversely the lower is the back contact.

In Fig. 1, there is shown a single station, remote control system of a well known type which includes apparatus embodying the features of our invention. In Fig. 1, the office or control location is shown at the left of the drawing with the single station at the right. However, it is

here noted that our invention is not limited to such single station systems but may be applied to remote control systems having a plurality of stations. Also, while in this present application the answer-back facilities are shown as being applied from the station to the office to check the transmission and reception of control codes, it is to be further understood that the system of our invention may be applied to provide answer-back facilities from an office to the various stations to check the transmission and reception of indication codes, especially where such codes may carry detailed information or data which must be properly recorded to be of value.

As shown in Fig. 1, the office and station are connected by a carrier communication channel. This carrier channel may be of any well known type and is shown as being of a duplex nature having two unidirectional carrier circuits. The first carrier circuit is from the office to the station, that is, left to right, and the second from the station to the office, that is, right to left. The first circuit utilizes a carrier current having a frequency F1, while the second carrier circuit utilizes a similar carrier current having a frequency F2. Carrier current of frequency F1 is produced in carrier transmitter F1 and is received by the F1 carrier receiver at the station. Similarly, carrier current of frequency F2 is produced by the F2 carrier transmitter at the station and is received by the F2 carrier receiver at the office. Both carrier currents are normally on during the at-rest condition of the system. The carrier circuits may be superposed on physical line circuits normally used for other types of communication or may be carried by radio or microwave channels. Details of the carrier transmitters, receivers, and the channels used are herein shown conventionally, as they are not part of our invention, such apparatus being well known to the art and any one of several different types may be used with the system.

The office location is provided with an office coding unit shown conventionally by the dot-dash box designated OCU. The system of our invention is applicable to any of several well known types of time code remote control systems. For example, the basic system used may be that shown in the previously mentioned Patent 2,442,603 or it may be similar to the system shown in the instruction pamphlet Manual No. 510 entitled, "Time Code Control System," published by the Union Switch & Signal, Division of Westinghouse Air Brake Company, in November 1944. Since the basic remote control apparatus is shown in detail in these publications, only such details of the basic system are herein shown as are necessary for an understanding of our invention, reference being made to the previously mentioned publications for a complete description of the operation of the coding units.

The coding unit OCU includes a master relay OM which is energized during a control code in the manner shown in the previously mentioned publications. It is sufficient here to understand that relay OM is energized and picks up to initiate a control code. This relay is then held energized during the entire control code, releasing during the final code step. Further, relay OM is not energized and remains released during indication codes. The office location is also supplied with a master relay repeater relay MP, which is energized from terminal B of the source through front contact c of relay OM and the winding of relay MP to terminal N. Relay MP thus picks up and remains up during an entire control code.

Unit OCU is also provided with two transmitter relays 01T and 02T. Each of these relays is of a slow release type and its release is further retarded by the use of a rectifier snub. An energizing circuit for relay 01T is completed over front contact a of relay OM at the beginning of a control code, this pickup circuit also including back contact b of relay 02T. Relay 02T is energized by a circuit which is completed from terminal B over front contact b of relay OM, front contact c of relay 01T, and the winding of relay 02T to terminal N. Each of the

transmitter relays has one or more stick circuits completed over front contacts of the corresponding relay. These stick circuits, as well as the initial energizing circuit for relay 01T, are shown in detail in the previously mentioned Patent 2,442,603 and need not be further discussed herein.

Briefly reviewing, the character of each transmitted impulse or code step is determined by the interval of time during which transmitted relay 01T is either picked up or released. It is to be noted that this relay is alternately picked up and released to produce the short code steps by back contacts of the odd numbered counting chain relays of the coding unit. Relay 02T is picked up each time relay 01T picks up to close its front contact c. It is obvious that relay 01T cannot pick up, however, until relay 02T has released, and thus the even numbered short code steps are controlled by the release time of relay 02T. When an odd numbered code step is to be long, relay 01T is held energized by energy over one of its stick circuits from the control function contact assigned to that particular code step. Likewise, when an even numbered code step is to be long, relay 02T is held energized over its stick circuit by energy from the control function contact assigned to that code step. Thus the characteristics of control code are determined by the operation of these two transmitter relays.

In the system of our invention, each of these transmitter relays is provided with an additional stick circuit. For example, relay 02T may be held energized by a circuit from terminal B over back contact b of code disagreement relay CD, front contact a, and the winding of relay 02T to terminal N. Likewise, a similar circuit for relay 01T includes back contact c of relay CD and front contacts a and b of relay 01T. The use of these special stick circuits will be discussed more fully hereinafter.

