

**Jan. 27, 1931.**

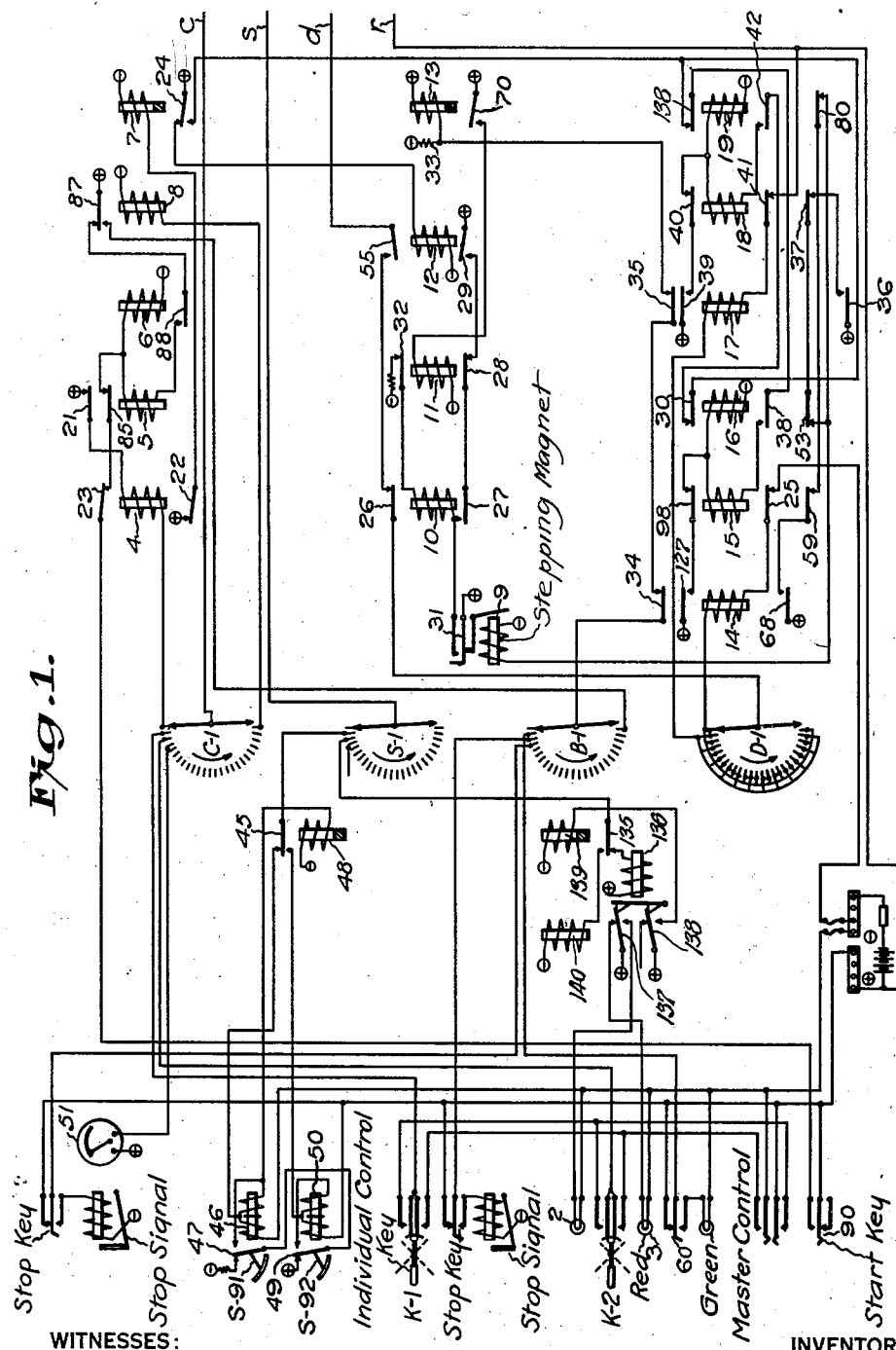
**T. U. WHITE**

**1,790,188**

**SUPERVISORY CONTROL SYSTEM**

Filed Dec. 17, 1925

2 Sheets-Sheet 1



**WITNESSES:**

G. S. Neilson

Samuel Petrolenk

INVENTOR

Thomas U. White

BY

BY  
*Charles E. Goss*  
ATTORNEY

**ATTORNEY**

Jan. 27, 1931.

