

**Aug. 30, 1938.**

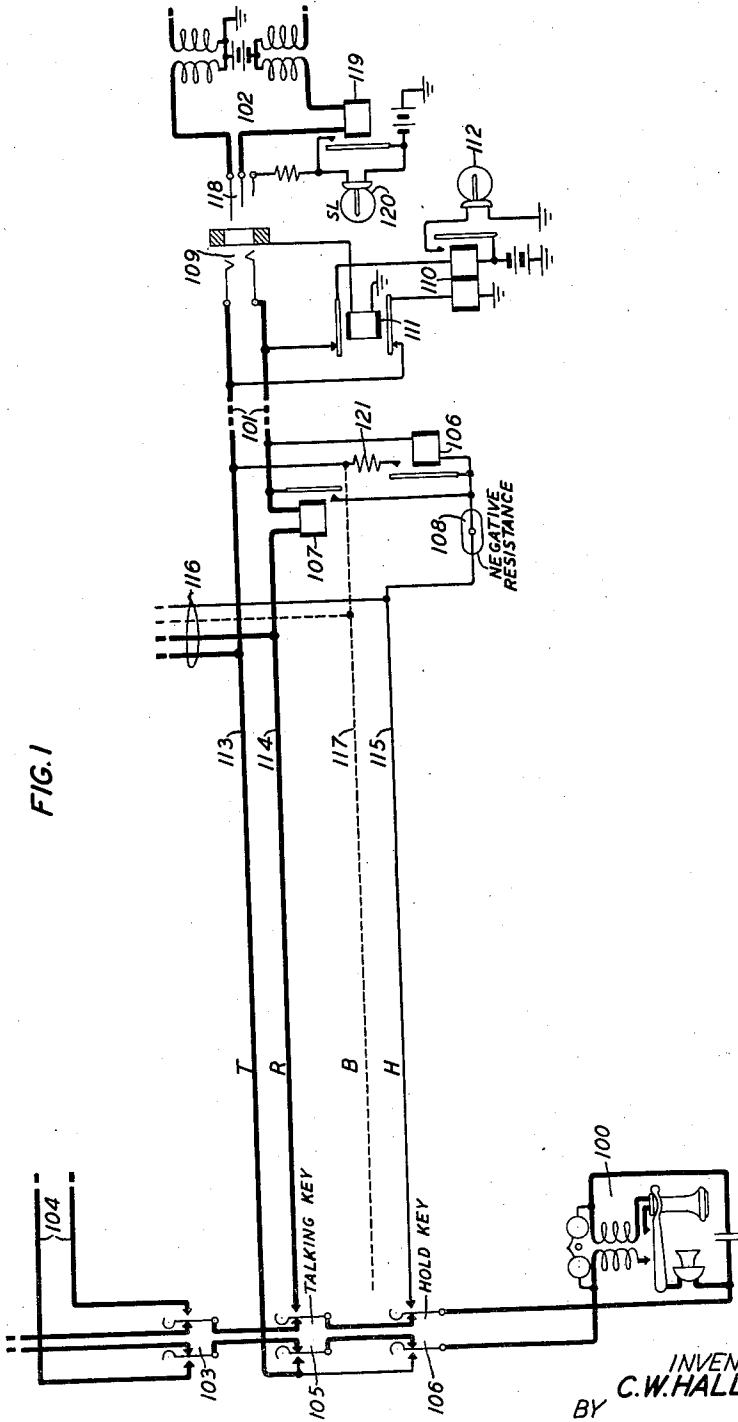
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TELEPHONE SYSTEM