The office is also supplied with a line relay OR which is of the biased type as indicated by the arrow shown inside the symbol for the relay winding. This relay, as well as other similar relays shown, picks up to close front contacts only when energized by current flowing in the direction of the arrow. Relay OR repeats the code pulses received over the communication channel or generated locally. During indication codes, for example, this relay is energized at times by the circuit traced from terminal B over front contact b of office carrier receiver relay OC, back contact b of relay MP, and the winding of relay OR to terminal N. Flow of current in this circuit is in the proper direction to cause the relay contacts to be picked up closing front contacts a and b. When relay OC releases, the opening of its front contact b releases relay OR and the contacts of this relay are released to close back contacts a and b. During control codes, however, relay OR is controlled by a circuit including back contact d of relay 01T and front contact b of relay MP, so that relay OR is operated to follow the code produced by the contacts of relay 01T. In either case, the ultimate operation of contacts a and b of relay OR between their front and back positions drives the timing and counting chain relays of coding unit OCU. This causes the code to progress as described in the various mentioned publications. During control codes, this operation of relay OR is necessary to properly produce the code.

The office is further provided with a carrier transmitter relay TC. This relay is controlled directly by first transmitter relay 01T over a circuit including back contact e of the latter relay. It is to be seen, therefore, that relay TC is normally energized and becomes deenergized to release its contacts when relay 01T picks up. In other words, relay TC is released during odd numbered code steps and is energized and picks up during even numbered code steps. Each release of relay TC suppresses the control carrier current of frequency F1 by shunting the carrier transmitter at its back contact b. Each sup-

pression of the control carrier creates or transmits an odd numbered code step.

At the office, another relay MCP is used to repeat the operation of relays OM and OC. The circuit for energizing relay MCP may be traced from terminal B over back contact *b* of relay OC, front contact *a* of relay MP, and the winding of relay MCP to terminal N. It is to be seen, therefore, that relay MCP follows the coded operation of relay OC only when relay MP is picked up, that is, during a control code. As will appear shortly, relay MCP is thus picked up during each odd numbered step of a control code and is released during even numbered code steps.

A code disagreement relay CD is also included in the circuit arrangement at the office. This relay is normally energized over back contact *c* of relay OM. Thus during reception of an indication code at the office, relay CD is continuously energized since relay OM remains released. During control codes, with back contact *c* of relay OM open, relay CD is held energized over one or the other of its two stick circuits. The first of these stick circuits may be traced from terminal B over front contacts *a* of relays TC, OC, and CD, and the winding of relay CD to terminal N. The second stick circuit is similar but includes back contacts *a* of relays TC and OC. Relay CD is an ordinary acting relay, but is provided with a retardation circuit arrangement which slows the release of this relay under certain conditions, as will be explained shortly. The first retardation circuit may be traced from terminal N through the half-wave rectifier unit Q1 in its forward direction over back contact *a* of relay MCP, front contact *a* of relay OC, front contact *a*, and the winding of relay CD to terminal N. The second and similar retardation circuit includes rectifier Q1, front contact *a* of relay MCP, and back contact *a* of relay OC, as well as front contact *a* and the winding of relay CD.

The previously mentioned office carrier receiver relay OC is of the biased type and is normally energized by the F2 carrier current receiver as long as carrier current of frequency F2 is being received from the station. At any time that this carrier current is suppressed, relay OC is deenergized and quickly releases.

The station location is also supplied with a station coding unit. This coding unit is similar to the office coding unit OCU and thus is completely described in either of the previously mentioned publications. It is herein shown conventionally by the dot-dash box designated SCU, and only the first transmitter relay FIT and its single back contact *a* are shown. The utility of this back contact *a* will appear shortly.

The station is also provided with a carrier receiver relay FC which is normally energized by the F1 carrier current receiver, over back contact *a* of relay FIT, as long as carrier current of frequency F1 is being received from the office. Back contact *a* of relay FC, when the relay is released, suppresses the F2 carrier current transmitter to halt the transmission of carrier current of this frequency. Front contact *b* of relay FC drives a field line relay FR to follow the coding action of relay FC. Relay FR in turn, through its contacts *a* and *b*, drives coding unit SCU to receive the control codes in a manner completely described in detail in the previously mentioned publications.

During the transmission of indication codes, relay FIT operates in the manner usual to such systems to transmit the code. Relay FIT controls relay FC during the transmission of indication codes through its back contact *a*, relay FC being deenergized when this back contact is open. Relay FC then releases and suppresses the carrier current of frequency F2 by shunting the transmitter F2 during the odd numbered code steps. Release of relay FC during indication codes also releases relay FR and the code following operation of this latter relay to alternately operate its contacts *a* and *b* between their

front and back positions drives the timing and counting relay chains of coding unit SCU to produce the indication code in the usual manner of such systems.