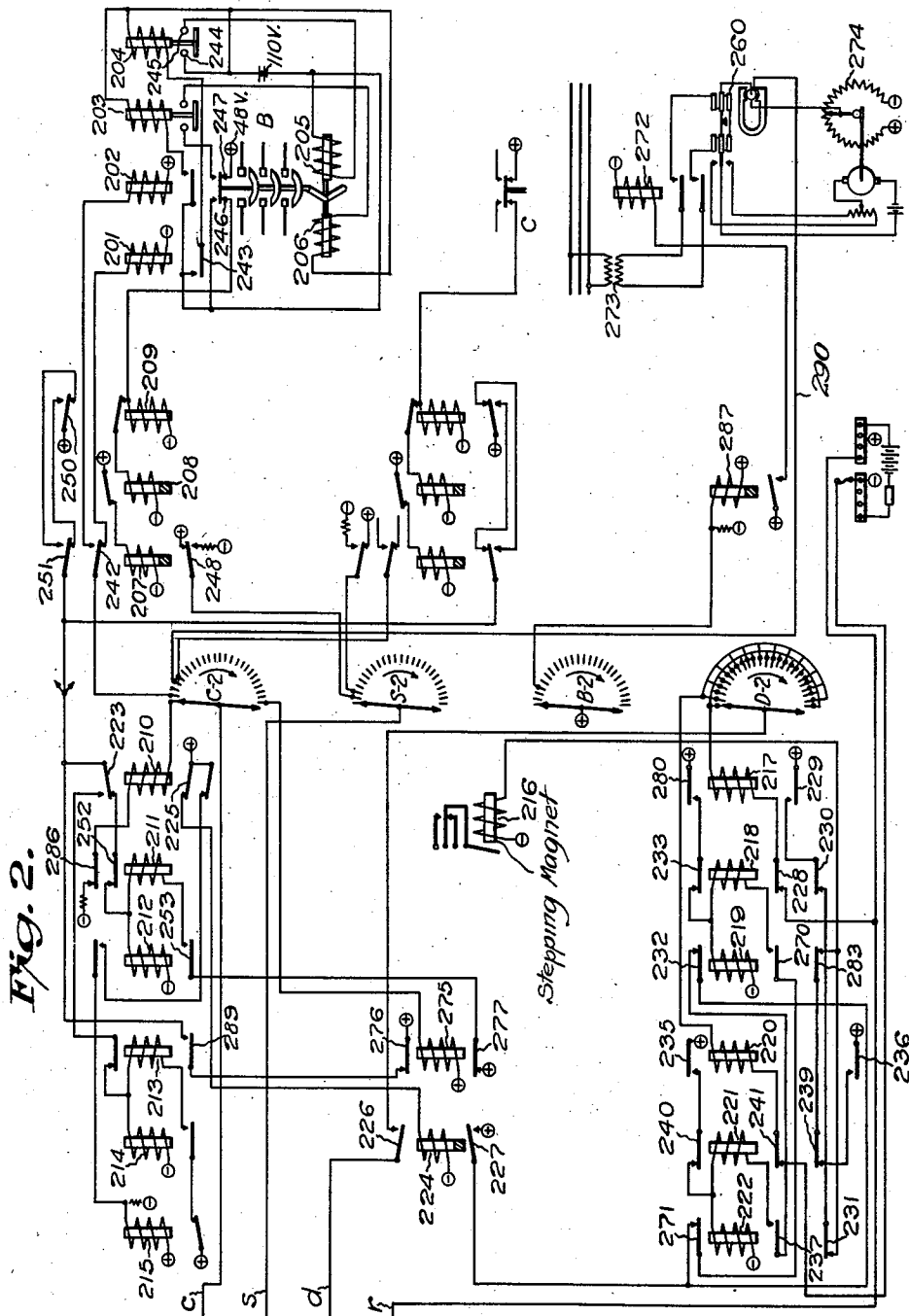
T. U. WHITE

1,790,188

SUPERVISORY CONTROL SYSTEM

Filed Dec. 17, 1925

2 Sheets-Sheet 2



WITNESSES:

G. S. Neilson  
Samuel Petroluk

INVENTOR

Thomas U. White

BY  
Herbert E. Carr  
ATTORNEY

# UNITED STATES PATENT OFFICE

THOMAS U. WHITE, OF PITTSBURGH, PENNSYLVANIA, ASSIGNOR TO WESTINGHOUSE  
ELECTRIC & MANUFACTURING COMPANY, A CORPORATION OF PENNSYLVANIA

## SUPERVISORY CONTROL SYSTEM

Application filed December 17, 1925. Serial No. 76,009.

My invention relates to selective control systems and particularly to such systems in which remotely disposed mechanism is supervised and controlled.

5 An object of my invention is to provide means for controlling and supervising remotely disposed apparatus.

Another object of my invention is to provide means for selectively controlling and supervising remotely positioned apparatus over simplified circuits.

Another object of my invention is to reduce the amount of mechanism necessary for operating supervisory control systems while still retaining all the necessary features required for accuracy of operation.

Still another object of my invention is to use a very simple self-synchronizing drive circuit with a selector switch.

20 Another object of my invention is to provide a simple, cheap and accurately operating selector system.

Still another object of my invention is to provide improved means for driving selector switches in synchronism.

Another object of my invention is to periodically open the synchronous driving circuit.