Filed Feb. 27, 1937

**2,128,411**

2 Sheets-Sheet 1



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FIG. 2

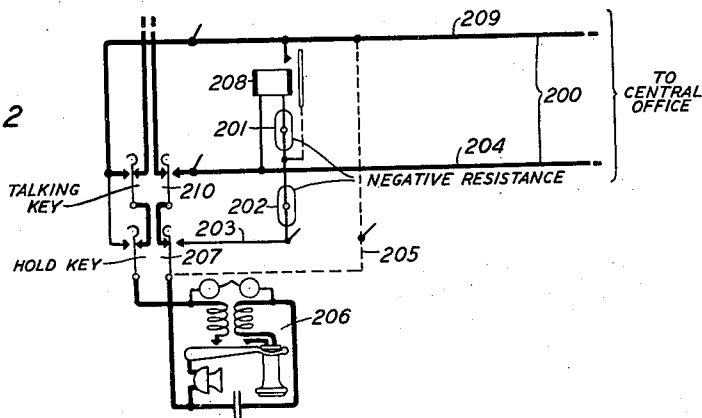


FIG. 3

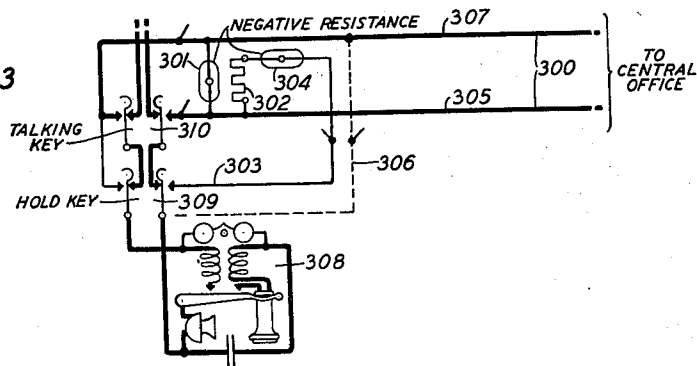
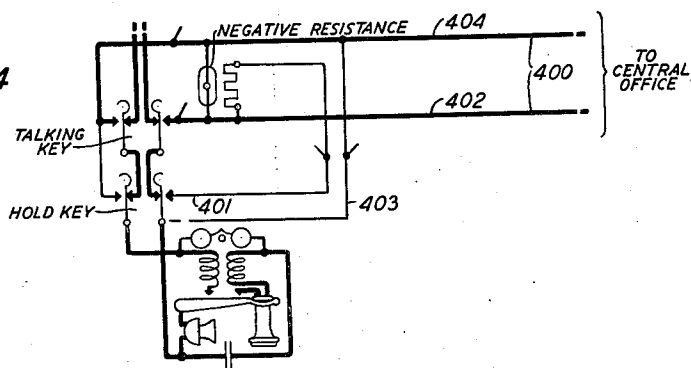


FIG. 4



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## UNITED STATES PATENT OFFICE

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## TELEPHONE SYSTEM

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7 Claims. (Cl. 179—42)

This invention relates to telephone systems and particularly to intercommunicating systems arranged for local and central office connections.

The objects of the invention are to simplify the circuits; to reduce the amount of equipment involved in setting up and maintaining conversational connections; to obtain improved transmission conditions for the established connections; and to secure other improvements and advantages in systems of this character.

It is common practice in intercommunicating systems to provide means whereby a subscriber can hold the central office line or trunk by establishing a holding bridge while he disconnects his telephone set from the line to converse with another station. For this purpose a third or holding conductor is extended to the subscriber's station, and a key is provided for operating a holding relay over this third conductor. Since the holding conductor is connected to one of the two talking conductors, the capacity between the holding conductor and other parts of the system adds to the capacity of the talking conductor to which it is connected. The result is that the capacity between one of the talking conductors and other parts of the system is greater than the corresponding capacity of the other talking conductor. This results in an unbalanced condition, which may produce noise or cross-talk. In the past this unbalanced condition, caused by the holding conductor, has been reduced by adding a fourth conductor to the group extending from the line equipment to the station, the only purpose of the fourth conductor being to add its capacity to one of the talking conductors and thereby maintaining a balanced condition between the two talking conductors.

According to the present invention advantages are obtained in systems of this kind by inserting in the third or holding conductor a resistance element which has a high normal resistance and which responds to the flow of current in said conductor to greatly lower its resistance and permit the flow of enough current to operate the relay that controls the holding bridge across the central office line. The holding conductor is thereby normally isolated from the other parts of the system, and its capacity does not add to the talking conductor to which it is joined. Thus the proper balance between the two talking conductors is maintained without the necessity of adding a fourth conductor to the group for this purpose. Any suitable substance having a high temperature coefficient of resistance, such as silver sulphide

and boron, may be used for the resistor connected in the holding conductor.