We shall now describe the operation of the apparatus during the transmission of a control code from the office. In the at-rest condition of the apparatus, relays OR, OC, CD, TC, FC, and FR are energized so that these relays are picked up with front contacts closed. When the operator at the office initiates a control code, relay OM is energized and picks up. As previously explained, this immediately results in the energization of repeater relay MP which also picks up closing its front contacts. The opening of back contact *c* of relay OM interrupts the energizing circuit for relay CD. However, at this moment, the first stick circuit for this relay is still complete, this circuit including front contacts *a* of relays TC and OC. The opening of back contact *b* and the closing of the corresponding front contact of relay MP transfers the control of relay OR from relay OC to relay 01T over back contact *d* of this latter relay.

The pickup of relay OM, thus closing its front contact *a*, completes the energizing circuit for relay 01T, as is more fully explained in either of the previously mentioned publications. Relay 01T then picks up to start the first step of the control code. The opening of back contact *d* of relay 01T deenergizes relay OR and, since this relay is of the biased type, it immediately releases to close its back contacts. The opening of back contact *e* of relay 01T deenergizes relay TC which shortly releases. The closing of back contact *b* of relay TC suppresses the F1 carrier current transmitter halting the transmission of current of this frequency over the communication channel. This causes the deenergization of relay FC at the station and this biased relay immediately releases to close its back contacts and open its front contacts. The release of relay FC, opening its front contact *b*, deenergizes relay FR at the station and this latter relay also immediately releases.

The closing of front contact *c* of relay 01T at the start of the first code step completes the energizing circuit for relay 02T, this circuit also including front contact *b* of relay OM. Relay 02T thus picks up and at its own front contact *a* completes a stick circuit. The opening of back contact *b* of relay 02T interrupts the energizing circuit for relay 01T. At the proper time, relay 01T is deenergized by the opening of its stick circuit network in the progress of the coding action. Relay 01T, when thus deenergized, releases after its slow release period and reenergizes relays OR and TC in an obvious manner. Relay OR immediately picks up to drive the office coding unit OCU to progress the code to the second code step. When relay TC picks up, the opening of its back contact *b* removes the shunt from transmitter F1 and allows the transmission of carrier current of frequency F1 to resume. This energizes relay FC at the station since relay FIT at that location is released. The energization of relay FC is followed by the reenergizing of relay FR which picks up to receive the second code step. The coding action continues with relay 01T picking up and releasing to drive the office coding unit through relay OR to drive the field coding unit SCU through the carrier channel and relays FC and FR. Relay 02T also picks up and releases during the coding action to control the length of the even numbered code steps under the supervision of relay 01T. This action is completely described in the previously mentioned publications and is here reviewed briefly only to establish a basis for the operation of the circuits of our invention.

Each time relay FC releases due to the suppression of carrier current of frequency F1 by relay TC releasing at the office, back contact *a* of relay FC shunts the carrier current transmitter F2 causing the suppression of carrier current of this frequency and halting its transmission over the communication channel to the office

location. The absence of the carrier current F2 at the office deenergizes relay OC and this relay, being of the biased type, immediately releases. It is to be noted here that this release of relay OC follows the release of relay TC as controlled by office transmitter relay 01T by only a short period, the delay being due only to the time necessary for the round trip of the carrier current, or in this case its suppression, from the office to the station and back. The release of relay OC to close its back contact *b* energizes relay MCP by completing the energizing circuit including back contact *b* of relay OC and front contact *a* of relay MP, the latter contact, of course, being closed at this time due to the transmission of the control code.

When relay TC initially releases at the beginning of the first code step, the opening of front contact *a* of this relay interrupts the stick circuit for relay CD. However, the release of relay CD is retarded by a shunt provided by rectifier Q1, the shunting circuit including back contact *a* of relay MCP and front contacts *a* of relays OC and CD. When relay OC releases shortly thereafter, due to the suppression of the indication carrier current from the station, the closing of its back contact *a* completes the second stick circuit for relay CD, this circuit including back contacts *a* of relays TC and OC as previously explained. This stick circuit is completed prior to the release of relay CD which, as explained, was retarded somewhat by rectifier Q1 shunted around the winding of the relay. Thus relay CD is reenergized and holds its front contacts closed, or back contacts open, during this normal coding action. The pickup of relay MCP upon the release of relay OC completes the second shunt circuit for relay CD. This second shunt circuit, as explained, includes back contact *a* of relay OC and front contact *a* of relay MCP. The opening of back contact *a* of relay MCP during this action interrupts the first shunt circuit which initially retarded the release of relay CD.