Another object of my invention is to provide means for insuring the complete operation of the power mechanism before the control energy therefor is disconnected.

In inventions of this class, there are usually a plurality of keys or operating devices located at one point and an equivalent number of mechanisms to be controlled at a remote point. Operating a key causes the corresponding remote mechanism to operate which in turn causes a lamp to light at the dispatcher's desk so as to give him a supervisory indication of the operation. The system usually comprises circuit arrangements or other means whereby these keys are consecutively associated with their respective equivalent mechanism at the distant point.

45 That is, each key or operating mechanism has related to it a device to be controlled at the distant point and it is connected to this device by mechanism between them. This mechanism, comprises switching means at each station connecting a key and its associated mechanism

at the distant station to a common signaling line simultaneously.

It becomes obvious at once that such switching means at the two stations must always be in synchronism if the correct mechanism is to operate. Since it is necessary, in systems designed for selective control of remotely disposed power mechanism, to obtain an absolutely correctly operating system, it is necessary to maintain the switching means in absolute synchronism. Heretofore, the arrangements for accomplishing this have been very complicated, requiring large numbers of relays and other equipment as shown in the system disclosed in application #689,975, filed Feb. 1, 1924, Patent Number 1,714,966, dated May 28, 1929. My invention is designed to accomplish all the functions disclosed in systems heretofore but with a very much reduced amount of apparatus and with very simple circuits. As a result, its use will mean a considerable reduction in the price of the system as well as simplified operation without sacrificing the requirement for correct operation of the mechanism.

Figure 1 of the accompanying drawing illustrates the mechanism at the dispatcher's or main office, and

Figure 2 illustrates the circuit arrangements at the remotely disposed station or substation.

Between a dispatcher's office, Fig. 1, and a substation, Fig. 2, there are four signaling conductors, comprising a control line for sending the control operations, a supervisory line over which the supervisory operations are sent back, a drive line for maintaining the switch mechanism in synchronism and a common return line for the above-mentioned lines.

At the dispatcher's office, there is a selector switch comprising a control bank C—1, a supervisory bank S—1, an individual key control bank B—1 and a synchronizing bank D—1.

Connected to each of the contacts on the control bank C—1 are individual control keys, such as K—1 and K—2. To the contacts on the supervisory bank there are connected supervisory indicators such as 46, as

55

60

65

70

75

80

85

90

95

100

well as relays, such as 136, 139 and 140, which, through their armatures, control supervisory lamps 2 and 3.

There are also a plurality of stop keys, each connected to its individual contact on the bank B—1. These, as will be described function to bring the selector switches to a stop at any position desired.

Associated with the bank D—1 are two groups of drive relays, of which more will be said hereafter. The group of relays 4, 5, 6 and 7 are the start relays associated with the start key and function to start the mechanism in operation responsive to movement of the key. A relay 8, as will be described, functions to return the mechanism to normal after the operations have been completed. A stepping magnet 9, turns the wipers of the banks C—1 to D—1 with a step-by-step movement.

At the substation, the control bank C—2 is associated with the bank C—1 over the conductor C. Each of the contacts on C—2 is connected to interposing relays such as 201 and 202, which, in turn through their armatures, control such contactors as 203 and 204. The contactors in turn control the closing and tripping magnets 205 and 206. This mechanism is individual to a circuit breaker. Similar individual mechanism is connected to each of the other contactors on the bank C—2.

Relays 207 to 209 are supervisory relays responsive to a movement of the power equipment for transmitting supervisory impulses over the line S. The relays 209 and 207 effect the starting of the synchronous selectors upon any movement of associated apparatus units. The relay 207 controls a circuit connection to the switch bank S—2, over which the supervisory indications are transmitted. This relay is also used to connect the control conductor associated with the switch bank C—2 to the interposing relays 201 and 202, shifting the said connection in accordance with the position of the circuit breaker under control. Thus, if the circuit breaker is open, 201 is connected to the line over armature 242 of relay 207; if closed, 202 will be connected over armature 242 in its deenergized position.

The relay 208 has a special characteristic, making it slow to de-energize, and is inserted in the individual equipment for the purpose of maintaining energy in the circuit of the relay 207 a period of time after the energizing circuit of the relay 209 has been opened, by reason of the movement of the circuit breaker B to closed position.

The function of this relay is important in that it maintains the control current in the energizing circuit of the closing interposing relay 201 for a period of time after the contact of the pallet switch of the circuit breaker C has been opened, in order to

insure that the circuit breaker is closed and mechanically latched in position before the energizing circuit of the closing coil of the circuit breaker C has been opened. The adjustable feature is accomplished either by the thickness of the copper slugs on the iron core or by spring tensioning of its armature.

The relays 210 to 215 control the starting of the supervisory operation, as will be described more in detail hereinafter. Stepping magnet 216 rotates the wipers of banks C—2 to D—2 in a step-by-step movement. Relays 217 to 222 comprise the driving circuits for energizing the stepping magnet at proper intervals.