Another feature of the invention is a system in which the holding bridge across the talking conductors of the central office line consists of a variable resistor, which normally has a resistance sufficiently high to prevent the flow of any substantial current in the holding bridge, and which lowers its resistance in response to the flow of current through a heating winding connected in the control or holding conductor and energized under the control of the subscriber at the substation. The lowered resistance of the resistor in the bridge permits an increased flow of current over the trunk to hold the connection at the central office and prevent the display of the disconnect signal while the substation is disconnected from the line. Also the holding or control conductor may be opened after the resistance of the bridge has been lowered, and the bridge maintains its low resistance by reason of the heating effect of the current flowing over the trunk from the central office through the resistance element. When the substation set is again connected across the talking conductors in parallel with the holding bridge, its shunting effect on said bridge reduces the current flowing through the resistor, causing the latter to increase its resistance to its normal high value. The bridge when in its high-resistance state does not appreciably shunt the talking current from the telephone set at the substation. With this arrangement the holding circuits for the central office trunk are greatly simplified, and relays which have heretofore been required may be eliminated.

The foregoing and other features of the invention will be described more fully in the ensuing specification and also in the appended claims.

In the drawings accompanying the specification:

Fig. 1 discloses a part of an intercommunicating system including a subscriber's station, a line interconnecting the subscriber's premises with the central office, and a portion of the operator's equipment at the central office. In this figure the holding conductor is provided with a variable resistor and the balancing conductor is eliminated.

Fig. 2 shows a modification of the holding circuits in which resistors are included in the holding conductor, and the balancing conductor and the supervisory relay are eliminated;

Fig. 3 illustrates a modification in which the holding bridge includes a variable resistor, and the balancing conductor is eliminated by provid-

ing a variable resistor in the holding conductor; and

Fig. 4 is a modification similar to that in Fig. 3 in which the balancing conductor is employed in lieu of a variable resistor in the holding conductor.

Intercommunicating systems of the kind to which the present invention is particularly applicable are, in general, well known in the art. They usually comprise a number of stations located in the same building or premises and are provided with keys and interconnecting circuits whereby any one of the stations may call any other station by depressing the proper key and signaling the wanted party over any suitable signaling circuit. Moreover, there is usually provided one or more central office lines extending to the central telephone office where connections may be established by the operator with other telephone subscribers in the central office. One of the requirements for these systems is that after any one of the stations has been connected to the line the party at such station may establish a holding condition on the trunk, to prevent display of a release signal at the central office, while he disconnects his station therefrom and communicates independently with some other station on the same premises. Thereafter any one of the stations may reestablish connection with the line and remove automatically the holding condition thereon. A system of this general character is disclosed in the drawings and reference may now be had thereto for an understanding of the invention and of the manner in which it is applied to these systems.

Referring first to Fig. 1, there is here disclosed one of the several stations 100 of the intercommunicating system, one of the central office lines 101 extending to the central office and there terminating in a jack circuit, and a part of one of the central office operator's cord circuits 102. The subscriber's station 100 is provided with keys for connecting the station with any one of the other local stations in the system. One of these keys, key 103, serves to connect the station 100 with another station (not shown) by way of line 104. Also the subscriber's station 100 is provided with a talking key 105 for making connections with the central office line 101. The trunk 101 is equipped at the subscriber's premises with a holding relay 106, which serves to establish a holding bridge across the tip and ring conductors of the trunk 101, with a supervisory relay 107, and with a variable resistor 108, the purpose of which will be described more fully hereinafter. The line 101 terminates at the central office in jack 109 and in the usual line circuit equipment including line relay 110, cut-off relay 111 and calling lamp 112. The operator at whose position the jack 109 appears makes connections with cord circuits, such as cord 102.

