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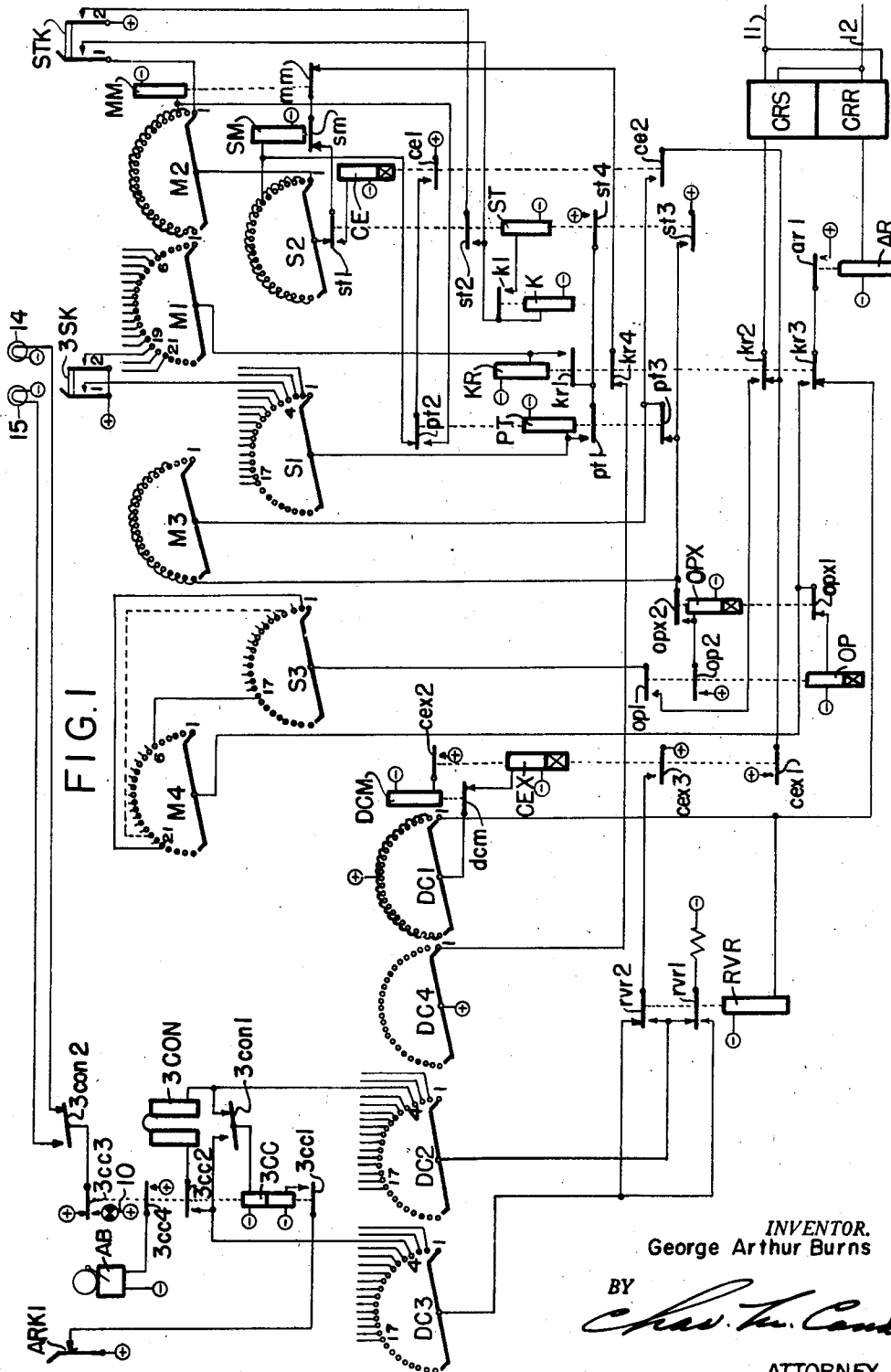
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REMOTE CONTROL AND SUPERVISORY SYSTEM