A feature of this invention is the circuit arrangements which rotate the selector switches in absolute synchronism at every step or in case of loss of synchronism prevents any rotation. There is no counting of impulses, no checking back of circuits or totalizing of impulses necessary. The apparatus either operates correctly or does not operate at all.

All the apparatus is normally at rest. The cycle of synchronous selecting operation takes place when the dispatcher initiates an action or when an apparatus unit changes position at the station. When an operation takes place at the distant station, the synchronous selecting action is effected at a very high speed and a pair of signalling conductors are repeatedly switched from position to position. When these conductors connect the apparatus unit that has changed its position to the corresponding signalling equipment at the dispatcher's office, the indicating lamps at the dispatcher's office are changed to show the operation which has taken place.

Similarly, in case the dispatcher desires to control a unit, he operates a key associated with the apparatus unit desired, an associated stop key and then operates a start key. The selector switch at each station moves from point to point in regular sequence with both equipment in exact synchronism until the stop key is reached. The two signalling wires are thus connected to the key at the dispatcher's office and to the desired apparatus unit at the distant station.

Upon closing the master key, operating current passes from the control key through its associated selector switch bank to the signalling circuit. At the substation, this current flows from the signalling circuit through the selector switch to the desired apparatus unit through its associated selector bank and interposing relays.

A desired operation having been effected, auxiliary contacts on the apparatus unit transmit the signal back over the supervisory selector switches and the supervisory circuit to operate the proper indicating lamps at the dispatcher's desk.

A detailed description of the operation will now be given. With the equipment at rest, a normal energizing circuit is completed for the relays 4 and 210 in series over a path which extends from positive battery, back contact and armature 21, winding of relay 4, the first contact of bank C—1 and its wiper, control line C, wiper of the switch bank C—2, its first contact, winding of relay 210, armature 286 and its back contact to negative battery. The relays 4 and 210 are energized over this circuit.

At the dispatcher's office an energizing circuit is closed for the relay 7 at armature 22 and its front contact. The start circuit controlled by the start key is also prepared at the armature 23 and its front contact. As a result of the energization of relay 7, an energizing circuit is closed for the relay 12 at the armature 24 and its front contact.

At the substation, as a result of the energization of relay 210, the start circuit controlled by the power mechanism is prepared at the armature 223. A circuit is also completed for the relay 224 at armature 225 and its front contact. The relay 12 at the dispatcher's office and the relay 224 at the substation, thus normally maintain the drive circuit D open at armatures 24 and 226, respectively.

Assuming the dispatcher desires to operate the power equipment B at the distant station to a closed position, he moves the start key so as to close its upper contact momentarily. As a result, an energizing circuit is completed for the relay 6 from positive battery, start key and its upper contact, armature 23 and its front contact, armature 85 and its back contact, winding of relay 6 to negative battery.

As a result of the energization of the relay 6, a circuit is prepared for the relays 5 and 6 in series over armature 87 and its back contact and armature 88 and its front contact. This circuit is not however, effective at this time, by reason of the fact that the winding of the relay 5 is shunted by the original energizing circuit for the relay 6.

The start key 90, however, is closed momentarily and immediately opened. The original energizing circuit for the relay 6 is, therefore, opened at the start key 90 and the energizing circuit for the relay 5 now becomes operative. As a result of the energization of relay 5, another point in the original energizing circuit for the relay 6 is opened at the armature 25.

A further result of the energization of relay 5 is to open the original energizing circuit for the normally energized relays 4 and 210 at armature 21.

De-energization of relay 4 opens another contact in the original energizing circuit for the relay 6 at the armature 23 and also opens the normally closed energizing circuit for

the slow-release relay 7 at armature 22. After an interval of time, the slow-release relay 7 retracts its armature and opens the energizing circuit for the relay 12 at its armature 24 and front contact and, at the same time, prepares a circuit for the drive relays at armature 24 and its back contact. The relay 12 is deenergized and its armature 55 closes a point in the drive circuit D.

As a result, therefore, of the closing and opening of the starting key at the dispatcher's office, the normally closed circuit over the control conductors has been opened and the normally open drive circuit has been closed at armature 55.

The effect of the movement of the start key at the substation will now be described. As will be recalled, the original normally closed circuit for the relays 4 and 210 was opened at armature 21. Relay 210 is deenergized and, as a result, transfers the circuit prepared for the relay 212 at the front contact of armature 223 to the relay 214 at the back contact of armature 223.

The original energizing circuit for the slow-release relay 224 is opened at the contact and armature 225. The slow-release relay 224 retracts its armatures after an interval of time and closes the last contact of the drive circuit at armature 226 and its contact. A further result of the deenergization of relay 224 is to prepare a locking circuit for the drive relay at the armature 227 and its back contact.