The relay equipment at the subscriber's premises, including relays 106 and 107, may be located at a considerable distance from the different substations in the intercommunicating system. This equipment is individual to the line 101, and the line is common to all or, at least, to a plurality of the subscribers' stations. The multiples of the tip, ring, and hold conductors are extended from the common relay circuit of the line 101 to each of the several substations having access to this line. The drawing shows these multiple conductors 113, 114 and 115 extending from the common relay equipment to the sta-

tion 100. There is also illustrated another set of multiple conductors 116 which may extend to a second substation. The multiple conductors 113, 114 and 115 and, likewise, those of other substations may be of considerable length, and, as hereinbefore explained, there may be an appreciable capacity between each of the talking conductors 113 and 114 and other parts of the system, such as the grounded elements. Similarly there will be a capacity between the hold conductor 115 and the grounded parts of the system. And, this hold conductor 115, being connected through the hold relay 106 to the talking conductor 114, adds its capacity to that of the conductor 114. This means that the capacity of conductor 114 to ground exceeds that of the conductor 113, and the result is that the talking circuit extending to the substation 100 is unbalanced. In the past this difficulty has been met by including in the group of conductors 113, 114 and 115, extending from the common relay equipment to the substation, a fourth conductor which is connected to the talking conductor 113 for the purpose of adding its capacity to that of said conductor 113. In this way the capacities of the conductors 113 and 114 are substantially balanced. The extra conductor is illustrated by the dotted line 117.

According to the present invention the necessity of using an auxiliary or dummy conductor is obviated by the novel use of a variable resistor in the circuit of the hold conductor 115. To this end a resistor 108 of some material, such as boron or silver sulphide, having an extremely high negative temperature coefficient of resistance is connected in the hold conductor 115, as shown in Fig. 1. When the circuit is normal and no current is flowing in conductor 115, the resistance of the element 108 is so high that it substantially isolates the conductor 115 from the ring conductor 114 of the talking circuit. Thus the capacity of the conductor 115 is disassociated from the conductor 114 and is not effective to unbalance the capacities of conductors 113 and 114. When, however, it is desired to take the hold conductor 115 in use, the resistance of the element 108 is lowered automatically, as will be presently described, to permit the flow of current and the operation of the hold relay 106.

Before taking up the other modifications of the invention illustrated in Figs. 2, 3 and 4, a brief description will be given of the operation of the circuits shown in Fig. 1. The calling subscriber at substation 100 may, of course, call any other subscriber in the intercommunicating system by manipulating the proper key and by signaling the wanted subscriber with the signaling circuits usually provided in systems of this kind. For example, he may call the subscriber over the circuit 104 by operating the key 103.

Should the subscriber at station 100 wish to make a call to the central office, he manipulates his talking key 105, and a circuit is established from battery through the winding of relay 110, contact of cut-off relay 111 over the ring conductor of the line 101 through the supervisory relay 107, multiple conductor 114 extending to the subscriber's station, contact of key 105, closed contact of key 106, through the subscriber's loop and returning through contact of keys 106 and 105 to the multiple conductor 113, thence over the tip conductor of the line through contact of relay 111 and the other winding of the line relay 110 to ground. The line relay operates and lights the calling lamp 112. The operator answers by inserting the plug 118 of her cord circuit 102 in

the jack 109. This closes an obvious circuit over the sleeve conductors of the cord and line for operating the cut-off relay 111. Relay 111 disconnects the line relay 110 and the talking circuit between the operator's cord and the calling station is now supplied with battery from said cord. The supervisory relay 119 in the operator's cord and also the supervisory relay 107 operate. Relay 119 short circuits the lamp 120 to prevent it from illuminating. The operator completes the connection to the desired called party, and conversation may then take place.

After the parties have finished conversing, the subscriber at station 100 may release the connection by releasing his talking key 105. This opens the circuit for the supervisory relays 107 and 119. Relay 119 removes the shunt from the supervisory lamp 120, and this lamp lights to give the operator the disconnect signal. She then takes down the connection by removing the plugs of the cord circuit.

Should the party at station 100, after having obtained connection with the central office operator, wish to retire from the line 101 to converse with another party in the intercommunicating system or for any other reason, he may do so without giving the central office operator the disconnect signal. To hold the line 101 in a case of this kind, the party at station 100 operates his hold key 106. This completes a circuit from battery in the operator's cord circuit 102, thence over the ring side of the connection as previously traced through the winding of hold relay 106, through the resistor 108, multiple conductor 115, closed contacts of key 106, through the subscriber's loop, closed contacts of key 106, thence over multiple conductor 113 and the other side of the trunk circuit to ground in the operator's cord circuit 102. Although the resistance of this circuit is normally of a high value the presence of current therein heats the resistor 108, progressively lowering its resistance and permitting the increased flow of current. Finally the resistance of unit 108 drops to a low value, and relay 106 operates. Relay 106 in operating closes a bridge across the tip and ring conductors of the line 101. This bridge may be traced from the tip conductor through the resistance 121, contact and winding of relay 106 to the ring conductor of the line. Battery current flowing from the central office cord circuit through this bridge holds the relay 106 operated and also holds the supervisory relay 119 in said cord. The party at station 100 now releases the hold key 106 and proceeds to establish connection with the desired local party.