When relay TC picks up at the beginning of the second code step the second stick circuit for relay CD is interrupted at the back contact *a* of relay TC. However, the second shunting circuit above traced retards the release of relay CD for a short period. As previously explained, the pickup of relay TC to open its back contact *b* removes the shunt from the control carrier transmitter and this results in the energization of relay FC at the station. Opening of back contact *a* of relay FC removes the shunt from the indication carrier transmitter and as a result relay OC at the office is reenergized by the reception of carrier current of the indication frequency F2. Relay OC picks up, releasing relay MCP and completing again the first stick circuit for relay CD, both of these actions having been previously discussed. Under normal operation, relay OC is reenergized and picks up to close its front contact *a* prior to the end of the retardation period for relay CD so that this latter relay holds its front contacts closed during the entire period. Thus, it is to be seen that code disagreement relay CD is not released during normal operation in transmitting a control code. Rather, relay CD feeds on the answer-back signals from the station to hold its front contacts closed and back contacts open. This allows the control coding action of unit OCU to continue until the completion of the control code, after which the unit resets itself and the entire system to the normal at-rest condition.

If some kind of a line or communication channel fault occurs, even though temporary in nature, or if an induced pulse of current blanks out a code step, relay FC at the station will fail to follow the operation of relay TC at the office in transmitting the control code. This causes a similar failure, as will be obvious from the previous description, in the operation of relay OC to likewise follow the operation of relay TC. Since each operation of relay TC opens the then effective stick circuit for relay CD and the other stick circuit is not

completed until relay OC likewise operates in a corresponding manner, the failure of relay OC to follow the operation of relay TC will result in the stick circuit network for relay CD remaining open. Relay CD then releases at the end of the retardation period furnished by rectifier Q1.

It may also occur that, after the corresponding operation of relays TC and OC at the office, a spurious pulse will be induced into one or the other of the carrier circuits which will result in the operation of relay OC to its opposite position prior to the proper operation of relay TC in the normal progress of the code. This again interrupts the stick circuit network for relay CD. Under these conditions, the shunt circuit across the winding of relay CD through rectifier Q1 is open and therefore ineffective, so that relay CD immediately releases. Thus a line fault or spurious pulse of a very short duration occurring during a code step will result in the release of relay CD and the halting of the coding action, as will be explained shortly. It is to be remembered that relay MCP follows the operation of relay OC so that, upon the reestablishment of the stick circuit network of relay CD, relay MCP has operated to establish the retardation circuit for the next code step. For example, consider the relays in the position in which they are shown in Fig. 1 and to which they would operate immediately after the beginning of each even numbered code step. If a spurious pulse causes relay OC to release, opening its front contact *a* and closing its back contact *a*, the retardation circuit for relay CD over this back contact *a* of relay OC is open at front contact *a* of relay MCP which released when relay OC picked up. Relay CD thus will immediately release, due to the interruption of the stick circuit network, prior to the time that relay MCP can pick up to reestablish this retardation circuit.

If relay CD releases as the result of a communication channel interruption or code transmission failure during an odd numbered code step, relay 01T will be held up over the special stick circuit established at back contact *c* of relay CD. This circuit may be traced from terminal B over back contact *c* of relay CD, front contacts *b* and *a* of relay 01T, and the winding of relay 01T to terminal N. Relay 01T is thus held energized, halting the coding action of unit OCU until the coding unit apparatus drops out and resets to its normal at-rest condition. Such a drop-out and reset action due to the halting of the code is fully explained in the previously mentioned publications and need not be here repeated. If relay CD releases during an even numbered code step, relay 02T is held energized over the stick circuit including back contact *b* of relay CD and front contact *a* of relay 02T. Again the coding unit apparatus drops out because of the halting of the code and the entire system resets to its normal at-rest condition. In other words, in either case, the release of relay CD interrupts the coding action of unit OCU, which likewise halts the transmission of the control code from the office. Since code is therefore no longer received at the station, the station coding unit drops out in synchronism with the office coding unit, the entire system returning to its at-rest condition at substantially the same time. Even though progressive registry of control functions is in use, any control function being transmitted by this final step of the code, that is, the step during which the interruption occurs and the coding action halts, will not be registered at the station since control function registry occurs at the beginning of the succeeding code step. Thus the false registry of an improper control function is prevented under these conditions.

Fig. 2 shows the form of our invention as disclosed in Fig. 1 when a direct current line circuit is used as the communication channel between the office and the station. In this figure, only the necessary line circuit connections are shown at office and station which re-

place the connections to the carrier communication channel of Fig. 1, the remainder of the circuit arrangement used with Fig. 2 being identical with that previously discussed for Fig. 1. It is to be noted that the receiver relay FC at the station is provided with two windings of different resistances. In other words, the upper winding of this relay is of relatively low resistance when compared with the higher resistance of the bottom winding. It may also be noted that the similar relay FC used at the station in Fig. 1 may also have different resistances in its two windings, although this is not critical to the operation of the apparatus when carrier communication is used.