Filed Feb. 7, 1941

2 Sheets-Sheet 1



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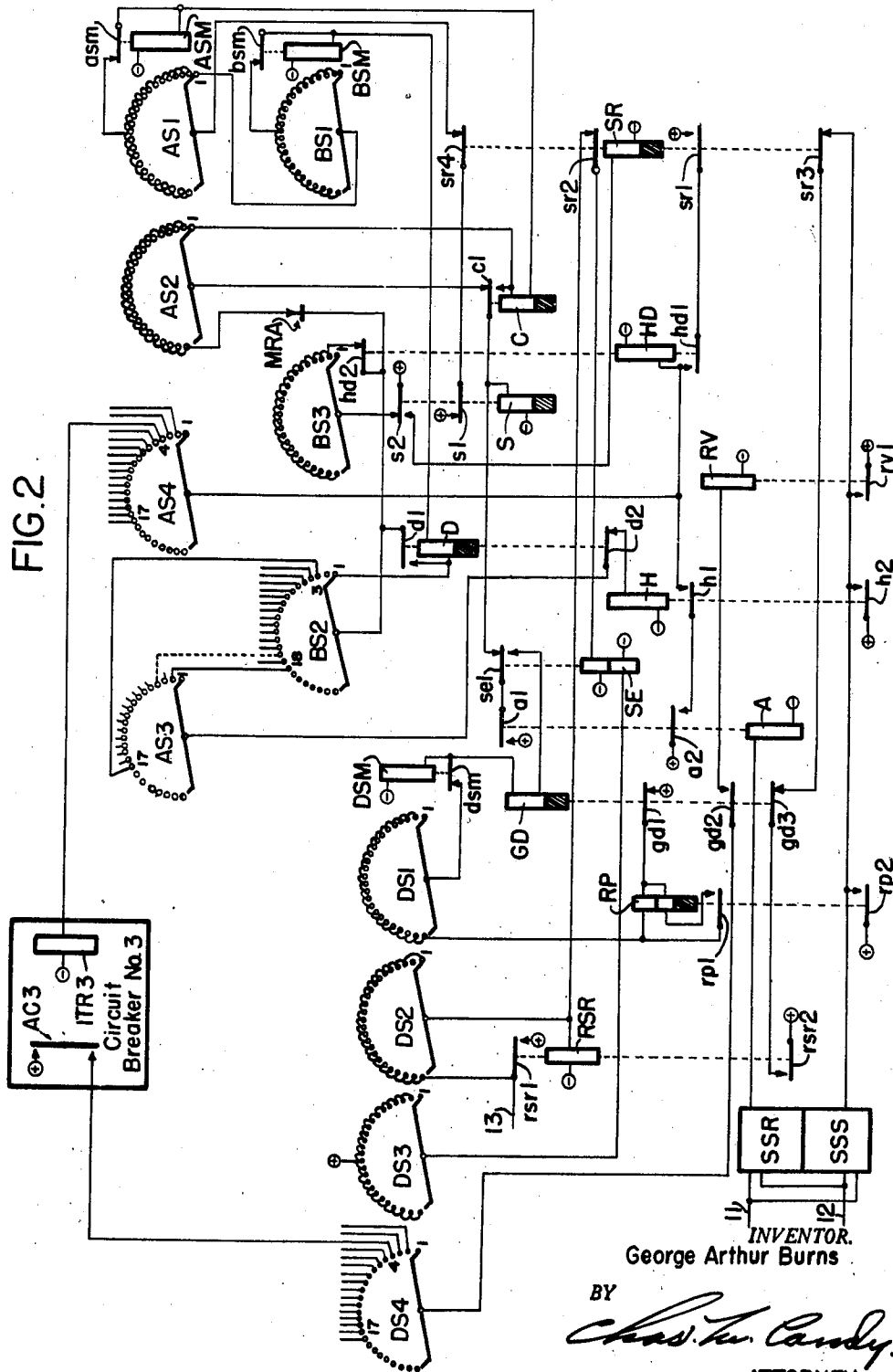
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REMOTE CONTROL AND SUPERVISORY SYSTEM

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2 Sheets-Sheet 2



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REMOTE CONTROL AND SUPERVISORY
SYSTEM

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7 Claims. (Cl. 177-353)

The present invention relates to improvements in systems for the remote supervision and/or control of electric power transmission equipment or the like and has for its general object the provision of an improved system of the above type in which the both-way signalling arrangements between a controlling and a controlled point are such as to allow ready use to be made of carrier or voice frequency signalling over an interconnecting line extending between these points.