The keys at the substation 100 are usually arranged so that the depression of the hold key 106 unlocks any previously operated talking key. Preferably the hold key 106 is of the non-locking type and restores to its normal position as soon as it is released by the subscriber. Upon the establishment of the holding bridge and the release of talking key 105 the supervisory relay 107 releases its armature. After the subscriber 100 has finished conversing with the local party he or any other party in the communicating system may take up the held line 101 by reoperating the talking key. If the party 100 returns to the connection, his operation of the talking key 105 recloses the tip and ring conductors of the line through the substation loop. This causes the reoperation of supervisory relay 107, and this relay closes a shunt around the winding of relay 106. This shunt may be traced from the ring conductor of the trunk through the contact of

relay 107, contact of relay 106, and resistance 121 to the tip conductor of the line. Relay 106 releases and opens the holding bridge across the line. The trunk is now restored to its conversational condition, and the party at station 100 may converse either with the operator or with a subscriber to whom the connection has been extended through the central office.

The line circuit 200 illustrated in Fig. 2 resembles that of Fig. 1, except that the supervisory relay has been eliminated and a second variable resistance unit has been added. The resistance units 201 and 202 connected in the hold conductor 203 serve to isolate that conductor from the ring conductor 204 of the trunk, thus obviating the necessity of the balancing conductor 205 indicated in dotted lines. Assuming that the subscriber at station 206 wishes to establish a holding condition, he manipulates his hold key 207. This closes a circuit from battery in the central office cord over the ring conductor 204 through the winding of hold relay 208, resistors 201 and 202, hold conductor 203, contacts of key 207, through the loop 206, contacts of key 207, thence over the tip conductor 209 to ground at the central office. The resistors 201 and 202 lower their resistance and permit sufficient current to flow to operate the hold relay 208. Relay 208 closes a bridge across the trunk from conductor 204 through the winding of said relay, resistor 201, contact of said relay to the other conductor 209. The relay 208 and the supervisory relay of the cord are held in this circuit. The release of the hold key 207 opens the circuit of the resistor 202, and this resistor returns to its normal high resistance. The high resistance of unit 202 under these conditions isolates the hold conductor 203 from the talking conductor 209 to which it is connected through the contact of the hold relay 208. Thus the capacity of the hold conductor 203 is not added to that of the talking conductor 209. When the subscriber at station 206 wishes to reestablish connection with the line 200, he reoperates the talking key 210. A circuit is now closed from battery in the cord circuit, over ring conductor 204 through contacts of key 210, closed contacts of the hold key 207 through the substation loop, contacts of keys 207 and 210, thence over the conductor 209 to ground at the central office. This circuit shunts the resistor 201, which restores its normal high resistance and decreases the flow of current through the bridge circuit to the point where relay 208 releases.

In the modification shown in Fig. 3 the holding bridge is connected permanently across the tip and ring conductors of the line 300. This bridge includes the variable resistor 301, which has a normal high resistance. The resistor 301 is equipped with a heating coil 302 for the purpose of lowering its resistance when current flows through said coil. The coil 302 is connected in the hold conductor 303, and a second unit 304 is connected in the hold conductor to isolate this conductor from the talking conductor 305, thereby eliminating the necessity of using the balance conductor 306 to balance the capacity of the other talking conductor 307. Assuming the subscriber at station 308 wishes to establish a holding condition on the line 300, he manipulates his hold key 309 and thus completes a circuit from central office battery over conductor 305 through the heating coil 302, resistor 304, conductor 303, thence through contacts of the hold key 309 and the substation loop 308 and the talking conductor 307 to ground at the central office. Current flow-