The direct current line circuit of Fig. 2 is supplied with energy from a line battery LB at the office location. The line circuit also includes pole-changing contacts *b* and *c* of relay TC, both windings of receiver relay FC at the station, back contact *a* of station transmitter relay FIT, the upper winding of office receiver relay OC, and line wires L1 and L2. It is obvious that, in the at-rest condition shown, line wire L1 has a positive polarity when compared with line wire L2. A line resistance R1 at the office is included in the circuit connections to limit the line current under all conditions. A second resistance R2 is connected in series with the windings of relay FC at the station. However, this resistance R2 and the bottom winding of relay FC normally are shunted by front contact *a* of relay FC. Thus the line current during normal at-rest conditions is of a relatively high level and relays OC and FC are energized sufficiently to pick up their contacts.

During a normal control code, the release of relay TC during the odd numbered steps pole-changes the polarity of the line circuit so that the normally positive line wire L1 becomes negative. However, during the even numbered code steps with relay TC picked up, line wire L1 again has a positive polarity when compared with line wire L2. During each odd numbered code step, with the line circuit from the office to the station pole-changed, relay FC releases, since this biased relay, as previously explained, releases when the flow of current through either of its windings is in the direction opposite to the arrow. The release of relay FC opens its front contact *a*, inserting its bottom winding and resistance R2 into the line circuit and thus materially reducing the line current. This reduced line current causes the energization of relay OC to be reduced below the level at which it will hold its front contacts closed and this latter relay also releases. This release of relay OC, or in other words, the reduction of the line current by the release of relay FC, constitutes the answer-back from the station, for this type installation, during the odd numbered code steps.

When relay TC picks up at the beginning of an even numbered code step, its contacts *b* and *c* return the polarity of the line circuit to normal. The low level current still in effect is of the proper direction and, since this current flows through both windings, relay FC is sufficiently energized and picks up. This action of relay FC closes its front contact *a*, shunting its bottom winding and resistance R2, thus increasing the line current to its normal value again. This increased line current results in the energization of relay OC to a sufficient level for it to pick up its contacts. Thus the increase of the line current and resulting pickup of relay OC constitutes the answer-back from the station during the even numbered code steps.

The operation of the local circuit arrangement at the office under this form of installation is the same as previously discussed for the carrier current installation. In other words, the operation of relay OC to follow the operation of relay TC holds the code disagreement relay CD picked up and allows the control code to continue. Again, if relay OC fails to follow the operation of relay TC due to a line circuit interruption or if a spurious

pulse causes relay OC to operate ahead of the corresponding operation of relay TC, relay CD is released and operates to halt the coding action. It is to be noted, of course, that the operation of relay FC at the station during the control code to alternately open and close its front contact *b* results in the similar operation of line relay FR and thus the coding unit SCU is driven to receive the control code.

During an indication code, the operation of transmitter relay FIT at the station alternately opens and closes the line circuit at back contact *a* of this relay. This results in the alternate releasing and picking up of relay OC at the office to drive, through line relay OR, office coding unit OCU to receive the indication code. As before, there is no answer-back during indication codes, relay CD being held energized over back contact *c* of relay OM. It should be noted, however, unless special circuits are added, that when the line circuit is reclosed at back contact *a* of relay FIT, at the beginning of each even numbered code step, relay FC picks up slightly ahead of relay OC at the office. This occurs because the level of the line current is initially low and is of a value to sufficiently energize relay OC only after front contact *a* of relay FC closes. This action may be avoided if a front contact *a* of the station master relay FM is connected in multiple with front contact *a* of relay FC, as shown by the dotted connections in the drawing. Since the station master relay, similar in purpose to relay OM at the office, picks up at the beginning of an indication code, and remains up during the entire code, its front contact *a* will be closed to shunt the lower winding of relay FC and resistor R2 so that the line current is always at a high level during each even numbered step of an indication code.

The second form of our invention, as shown in Fig. 3, is an adaptation of our invention which is applicable to installations where only long code steps are used to carry control functions which are registered at the station progressively during the code or where all control functions transmitted to a station are registered during the final step of a complete code. A special advantage of this second form of the apparatus is that it does not require any modification of the office coding units OCU from the standard form as shown in the previously mentioned Manual 510. Thus, all office coding units which may be required for a large installation using several channels in different directions would be interchangeable and only one type of spare unit would be necessary. In fact, in most installations, all coding units, whether intended for the office or the station, would be interchangeable one with the other if this second form of our invention is used.