In one known system of remote control of a number of pieces of apparatus such as circuit breakers located at a distant substation, two selecting switches are provided at the substation and are positioned in response to impulses transmitted from the controlling station over an interconnecting line. In order to check that these switches correctly respond to a signal train of control pulses, it is arranged that the number of impulses sent is constant regardless of the particular selection being effected, the signal consisting of two groups of pulses, one positive and the other negative. The total number of impulses in the two groups remains unaltered whatever the signal, but the number in each group varies according to the particular selection which is to be made. These two groups of impulses are received on two corresponding switches at the substation and if the exact complement of so many positive and so many negative pulses has been received, a checking and confirming circuit is completed which initiates the sending back of a "selection correct" signal to the control point to advise the attendant thereat that the selection has been made correctly.

Such a system can be operated readily when direct current signalling is employed, but if the circumstances are such that signalling is to take place over a carrier or voice frequency channel on the interconnecting line, the need for utilising two frequencies for signalling in each direction constitutes a distinct disadvantage.

According to one feature of the invention, in a remote control and supervisory system suitable for the control of circuit breakers or like devices at a substation in an electric supply network the selection of the required circuit breaker is effected and checked in response to the sending from the control station of two trains of alternating current impulses of similar type the total number of impulses in the two trains being the same whatever the selection.

According to another feature of the invention, in a remote control and supervisory system suitable for the control of circuit breakers or like

devices at a substation in an electric supply network, the control impulses for the selection and operation of the circuit breakers are of alternating current of one frequency while the check back and indicating signals sent to the control station are of alternating current of different frequency and are transmitted over the same interconnecting line circuit.

The invention will be better understood from the following description of one method of carrying it into effect, reference being had to the accompanying drawings comprising Figs. 1 and 2 which should be arranged side by side with Fig. 1 to the left of Fig. 2. These show suitable circuit arrangements at a control room (Fig. 1) and a substation (Fig. 2) by means of which the supervision and control of up to sixteen different pieces of apparatus at the substation can be effected over a single interconnecting line extending between the two points.

Considering now the details of the operation of the circuit, it will be understood that a separate selection key is provided at the control room for each piece of apparatus at the substation, and since in the present instance sixteen different pieces of apparatus are assumed to be provided for, there will be sixteen selection keys 1SK-16SK at the control room, only the contacts of a typical key 3SK being shown. The control room equipment also includes a common start key STK and three 25-point electromagnetically-operated reverse-drive rotary stepping switches. A pair of contacts on each of the selection keys 1SK-16SK is connected to the appropriate contacts in the banks S1 and M1 of two of the selecting switches S and M which together produce the signal impulses required for selection and control purposes. For reasons which will be appreciated later in the description, these key contact connections are made to contacts 2-17 respectively of switch bank S1 and to contacts 21-6 of switch bank M1, that is to say, in reverse order.

Assuming now that the control room operator wishes to select circuit breaker No. 3 at the substation, he depresses selection key 3SK whereupon at contacts 3SK1, contact 4 in the S1 bank is marked with positive potential and at contacts 3SK2 contact 19 in the M1 bank is marked with positive potential.