Since the relays 12 at the dispatcher's office and 224 at the substation which are normally held energized during the non-operating period to hold the drive circuit open, have now been deenergized, the drive circuit is closed and an energizing circuit is completed for the relays 14 and 217 from negative battery, at the dispatcher's office back contact and armature 25, winding of relay 14, the first contact of bank D—1 and its wiper, armature 26 and its back contact, armature 55 and its back contact, drive line *d*, armature 226 and its back contact, wiper and first contact of bank D—2, winding of relay 217, armature 228 and its back contact to positive battery and over the common return line *r*.

The circuit just traced, it will be noted, includes besides the armatures 55 and 226 and their contacts, the wipers of banks D—1 and D—2 and their contacts, the armature 26 and the relays 14 and 217. The armatures 55 and 226, as already described, function to hold the drive circuit normally open during the non-operating period. The wipers of the banks D—1 and D—2 act to check the synchronism of the banks at the two stations, as will be described, the armature 26 functions to hold the driving circuit open during the stepping operation and relays 14 and 217 control the stepping magnets.

As a result of the completed circuit just

traced, the relays 14 and 217 are energized. At the dispatcher's office, as a result of the energization of relay 14, an energizing circuit is completed for the relay 16 from positive battery, armature 127 and its front contact, armature 98 and its back contact and winding of relay 16 to negative battery. Energization of relay 16 opens a possible locking circuit for relays 18 and 19 at armature 30, prepares an energizing circuit for relays 15 and 16 in series over armature 38 and its front contact, armature 138 and its back contact and armature 24 to ground and opens the circuit whereby relay 17 controls the stepping magnet at armature 53. The series circuit for relays 15 and 16 is not effective at this time due to the fact that the relay 15 is shunted by the original energizing circuit for relay 16.

A further result of the energization of relay 14 is to energize the stepping magnet 9 over a circuit from positive battery, armature 68 and its front contact, armature 59 and its back contact, armature 80 and its back contact, and the winding of stepping magnet 9 to negative battery.

The pawl of the stepping magnet is so arranged that, upon the energization of the stepping magnet, it prepares to step the wipers one step. The actual stepping, however, does not take place until the stepping magnet is deenergized.

At the substation, it will be recalled that the original closing of the drive circuit closed an energizing circuit for the relay 217 simultaneously with the energization of the relay 14 at the dispatcher's office. The energization of relay 217 closes an energizing circuit for the relay 219 at armature 280 and its front contact. A further result of the energization of relay 217 is to close an energizing circuit for the stepping magnet 216 over a circuit from positive battery, armature 229 and its front contact, armature 230 and its back contact, armature 231 and its back contact, winding of stepping magnet 216 to negative battery. The stepping magnet 216, like stepping magnet 9, is arranged to prepare its pawl, upon energization, for stepping the wipers of banks C—2 to D—2 one step, the actual stepping, however, not taking place until the stepping magnet is deenergized.

As a result of the energization of relay 219, as previously explained, a circuit is prepared for the relays 219 and 218 in series over armature 270 and its contact, armature 271, and armature 227 to positive battery. This circuit, however, is not affected at this time, due to the fact that the relay 218 is shunted by the original energizing circuit for the relay 219. A further result of the energization of relay 219 is to open a series locking circuit for the relays 222 and 221 at the armature 232. A circuit for the stepping magnet 216,

independent of the circuit previously traced, is also opened at the armature 283.

We have then, at this point, series circuits for the relays 16 and 15, at the dispatcher's office and the relays 218 and 219 at the substation which are not energized at this time by reason of the original energizing circuits for the relays 16 and 219, respectively.

As a result, however, of the energization of the stepping magnet 9 at the office an energizing circuit is closed for the relay 10 over a circuit from positive battery, armature 31 of the stepping magnet and its contact, winding of relay 10, armature 32 and its back contact to negative battery.

The relay 10 is energized over this circuit and closes a locking circuit for itself over armature 27 and its front contact, armature 28 and its back contact, armature 29 and its back contact to positive battery. At the armature 26, the drive circuit is opened. As a result, the original energizing circuits for the relays 14 and 217 are opened. Deenergization of relay 14 at the office opens the original energizing circuit for the relay 16 and the relays 16 and 15 are now energized in a series circuit as previously traced. The stepping magnet circuit is also opened at armatures 68 and 59, and the wipers of banks C—1 to D—1 are stepped from their first to their second contact.

At the substation the deenergization of the relay 217 opens the circuit for the stepping magnet 216 at armature 229 and the wipers of banks C—2 and D—2 are stepped from their first to their second contact.

Deenergization of relay 217 also opens the original energizing circuit for relay 219 and the series circuit for relay 218 and 219 becomes effective. As a result of the energization of relay 218, another point is opened in the original energizing circuit for the relay 219 at armature 233, and another point is opened in the original drive circuit at armature 228. Another point in the stepping magnet circuit is opened at armature 230.