The basic principle of operation previously discussed in connection with Fig. 1 is the same for the apparatus shown in Fig. 3. Certain changes in the circuit arrangement are made in order to eliminate the modifications to the office coding unit. The first one of these changes is the additional shunt circuit provided for the carrier current transmitter F1. This shunt circuit is completed over back contact *e* of relay CD and thus is effective when relay CD is released. The energizing circuit for relay OC from the carrier current receiver F2 is carried over front contact *d* of relay CD so that this circuit is interrupted any time that this latter relay releases. Another change is in the control circuit for relay OR which is effective during control codes. This circuit in this form of the apparatus includes front contact *b* of relay CD as well as front contact *b* of relay MP and back contact *d* of relay 01T. A final change inserts front contact *c* of relay CD into the energizing circuit for relay TC, the circuit also including the previously discussed back contact *e* of relay 01T.

In this form also, during the transmission of a control code, relays OM and MP are picked up during the entire code. Relay OR is thus driven by the operation of relay 01T, as previously discussed, as long as relay CD remains held up, the alternate opening and closing of back con-

tact *d* of relay 01T causing the alternate release and pick-up of line relay OR. Coding unit OCU is thus driven by the operation of relay OR to cause the control code to progress from one step to another. As discussed before, relay TC is released during each odd numbered code step by the opening of back contact *e* of relay 01T. Closing of back contact *b* of relay TC suppresses the control carrier current causing the release of relay FC at the station. Relay TC picks up during each even numbered code step, energized by the closing of back contact *e* of relay 01T. This removes the shunt from the control carrier current transmitter and allows relay FC at this station to pick up.

The code following operation of relay FC at the station alternately shunts and unshunts the carrier current transmitter F2. This, of course, causes relay OC at the office to follow the code shortly behind the operation of relay TC, as previously discussed. This corresponding operation of relays TC and OC cooperates to hold up code disagreement relay CD, with the stick circuit network for this latter relay alternately being completed over front contacts *a* of relays TC and OC and back contacts *a* of these relays. Relay MCP follows the operation of relay OC, as previously described, to transfer the retardation circuits for relay CD between its front and back contacts *a*. Thus as long as the control coding operation progresses in the normal manner, relay CD is held up by the cooperative action of relays TC and OC as influenced by the answer-back indications received from the station due to the operation of relay FC.

If relay OC fails to follow the operation of relay TC due to some line interruption or the failure of a particular code step to reach the station, the stick circuit network for relay CD remains open for a period longer than the retardation period established for relay CD by rectifier Q1 and the latter relay releases. If relay OC should operate ahead of relay TC during an existing code step because of a spurious pulse induced into the carrier channel, the stick circuit network for relay CD is again opened and since, as previously discussed, no retardation circuit is at that time effective for relay CD, this latter relay releases immediately to halt the coding action, as will be described shortly. Thus relay CD is responsive to an induced and erroneous impulse of very short duration.

Release of relay CD, under either condition, permanently opens its stick circuit at its own front contact *a*. In addition, the opening of front contact *b* of relay CD interrupts the energizing circuit for relay OR which is effective during control codes and relay OR releases or is held in its release condition. The opening of front contact *c* of relay CD interrupts the energizing circuit for relay TC and this latter relay either releases or remains in a released condition. Similarly, the opening of front contact *d* of relay CD interrupts the energizing circuit for relay OC from the F2 carrier receiver and relay OC is immediately released or is held in its released condition regardless of subsequent operation of relay FC. The closing of back contact *e* of relay CD provides an additional shunt upon the carrier current transmitter F1 which is effective immediately to suppress the carrier current of frequency F1 to end an even numbered code step prior to the subsequent release of relay TC. The shunting of the control carrier current causes relay FC at the station to release followed by the release of relay FR. With relays OR and FR both released or held released, the coding units at the office and the station are set to the next odd numbered code step or are held upon the existing odd numbered code step, respectively, depending upon the code step during which the release of relay CD occurs. In either event, the entire system resets under the condition of a code halted during an odd numbered step. Relay CD is reenergized when relay OM releases to close its back contact *c* at the completion of the reset action.

As explained above, if the release of relay CD occurs during an even numbered code step, the coding units are advanced to the next odd numbered code step by the re-

lease of the line relays at each location. However, this cannot cause the improper registration of a control function even though such functions are being registered progressively during the code. The system shown in Fig. 3, as previously mentioned, is limited to the progressive registration of control functions carried by long code steps only. Thus the cutting off of an even numbered code step by the release of relay CD and the stepping of the units to the next odd numbered code step results in the reception of the even numbered code step at the station as a short step. Thus no control function is indicated or registered. Of course, if the final registry of all control functions is held and accomplished only during the final step of a complete code, no control function registry at all occurs during a code interrupted due to improper transmission. Thus the circuits of the second form of our invention protect against improper registry of control functions, to the extent of the limitations applied to this form of the apparatus.