To initiate the selection, the start key STK is now operated at the control room, whereupon if all the rotary switches are normal relay K is operated over the following circuit: positive, wiper DC4 in position 1, contact kr4, interrupter contacts mm and sm, resting armature st1, wipers

S2 and M2 in position 1, contact STK1, relay K and negative. Relay K at armature k1 operates relay ST and both relays then lock up over contacts STK2 and st2 in series. Relay ST at armature st1 brings up relay CE (which is slow to operate and release) over the following circuit: positive, wiper DC4 in position 1, contact kr4, interrupter contacts mm and sm, operated armature st1, relay CE and negative. Relay CE, on operating, at armature ce1 completes an energising circuit over resting armature pt2 for magnet SM of switch S whereupon at the magnet interrupter contacts sm the initial energising circuit for relay CE is disconnected. Relay CE now releases and in so doing de-energises the magnet SM, whereupon, since the switch S is of the reverse drive type, the wipers are advanced to the next position 2. The magnet on releasing re-completes the operating circuit for relay CE whereupon the cycle of operations repeats itself. The interaction between relay CE and the magnet SM causes the wipers of the switch S to be advanced step-by-step round the banks at the rate of about ten steps per second. Relay CE impulses at the same speed and at armature ce2 applies positive impulses over armatures st3, pt3, ce2 and kr2, to the control room carrier or voice frequency sender CRS which may be of any suitable design and from which are delivered carrier or voice frequency impulses which extend over the interconnecting line conductors 11 and 12 to the substation receiver SSR, Fig. 2. The local receiver CRR, will not be responsive to these impulses as it will be tuned to respond only to signals of the different frequency employed for signals transmitted from the substation.

When the voice frequency or carrier impulses are received at the substation, they are translated by the receiver SSR into direct current impulses which operate relay A and this in turn at armature a1, steps the magnet ASM of switch AS over the following circuit: positive, contact a1, resting armatures se1 and c1, wiper AS2 in position 1, relay C, magnet ASM and negative. Relay C also operates on the first impulse and due to its slug remains operated during the train in series with the magnet ASM so that at armature c1 it maintains a circuit for the magnet independently of wiper and bank AS2. Relay S is also operated from the A relay pulses and being slow remains energised throughout the train. At armature s2 it operates a relief relay SR which is also slow and these relays at armatures s1 and sr4 hold open the homing circuit of the switches AS and BS.

In the present instance since it is assumed that key 3SK is operated, when three impulses have been transmitted from the control room and the switch S thereat has been stepped to position 4, positive will extend over contacts 3SK1, and wiper S1 in position 4 to operate relay PT which locks over its armature pt1 in series with contact st4. At armature pt2 it switches over the CE relay pulsing circuit to the magnet MM of the M switch and at armature pt3 it disconnects the impulsing circuit to the control room sender CRS so that the outgoing pulses cease. Switch M now steps round under control of relay CE but no further operations result until its wipers reach position 4. During this time relay C at the substation will have released and thus at armature c1 prepared an impulsing circuit for the magnet BSM of the second switch BS, but it will be

understood that relay SR will not release during this inter-digital pause.

Returning again to the control room, when switch M reaches position 4, the following circuit is completed over bank and wiper M3 for connecting positive to the control room sender CRS: st3, wiper M3 in position 4, contact ce2, and resting armature kr2. Accordingly, while the M switch is stepping on to subsequent positions, impulses are again sent out over the line to the substation, these impulses being of the same kind and being transmitted in the same manner as the previous set of impulses. This time, however, switch BS at the substation responds instead of switch AS, since each time the relay A operates, positive is extended over armatures a1, se1 and c1, wiper and bank AS2, rectifier MRA in a conductive direction, and wiper BS2 in position 1 to energise relay D in series with magnet BSM. Relay D operates and performs similar functions to relay C by maintaining the magnet circuit after the switch BS moves off-normal.

After fifteen further steps of the switch M by which time its wipers will have reached position 19, relay KR, Fig. 1, is operated over the M1 wiper and bank from positive applied by contacts 3SK2 of key 3SK. Relay KR locks up over its armature kr1, at armature kr2, cuts off the pulsing circuit, at armature kr3 prepares the operating circuit and at armature kr4 interrupts the circuit for relay CE so that the switches M and S remain in the positions to which they have been set.

The complete signal train will therefore have consisted of three plus fifteen impulses with an interval between the two portions and switch AS will have been set to position 4 and switch BS to position 16.