At the dispatcher's station, relay 13 is normally energized over a circuit from positive battery, the winding of relay 13, resistance element 33 to negative battery. Relay 13 is normally slow-to-deenergize relay. When the wiper of bank B—1 reaches its second contact, a circuit is completed from positive battery through the upper contact of the stop key 60, second contact of the bank B—1 and its wiper, armature 34 and its back contact, armature 35 and its back contact, resistance 33 to negative battery. The winding of the relay 13 is thereby shunted and the relay is deenergized.

After an interval of time, its armature 32 is released and closes a circuit for the relay 11 at its contact. Energization of relay 11 opens the locking circuit for the relay 10 at armature 32 and 28. The relay 10 is de-

energized to close the drive circuit at armature 26 a second time.

The circuit over the drive line is now the same as traced before except that since the wiper of bank D—1 at the dispatcher's office is on its second contact, relay 17 is now in the circuit instead of relay 14 and, since the wiper of bank D—2 is on its second contact, relay 220 will be energized instead of relay 217.

It will also be noted that the circuit now is completed from positive battery at the dispatcher's office over the winding of relay 17 and through the winding of relay 220 to negative battery at the substation. The first drive circuit, it will be recalled, was from negative battery at the dispatcher's office over the winding of the relay 14 through the winding of relay 217 to positive battery at the substation. In other words, the direction of flow of current has been reversed by the stepping of the wipers of the banks D—1 and D—2 from their first to their second contacts.

It should be noted at this time that unless the wipers of the banks D—1 and D—2, respectively, are on equivalent contacts no current will flow in the drive circuit and therefore no stepping can take place. That is, if the wiper of bank D—1 is on its first contact, the wiper of bank D—2 must also be on its first contact or, if D—1 is on its second contact, D—2 must be on its second contact or the batteries will not be connected so as to permit a flow of current. If D—1 is on its first contact and D—2 is on its second contact, negative battery at the dispatcher's office will be connected to negative battery at the substation and as a result, no operation will take place. Similarly, if the wiper D—1 is on its second contact when the wiper D—2 is on its first contact, positive battery at the dispatcher's office will be connected to positive battery at the substation.

Since all the operations that have been described depend upon the connection of opposite polarities at each end of the line controlled by the bank D—1, and D—2, unless the wipers of these banks are in synchronism, no operation can take place. As must be apparent by now, the relay 14 and its associate relays 15 and 16 comprise one group of drive relays for controlling the stepping magnet 9 and the relay 17 and its associated relays 18 and 19 are a second group of drive relays for controlling the stepping magnet 9.

The relay 14 is connected in multiple with the first and all the odd contacts of the bank D—1 and to the negative side of the battery. The relay 17 is connected to the second and all the even contacts of the bank D—1 and the positive side of the battery.

At the substation, relays 217 to 219 represent similarly one group of drive relays and 220 to 222 a similar group. Relay 217 is connected to the first and all the odd contacts

and to the positive side of the battery and relay 220 is connected to the second and to all the even contacts and to the negative side of the battery. Relays 217 and 14 must always be energized simultaneously over the same circuit and, when they are so energized, the banks C—1 to D—1 and C—2 to D—2 must necessarily be in synchronism. Similarly, relays 17 and 220 must always be energized simultaneously over the same circuit and, when they are so energized, the wipers of the banks C—1 to D—1 and C—2 to D—2 must necessarily be in synchronism. Should either group of wipers for some reason move out of step with the other group of wipers, the circuits for the pairs just mentioned can no longer be completed and all operations cease.

If, however, the wipers of the two groups remain in synchronism, the relays 17 and 220 are energized as already described.

As a result of the energization of relay 17 at the dispatcher's office, the shunt circuit of the relay 13 is opened at armature 35 and the relay 13 is again energized to open the circuit for the relay 11 at the armature 70. A further result of the energization of the relay 17 is to close an energizing circuit for the relay 19 from positive battery, armature 39 and its front contact, armature 40 and its back contact, winding of relay 19 to negative battery. The energization of relay 19 opens the locking circuit for the relays 15 and 16 at armature 138, prepares a locking circuit for the relays 18 and 19 in a series circuit over armatures 42, 30 and 24 and opens one circuit for the stepping magnet 9, at armature 80. Opening this circuit for the stepping magnet 9 prevents the control of the stepping magnet by the first group of drive relays 14 to 16 and opening the locking circuit for the relays 15 and 16, deenergizes these two relays to restore their armatures to their original condition.

A further result of the energization of relay 17 is to close an energizing circuit for the stepping magnet 9, following the deenergization of the first group of drive relays from positive battery, armature 36 and its front contact, armature 37 and its contact, armature 53 and its contact, winding of stepping magnet 9 to negative battery. As stated before, the pawl of the stepping magnet 9 is now prepared to move the wipers of the associated banks.