ing through the unit 304 lowers its resistance to permit greater current to flow through the heating winding 302. The heat generator by winding 302 lowers the resistance of the unit 301, and more and more current flows through the bridge across the conductors 305 and 307. The increased current flowing through the bridge by reason of the lowered resistance of unit 301 is sufficient to hold the supervisory relay in the operator's cord circuit to prevent the display of a disconnect signal. When the hold key 309 is released by the party at station 308, the resistance of unit 304 assumes its normal high value, and the hold conductor 305 is thereby isolated from the talking conductor 305. Although the heating effect of the coil 302 is now removed, the unit 301 maintains its low resistance by reason of the continued flow of current through the bridge. When the party at station 308 again operates the talking key 310, a low resistance shunt is placed around the bridge unit 301 through the substation loop. This reduces the current flowing through the bridge, and the unit 301 restores to its high resistance, thereby permitting substantially all of the current from the central office battery to flow through the subscriber's loop, placing the control of the operator's supervisory relay with the substation switchhook.

The circuit in Fig. 4 is much the same as that disclosed in Fig. 3, except that the variable resistance unit is not provided in the hold conductor. The capacity of the hold conductor 401 is therefore added to the talking conductor 402 of the trunk 400, and it may be desirable to balance this capacity by adding a balancing conductor 403, which is connected as shown to the other talking conductor 404. The operation of the circuit shown in Fig. 4 is substantially the same as that of Fig. 3.

The resistors used in the circuits of these systems may be of any suitable type, such as those disclosed in the British Patent No. 472,144, accepted Sept. 17, 1937.

What is claimed is:

1. The combination in a telephone system of a subscriber's station, a central office line serving said station, switching means for connecting the talking conductors of said central office line to said station, a bridge circuit for bridging the talking conductors of said central office line, a variable-resistance element associated with said bridge, a control conductor extending to said station, and means at said station for establishing a circuit over said control conductor to alter the resistance of said variable element to render said bridge effective for holding a connection over said central office line.

2. The combination in a telephone system of a subscriber's station, a central office line serving said station, means for connecting said station to the central office line, a bridge circuit for bridging the talking conductors of said central office line, a variable-resistance element associated with said bridge, a control conductor, means controlled by the subscriber at said station for causing current to flow over said control conductor to lower the resistance of said element to render said bridge effective for holding a connection over

the central office line, and means for disabling said holding bridge.

3. The combination in a telephone system of a plurality of stations, a central office line for serving said stations, switching means for connecting any station to said central office line, a control conductor for said line having branches extending respectively to said stations, a variable-resistance element included in said control conductor, a bridge for bridging the talking conductors of said line, and circuit means controlled from any one of said stations and including the corresponding branch of said control conductor for altering the resistance of said variable-resistance element to render said bridge effective for holding a connection over said line.

4. The combination in a telephone system of a subscriber's station, a central office line serving said station, switching means for establishing connections between the station and said line, a bridge circuit for bridging the talking conductors of said line, a control conductor having a variable-resistance element therein, means at said station for establishing a circuit over said control conductor to change the resistance of said element, and relay means operable in response to a change in the resistance of said element for closing said bridge to hold a connection over said line.

5. In a telephone system, a subscriber's station, a line, switching means for establishing connections between said station and said line, a holding bridge extending between the talking conductors of said line, a control conductor extending to said station, a resistor in said control conductor having a normal high resistance, means at said station for establishing a circuit including said control conductor to lower the resistance of said resistor, and relay means operable in response to an increased flow of current resulting from the lowered resistance of said resistor for closing said bridge to hold a connection on said line.

6. In a telephone system, a subscriber's station, a line circuit, switching means for establishing connections between said station and said line, a bridge extending between the talking conductors of said line, a variable-resistance element in said bridge, and means at said station for altering the resistance of said element to render said bridge effective to hold a connection on said line.

7. The combination in a telephone system of a central office, a substation, a line extending to said central office, switching means for establishing connections between said station and said central office, supervisory means and a source of current at said central office, a bridge across the conductors of said line, a variable-resistance element in said bridge having a normal high resistance, means at said station for controlling said supervisory means when the station is connected to said line, means at said station for lowering the resistance of said element to permit current to flow through said bridge from said central office source, and means responsive to the flow of current through said bridge for preventing the operation of said supervisory means.

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