The positions to which the switches S and M at the control room and AS and BS at the substation will be set in response to the operation of the various keys 1SK-16SK together with the particular signal trains transmitted in response to the operation of each key will be appreciated from the following table:

Key	S	M	AS	BS	Pulses
1SK	2	21	2	18	1-17
2SK	3	20	3	17	2-16
3SK	4	19	4	16	3-15
4SK	5	18	5	15	4-14
5SK	6	17	6	14	5-13
6SK	7	16	7	13	6-12
7SK	8	15	8	12	7-11
8SK	9	14	9	11	8-10
9SK	10	13	10	10	9-9
10SK	11	12	11	9	10-8
11SK	12	11	12	8	11-7
12SK	13	10	13	7	12-6
13SK	14	9	14	6	13-5
14SK	15	8	15	5	14-4
15SK	16	7	16	4	15-3
16SK	17	6	17	3	16-2

For the purpose of checking and confirming the receipt of the correct total number of impulses at the substation, contacts 2-17 in bank AS3, of switch AS are cross-connected to contacts 18-3 (i. e. in reverse order) in bank BS2 of switch BS. Hence, if the eighteen pulses comprising the train have been correctly received, when relays D and S restore shortly after the end of the train, a circuit is completed from positive, armature s2, wiper and bank BS3, armature hd2, banks and wipers BS2 and AS3 and contact d2 to operate relay H. Relay H thereupon at armature h2, starts up the substation carrier or voice frequency sender SSS and this sends the "selection correct" signal comprising an impulse of carrier or voice

frequency to the control room, the frequency employed being different from that used for transmitting forward from the control room.

The control room receiver CRR, responds and operates relay AR which at its armature *ar1* brings up relay OP over operated armature *kr3* and armature *opr1*. Relay OP in turn energises the slow-to-operate relay OPX. At the same time at armature *opi* positive is extended over contact *ar1*, operated armature *kr3*, wiper M4 in position 19, wiper S3 position 4, (the bank contacts associated with these two wipers being cross-connected as shown in the table under the headings S and M contact *opi* and operated armature *kr2* to the control room transmitter CRS which accordingly transmits a further impulse of its own carrier frequency to the substation so as to bring about a changeover in the position of the selected device.

At the substation the receiver SSR in responding to the changeover signal from the control room again operates relay A and this relay then at armature *a1* re-energises relay S. The latter relay upon operating opens the above-traced circuit for relay H at contact *s2*, but relay H does not restore, since relay A has completed the following holding circuit for relay H: positive, contact *a1*, resting armatures *se1* and *c1*, wiper AS2 in position 4, rectifier MRA, wiper BS2 in position 16, wiper AS3 in position 4, contact *d2*, relay H and negative. It will be understood that the release lag of relay SR is such as to enable it to hold during the transmission of the signals in the two directions and it therefore continues to hold open the AS and BS switch homing circuits. Relay A also at armature *a2*, connects up positive over contact *h1* to operate relay HD, and this positive is also extended over wiper and bank AS4 so that in accordance with the position of the switch AS the one of the sixteen interposing relays ITR1—I TR16 associated with the particular piece of apparatus it is desired to control is operated. These interposing relays are connected as shown to contacts 2-17 of bank AS4 and the switch AS is positioned to correspond with the operated one of the distant selection keys 1SK-16SK.

In the present instance the third interposing relay will be operated so that circuit breaker No. 3 associated therewith will be caused to take up a new position, an indication of which will be transmitted back to the control room in a manner to be subsequently described to advise the attendant thereof that the desired changeover has been carried into effect.

Returning again to the control room, when relay OPX, Fig. 1, operates, relay OP is released by armature *opi1* and at armature *opi* terminates the transmission of the changeover signal from the sender CRS so that relay A at the substation releases. Relay S (Fig. 2) therefore commences to release slowly due to its slug, while relay H is released immediately. On the release of relay S, relay SR commences to release in turn and when it does so, the holding circuit for relay HD, is disconnected and positive is connected over contacts *s1* and *sr4* to wiper AS1, so as to complete a self-interrupted driving circuit for magnet ASM via wiper and bank AS1 and the interrupter contacts *asm* and so restore the switch AS to its home position 1. When this occurs, the positive is extended through to wiper BS1 whereupon switch BS also drives through to its home position.