At the substation, as already described, the relay 220 is energized in series with the relay 17. Energization of the relay 220 closes an energizing circuit for the relay 222 at the armature 235 and its contact. A further result of the energization of relay 220 is to close an energizing circuit for the stepping magnet 216 from positive battery, armature 236 and its front contact, armature 239 and its back contact, armature 283 and its back

contact and winding of the stepping magnet 216 to negative battery. The pawl of the stepping magnet is now positioned to step the wipers C—2 to D—2.

5 Energization of relay 222 prepares a locking circuit for the relay 222 and 221 in series from negative battery, windings of relays 222 and 221 in series, armature 237 and its front contact, armature 232 and its back contact, armature 227 and its back contact to  
10 positive battery. This circuit, however, is not effective at this time, due to the fact that relay 221 is shunted at armature 235.

A further result of the energization of relay 222 is to open a circuit for the stepping magnet 216 at armature 231, controlled by the relay 217. The first group of drive relays cannot, therefore, at this time control the stepping magnet.

20 Returning now to the operations at the dispatcher's office, it will be recalled that the stepping magnet 9 was energized over armature 30. As a result of the energization of stepping magnet 9, an energizing circuit for the relay 10 is closed at armature 31 and its contact in a manner similar to the first energization of the stepping magnet 9.

As a result of the energization of the relay 10, a locking circuit therefor is closed at armature 27 over armatures 32, 28 and 29.

A further result of the energization of the relay 10 is to open the drive circuit at armature 26. As a result of the opening of the drive circuit at 26, the original energizing circuit for the relays 17 and 220 is opened. Relay 17 is deenergized and, as a result, opens the original energizing circuit for the relay 19 at armature 39. The series locking circuit for the relays 19 and 18 now becomes effective.  
40

As a result of the energization of relay 18, a further point is opened in the original energizing circuit for the relay 19 at armature 40, a further point in the original energizing circuit for the relay 17 is opened at armature 41 and the circuit for the stepping magnet 9 is opened at armature 37.

At the substation, as a result of the opening of the drive circuit at armature 26, the original energizing circuit for the relay 220 is opened. As a result of the deenergization of relay 220, the original energizing circuit for the relay 222 is opened at armature 235. The relays 222 and 221 are now energized in a series circuit already traced. As a result of the energization of relay 221, another point is opened in the original energizing circuit for the relay 222 at armature 240, a further point is opened in the energizing circuit for the relay 220 at armature 241, and the stepping magnet circuit is opened at armature 239. The stepping magnet is deenergized simultaneously with the stepping magnet 9 and operates to step the wipers to  
65 their next contact.

Returning now to the dispatcher's office, the deenergization of relay 17 causes its armature 35 to drop back and close its contact. A circuit shunting the relay 13 is again closed over the bank B—1, its wiper and third contact, the closed stop key 61 to positive battery. Relay 13 is deenergized and, after an interval of time, causes its armature to drop back to close an energizing circuit for the relay 11. Energization of relay 11 opens the energizing circuit for the relay 10.  
70 75

The cycle of operations thus far traced show the manner in which the wipers of the banks at the two stations are stepped from contact to contact. The drive relays 14 to 16 energize and deenergize simultaneously with the drive relays 217 to 219, and the drive relays 17 to 19 and 220 to 222 similarly operate simultaneously.  
80 85

The circuits are so designed that, responsive to any operation at the dispatcher's office, the relay 7 is deenergized to open the energizing circuit for the relay 12 and close the drive circuit. The relays 14 and 217 are then energized in a series circuit over the drive line and the first contacts of the banks D—1 and D—2, respectively. These relays function first to energize their stepping magnets and then to energize the relays 16 and 219, respectively, the purpose being to ultimately open the energizing circuit for the stepping magnets and also transfer the circuits to the second group of drive relays.  
90 95

The relays 16 and 219 control locking circuits for themselves and for the other group of drive relays and also close energizing circuits for the relays 15 and 218, respectively, which in turn control the circuit for relays 14 and 217.  
100 105

When the stepping magnets are energized, they are arranged to open the drive circuit so as to deenergize relays 14 and 217, which results in the energization of relays 15 and 218 so as to open the circuit for the stepping magnets. In this manner, we have the relay 14 closing a circuit for the stepping magnet 9 which in turn indirectly deenergizes the relay 14.  
110 115

The cycle of operation will continue as long as the relay 13 is shunted over the contacts of the bank B—1, which are connected to stop keys, as shown. If the contacts of any one of these stop keys is opened, the relay 13 will not be shunted at that point and will not, therefore, deenergize. The locking circuit for the relay 10 resulting during the prior energization of the stepping magnet 9 will not, therefore, be opened at armature 28 and 32 since the relay 11 will not find an energizing circuit. The drive circuit will remain open at armature 26 and no further stepping will take place. In this manner, the wipers can be brought to a stop position at any contact.  
120 125 130