In Fig. 4 we have shown the application of the apparatus of the second form of our invention to a direct current line circuit. These line circuit connections here shown are very similar to those shown in Fig. 2. The only change is the insertion of a front contact *d* of relay CD in the line circuit connections at the office location. As in Fig. 2, only the line circuit connections are shown in Fig. 4, the remainder of the apparatus being identical with that already shown and discussed in Fig. 3. Likewise, the operation of the apparatus when a direct current line circuit is used is very similar to that already discussed for the showing of Fig. 2 and need not be discussed again in detail. If relay CD is released due to the improper transmission of a control code and the lack of a proper answer-back pulse from the station, its front contact *d* opens to deenergize the entire line circuit. This releases relays OC and FC at once. Again each coding unit, responsive to the release of the corresponding line relay, holds on the existing odd numbered code step or, if relay CD is released during an even numbered code step, steps to the next odd numbered code step. Here the coding action is halted and the system resets to its normal at-rest condition. As previously discussed in connection with Fig. 3, the improper registry of control functions is thus prevented.

It has been described, therefore, how the system of our invention in either of its forms provides for a check of the proper transmission of control codes in remote control systems of the general type here shown. The answer-back pulse received from the station upon the proper reception of each step of the control code assures the office location that the control step has been properly received and allows the code to continue to completion. If there is no reception of the control code step at the station, if there is an improper reception, or if some improper action occurs in the communication channel, the lack of a proper answer-back immediately causes the coding action to be halted. This also prevents the registry of any control function which would cause an improper action at the station. This is true even though the control code is being registered progressively as the coding action continues. Thus the system of our invention assures that the desired control actions at the station will be performed properly or that the coding action will be halted until proper transmission of the control functions can be accomplished.

It is to be understood, although the preceding description has dealt specifically with the provision of answer-back indications during control codes, that similar arrangements may be used to check the transmission of indication codes from the station. In other words, the system of our invention may be applied to provide, at any location originating a code, a check as to the proper reception of that code at its intended destination, the check being accomplished through the medium of a simultaneous answer-back code originating at the receiv-

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ing station. Unless the answer-back indicates that each code step has been properly received, the transmission of the code is interrupted and the registry of incorrect functions prevented.

Furthermore, although we have herein described and shown but two forms of apparatus embodying our invention, it is to be understood that various changes and modifications may be made therein within the scope of the appended claims without departing from the spirit and scope of our invention.

Having thus described our invention, what we claim is:

1. In a remote control system including at least a first and a second location connected by a communication channel, said first location being provided with coding apparatus having connections to said channel for transmitting stepped codes to said second location, each code step having a particular selected time length, the combination comprising, means at said second location having connections to said channel for retransmitting to said first location a code step identical to the received code step in selected time length simultaneously with the reception of each code step from said first location, receiving means at said first location having connections to said channel for receiving the retransmitted code steps; disagreement means at said first location controlled by said coding apparatus and by said receiving means for detecting disagreement in time length between each transmitted code step and the corresponding retransmitted code step, said disagreement means having other connections for halting the operation of said coding apparatus if disagreement is detected; retardation means having connections to said disagreement means for compensating for the transmission delays of said channel between the transmission of a code step and the reception of the corresponding retransmitted code step, and other means controlled by said receiving means for cancelling the compensating effect of said retardation means after a retransmitted code step is received to detect interference induced in said channel which interrupts the selected time length of a code step.

2. In a remote control system including an office and at least one station connected by a communication channel, said office being equipped with a coding unit to transmit stepped control codes over said channel which said station is adapted to receive, each code step having a particular selected time length, the combination comprising, a code disagreement relay at said office effective when deenergized to halt the transmission of a control code, an energizing circuit and a stick circuit network for said relay, said energizing circuit including a normally closed contact which is open during the transmission of control codes; said stick circuit including a first pair of contacts alternately closed during the transmission of successive control code steps, a second and a third pair of contacts alternately closed in response to the reception of successive code steps each retransmitted back from said station simultaneously with the reception at said station of successive ones of said control code steps, and a half-wave rectifier; said first and said second pairs of contacts cooperating during the transmission of a control code to maintain said disagreement relay energized only if each received retransmitted code step is identical in selected length with the corresponding transmitted control code step, said second and said third pairs of contacts cooperating during a control code to connect said rectifier at times in multiple with the winding of said relay to retard the relay release to compensate for transmission delay periods in the coordinated operation of said first and said second pairs of contacts and to disconnect said rectifier to cancel the retardation of said relay if said second pair of contacts operates to its other position prior to the corresponding operation of said first pair of contacts as a result of induced extra code steps.