When the start key STK at the control room is restored, relays K, ST, PT, KR and OPX release and a homing circuit is completed from positive over wiper and bank DC4, armature *kr4*, contacts *mm* and *sm*, and armature *st1* and thence via banks and wipers S2 and M2, to restore the switches S and M in turn to their home positions in readiness for further use.

It should be explained that a change in position of any of the devices at the substation, either due to the remote control already described or as a result of local conditions thereat, brings about the application of a momentary positive to lead 13, Fig. 2, which operates relays RSR and SE over bank and wiper DS2. The operation of relay SE is dependent on the normal condition of relay SR so that as long as relay SR is operated, e. g. until the conclusion of a selection operation, the operations about to be described will be deferred and will only take place when relay SR releases at which time relay SE is able to operate from the locking armature *rsr1* of relay RSR. When relay SR releases, a circuit is also completed over armatures *rsr2*, *gd3* and *sr3* for operating the substation sender SSS so as to energise relay AR at the control room. Relay AR at armature *ar1* thereupon completes a circuit over resting armature *kr3* to bring up relay RVR and also completes a circuit for relay CEX over resting armature *kr3*, wiper DC1 in position 1 and interrupter contact *dcm*. Relay CEX at armature *ce2* now interacts with the magnet DCM of the switch DS to step the switch and also to produce over armature *ce1* and resting armature *kr2* a train of impulses in the same manner as described in connection with switches S and M, these impulses being transmitted forward to the substation from the control room sender CRS. In this case the impulses received on relay A at the substation are repeated at contact *a1* over operated armature *se1* and low resistance relay GD to magnet DSM of the switch DS, relay GD operating and holding in series therewith during the train. Relay GD at armature *gd1*, opens the homing circuit of the switch DS, at armature *gd2*, connects relay RV to wiper DS4 and at armature *gd3* disconnects the start potential from the substation sender SSS so that relay RVR is released. When wiper DS2 reaches contact 2, relay RSR is released and cannot re-operate as the start positive connection received over lead 13 is only momentary; relay SE however holds operated over its lower winding and wiper and bank DS3.

As the switch DS is stepped round in synchronism with the switch DC at the control room, wiper DS4 will encounter positive on some of the contacts of the bank and will encounter no potential on other contacts in accordance with the state of the various devices at the control room, since each of the sixteen devices is provided with a pair of indicating contacts AC1-AC16 which connect up with contacts 2-17 of the bank DS4 and which extend positive thereto if they are in the operated position.

At the control room, pairs of corresponding contacts in the banks DC2 and DC3 are connected up to two-coil magnetic locking relays 1CON-16CON, which serve to control the indicating of the normal or operated condition of the various substation devices. These relays 1CON-16CON respectively have associated therewith a set of relays 1CC-16CC. Whenever wiper DS4, Fig. 2, encounters positive, relay RV is operated and initiates the sending out of a signal from sender

SSS to receiver CRR so as to bring up relay AR at the control room. Each time relay AR operates, relay RVR is operated and this at armature *rvr1* and *rvr2* reverses the potentials extended to wipers DC2 and DC3.

Assuming for example that devices Nos. 1 and 2 at the substation are in a tripped condition and have not altered their condition while device No. 3 has been moved from the tripped to the closed condition in response to the previous control signal, then with the wipers of switch DS in positions 2 and 3 no signal will be sent back to operate relays AR and RVR at the control room, and the relays 1CON and 2CON connected to contacts 2 and 3 respectively of banks DC2 and DC3 will therefore remain in the positions to which they have previously been set, i. e. with their armatures in the position shown for relay 3CON and the relays ICC and 2CC will be unresponsive. Corresponding "circuit breaker open" indicating lamps such as 14 will be lit to indicate the tripped condition of the distant circuit breakers. If these circuit breakers had been in the operated position and had not changed position, the relays CON would have remained in an operated position so as to light lamps such as 15 corresponding thereto and indicating the operated condition thereof but again relays ICC and 2CC would not have been operated.