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3. In combination with a coding unit at the office location of a remote control system, said system also including at least one station connected to the office by a communication channel, said coding unit being capable of producing control codes comprising a plurality of successive code steps each having a particular selected time length and including a transmitter relay arrangement having connections to said channel to transmit said code steps over said channel, said station being capable of receiving said codes and simultaneously retransmitting each code step in identical time length form as received over said channel to said office; a code disagreement relay effective when released to interrupt the operation of said transmitter relay arrangement, an energizing circuit and a stick circuit network for said disagreement relay; said energizing circuit including a normally closed contact which is opened during control codes, said stick circuit network including a first pair of contacts alternately closed during successive code steps in response to the operation of said transmitter relay arrangement to transmit a control code, a second and third pair of contacts each alternately closed in response to the reception at said office of the successive retransmitted code steps, and a half-wave rectifier; said first and said second pair of contacts cooperating during a control code to maintain said stick circuit network completed only if each retransmitted code step is identical in time length with the corresponding transmitted control code step, said second and said third pairs of contacts cooperating during a control code to connect said rectifier in multiple with said disagreement relay over contacts of these pairs to retard the release of said disagreement relay while said stick circuit network is interrupted between the corresponding operation of said first and said second pairs of contacts during transmission delay periods, said third pair of contacts being effective to interrupt said multiple connection if said second pair of contacts operates to its other position prior to the corresponding operation of said first pair of contacts as a result of an erroneous code step induced into said channel.

4. In a remote control system including at least a first and a second location, said first location being provided with coding apparatus for transmitting stepped codes which said second location is capable of receiving, each code step having a particular selected time length, the combination comprising, a receiver relay of the biased type at said second location having a first and a second winding, said second winding having a higher resistance than said first winding; a line circuit including a source of direct current energy, two line wires extending between said first and second locations, both windings of said receiver relay, and pole-changing contacts responsive to the operation of the coding apparatus, said pole-changing contacts being effective to transmit code steps by alternately pole-changing the relative polarity of said line wires; a shunt circuit including a normal energy position contact of said receiver relay and connected in multiple with said second winding of said receiver relay, said shunt circuit being effective to materially change the current flowing in said line circuit when said receiver relay periodically operates due to the pole changing action of said pole-changing contacts to produce an answer-back code step at said first location having a time length identical to that of the corresponding transmitted code step, receiving means at said first location having connections to said line circuit for receiving the answer-back code steps, disagreement means at said first location controlled by said coding apparatus and by said receiving means for detecting disagreement in time length between each transmitted code step and the corresponding answer-back code step, said disagreement means having other connections for halting the operation of said coding apparatus if disagreement is detected; retardation means having connections to said disagreement means for compensating for the transmission delays of said line cir-

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cuit between the transmission of a code step and the reception of the corresponding answer-back code step, and other means controlled by said receiving means for cancelling the compensating effect of said retardation means after an answer-back code step is received to detect interference induced in said channel which interrupts the selected time length of a code step.

5 5. In a remote control system including an office and at least one station, said office being provided with coding apparatus for transmitting stepped codes which said station is capable of receiving, each code step having a particular selected time length, the combination comprising, an office receiver relay, a station receiver relay of the biased type having a first and a second winding, said second winding having a higher resistance than said first winding; a line circuit including a source of direct current energy at said office, two line wires extending between said office and said station, the winding of said office receiver relay, both windings of said station receiver relay, a resistor, and pole-changing contacts responsive to the operation of said office coding apparatus to transmit successive code steps by alternately pole-changing the polarity of the energy applied to said line wires; a shunt circuit including a normal energy position contact of said station receiver relay connected in multiple with said resistor and said second winding of said station receiver relay in series, said shunt circuit being effective to materially change the current flowing in said line circuit to transmit an answer-back code step having a time length identical to that of the corresponding transmitted code

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step each time said station receiver relay periodically operates due to the pole-changing of the polarity of said line circuit, said office receiver relay being responsive to each change of line circuit current to receive the answer-back code steps, disagreement means at said office controlled by said coding apparatus and by said office receiver relay for detecting disagreement in time length between each transmitted code step and the corresponding answer-back code step, said disagreement means having other connections for halting the operation of said coding apparatus if disagreement is detected; retardation means having connections to said disagreement means for compensating for the transmission delays in said line circuit between the transmission of a code step and the reception of the corresponding answer-back code step, and other means controlled by said office receiver relay for cancelling the compensating effect of said retardation means after an answer-back code step is received to detect interference induced in said channel which interrupts the selected time length of a code step.

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