When the switch DS at the substation reaches position 4, relay RV is operated and brings about the operation of relays AR and RVR at the control room so that the battery connections to wipers DC2 and DC3 are reversed thereby indicating that circuit breaker No. 3 has changed its position. Relay 3CON associated therewith and connected to contacts 4 in banks DC2 and DC3 occupies the position shown and relay 3CC will therefore now be operated. Relay 3CC thereupon at armature 3cc2 connects relay 3CON to the operating battery and this relay is now energised in the reverse direction and moves over to its other position after which it remains magnetically locked. Relay 3CC also locks over armature 3cc1 and contacts ARK1 of a common alarm reset key ARK and at armature 3cc4 completes a circuit for an alarm bell AB. At the same time at armature 3cc3 it connects up interrupted positive over common lead 10, armatures 3cc3 and 3con2 to the "circuit breaker closed" indicating lamp 15 so that the attendant will have his attention called to the fact that the circuit breaker in question has been changed over from the tripped to the closed position. These conditions remain until the alarm is acknowledged by the operation of the reset key ARK whereupon relay 3CC releases and at armature 3cc3 alters the flicker indication to a steady glow. When the switches DC and DS reach their home position their operation is terminated and all relays previously operated will now restore. It will be noted that the transmission of the indicating signalling train takes place regardless of whether the start key has been restored or not.

If the indication impulse train is in any way mutilated, the switch DS will not finish its operation on its home contact and hence on the release of relay GD at the end of the train, positive will be supplied via relay RP, and bank and wiper DS1 to drive switch DS through to the home position. Relay RP operates and holds during this time and at armature *rp2* initiates the sending of a further pulse back to the control room which produces the same effect as the initial pulse from relay RSR so that the impulse train

will be repeated until it is correctly received at the control centre.

In case during the initial control operations the impulse train is in any way mutilated, it will not be possible to complete a circuit for relay H through banks and wipers BS2 and AS3, at the substation and the "selection correct" signal will not be sent back to the control room. On the release of relays S and SR in turn at the end of the train, the switches AS and BS will be restored to their home position without having extended any signal to the interposing relays. The indications at the control room will moreover not be changed so that the attendant will realise that the control signals have been prevented from performing their function and he will therefore reset up the selection.

In case during the sending out of indication signals as a result of the change in position of one substation device another device should also change position, relay RSR will be re-operated and will remain locked at the end of the train over bank and wiper DS2. When relay GD releases, the substation sender will therefore be started up again and the cycle will be repeated and will this time include the change to the second device.

Referring to Fig. 2, it will be appreciated that the function of the rectifier MRA is to prevent the positive potential, which is fed over resting armature *s2*, wiper and bank BS3 and armature *hd2* to operate relay H after a selection operation, from extending backwardly and bringing about the re-operation of relay S which would thereupon cut its own circuit and proceed to chatter.

From the foregoing description it will be seen that the invention provides an efficient method of utilising medium or high frequency alternating current signals for remote supervisory control and employs a minimum of different frequencies, namely, one frequency only for signalling in each direction by virtue of the particular method of signal train checking which is employed.

I claim:

1. In combination, a signalling circuit having an input and an output, one device at the input of said circuit, another device at the output of said circuit, means for generating a plurality of impulse trains, each train having a variable number of impulses, and for impressing said trains upon the input of said circuit, a receiver linked to the output of said circuit for responding to said impulses, means effective after the last of said impulse trains has been received for determining if the total number of received impulses in all of said trains equals a predetermined number and, if it does, for automatically operating said one device, and means rendered effective responsive to the operation of said one device for determining if the total number of impulses impressed upon the input of said circuit equals said predetermined number and, if it does, for automatically operating said other device.

2. In combination, a signalling circuit having an input and an output, one device at the input of said circuit, another device at the output of said circuit, means for impressing a series of impulses upon the input of said circuit, a receiver linked to the output of said circuit for responding to said impulses, means effective after all of the impulses have been received for determining if the received impulse series comprised a predetermined total number of impulses and, if it did, for automatically operating said one device, and means rendered effective responsive to the opera-

tion of said one device for determining if the series of impulses impressed upon said input comprised a predetermined total number of impulses and, if it did, for automatically operating said other device.

3. In a remote control system, two stations connected by a signalling circuit, means at one of said stations for generating two trains of impulses and impressing them upon said circuit, a plurality of devices at the other of said stations, means at said other station controlled by said impulses for selecting one of said devices, other means at said other station controlled by said impulses for transmitting a signal to said one station only if the total number of impulses received in both of said trains equals a predetermined number, means at said one station operated responsive to said signal for thereupon transmitting a signal to said other station only if the total number of impulses in both of the trains impressed upon said circuit also equals said predetermined number, and means at said other station for operating the selected one of said devices responsive to said last signal.

4. In a remote control system, two stations connected by a signalling circuit, means at one of said stations for generating two trains of impulses and impressing them upon said circuit, said means including a first switch operated in accordance with the number of impulses in one of said trains and a second switch operated in accordance with the number of impulses in the other of said trains, a third switch and a fourth switch at the other of said stations, means at said other station responsive to said impulses for operating said third switch in accordance with the number of impulses in one of said trains and operating said fourth switch in accordance with the number of impulses in the other of said trains, means controlled by said third and fourth switches, if the total number of impulses in the two trains received at said other station is a predetermined number, to transmit a signal over said circuit to said one station, means at said one station controlled by said first two switches if the total number of impulses in the two trains impressed upon said circuit was a predetermined number for transmitting a signal to said other station responsive to the receipt of said signal from said other station, and means in said other station operated responsive to the signal transmitted by said last means.

5. In a remote control system, two stations connected by a signalling circuit, two switches at one of said stations, means for operating one of said switches step-by-step, means operated under control of said first switch after it has taken a variable number of steps for halting said operation of said first switch and initiating the operation of the second of said switches step-by-step, means for halting said operation of said second switch after a variable number of steps, means

controlled by said first switch during its operation for impressing upon said signalling circuit an impulse train depending upon the number of steps taken by said first switch, means controlled by said second switch during its operation for impressing upon said signalling circuit an impulse train depending upon the number of steps taken by said second switch, a plurality of devices at the other of said stations, means at said other station for responding to said impulses transmitted over said signalling circuit and in accordance therewith selecting one of said devices, other means at said other station controlled by said impulses for transmitting a signal to said one station only if the total number of impulses received in both of said trains equals a predetermined number, means at said one station operated responsive to said signal for thereupon transmitting a signal to said other station only if the total number of impulses in both of the trains impressed upon said circuit also equals said predetermined number, and means at said other station for operating the selected one of said devices responsive to said last signal.

6. A remote control system as claimed in claim 5, wherein said means controlled by said second switch is effective to begin impressing impulses upon said signalling circuit only after said switch has taken a predetermined number of steps, thereby to cause the second impulse train to be separated from the first by a pause.

7. In a remote control system, two stations connected by a signalling circuit, means at one of said stations for generating two trains of impulses and impressing them upon said circuit, each of said impulses comprising alternating current of a predetermined frequency, a plurality of devices at the other of said stations, a receiver at said other station responsive only to alternating current of said frequency, means controlled by said receiver for selecting one of said devices in accordance with the number of impulses received in one of said two trains, other means at said other station controlled by said receiver for transmitting an alternating current signal of a different frequency to said one station only if the total number of impulses received in both of said trains equals a predetermined number, a receiver at said one station responsive only to alternating current of said other frequency, means under the control of said last receiver operated responsive to the receipt of said signal by said last receiver for thereupon causing an alternating current signal of said predetermined frequency to be transmitted to said other station only if the total number of impulses in both of the trains impressed upon said circuit also equals said predetermined number, and means at said other station controlled by said first receiver for operating the selected one of said devices responsive to said last signal.

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