A series of stop signalling devices are arranged to operate when the switches have reached the stop position associated with the operated stop key. The operation of the stop signal when the switches have reached the proper contact and come to a stop indicates to the dispatcher that the system is in condition for operation. Thus, for example, if the stop key adjacent K—1 is operated to its operate position, a circuit is completed for the relay associated with this key when the wiper of the switch B—1 reaches its third contact, the circuit being completed from the negative side of battery, through the winding of the relay shown just below the stop key through the contacts of the stop key, the third contact of the switch B—1, through the wiper over the armature 34 and its back contact, armature 35 and its back contact, and through the winding of relay 13 to the positive side of battery. It will be recalled that, with the stop key in its non-operated position, a by-pass circuit is at this time completed for the battery, by-passing the winding of relay 13, through the resistance 33 from negative side of battery to the positive side of battery. The relay 13, under those conditions, remains deenergized and energizes relay 11 to, in turn, open the locking circuit of the relay 10 which thereupon closes the drive line at armature 26. In the present case, however, when the stop key is in its operate position, the relay winding of the stop signal is energized in series with the relay 13, as described above, and the relay 13 remains energized, thereby holding open the energizing circuit for the relay 11 and, accordingly, the relay 10 remains locked for armatures 27, 28 and 29, as described in detail above. The energization of a stop signal being individual to the particular position of the switch wiper provides the dispatcher with a signal of the position of the switch wiper, and that the system is now in condition for the remote control and operation of the circuit breaker.

The operation that takes place when the wipers reach the contact on the banks to which the individual control key, which has been moved, is connected, will now be described. In this case, it was assumed that the dispatcher desired to close the circuit breaker B shown open. To perform this, in addition to moving the start key to close its upper contact and opening the stop key individual to the circuit breaker, the master control key must also be moved to close its contacts, and the individual control key K—2 is operated to close its upper contact. When the wiper of the bank C—1 reaches its second contact, the wiper of bank C—2 as already described simultaneously reaches its second contact and a circuit will be completed from positive battery at the dispatcher's office, lower contact of the master control key, upper contact of individual control key K—2,

second contact of the bank C—1, its wiper, control line C, wiper of bank C—2 and its second contact, armature 242 and its front contact, winding of relay 201 to negative battery.

Energization of the relay 201 closes a circuit for the pallet switch 204 from the 110-volt battery, winding of the pallet switch 204, armature 243 and its front contact to negative battery. Energization of the pallet switch 204 closes an energizing circuit for the solenoid 205 from positive battery, contacts 244 and 245, winding of the solenoid 205 to negative battery.

As a result of the energization of the solenoid 205, the circuit breaker B is moved to its closed position. The original energizing circuit for the relays 209 and 208 over the contacts 246 and 247 are now opened. Relay 208 deenergizes and after an interval of time retracts its armature to open the energizing circuit for the relay 207. After an interval of time, the relay 207 is deenergized to permit its armature 248 to retract to its back position. The time for this is adjusted depending on the time it takes the circuit breaker to close and latch. A circuit is now completed from negative battery, back contact and armature 248, second contact of the bank S—2, its wiper, supervisory line S, wiper of the bank S—1, and its second contact, armature 45 and its back contact, winding 46 to battery.

As a result of this, the armature 47 and its indicator is moved to its front contact, thereby indicating that the circuit breaker B has been closed, as desired. An energizing circuit is also closed for the relay 48 from negative battery, winding of relay 48, armature 47 and its front contact, armature 49 and its back contact to positive battery. Relay 48 is energized to move its armature 45 to its front contact so that the next supervisory indication will effect the winding of the relay 50, should any change take place at the substation. When relay 46 is energized, a circuit is completed from negative battery, through the winding of relay 46, front contact and armature 47 and armature 49 and its back contact, to positive battery. Relay 46 is thus maintained energized until the relay 50 is energized.

It will be recalled that in starting the control operations, it was first necessary to open the normally energized circuit for the relays 4 and 210 in series. Similarly, to start a supervisory operation, these normally energized relays should be de-energized. This is effected as follows. If the relay 209 should be deenergized as a result of the automatic closing of the circuit breaker C, its armature 250 will drop to its back position and a circuit will be completed from positive battery, armature 250 and its back contact, armature 251 and its front contact, armature 223 and

its front contact, armature 252 and its back contact, winding of relay 212 to negative battery.

Energization of relay 212 prepares an energizing circuit for relays 211 and 212 in series over the armature 253. This circuit, however, is not effective at this time, due to the fact that the original energizing circuit for the relay 212 shunts the relay 211. Relay 208, however, is a slow-release relay and will be deenergized to open its armature a short interval of time following the deenergization of relay 209 and, as a result, will open the energizing circuit for the relay 207 which being also a slow-release relay, will, after an interval of time, cause its armature 242 and 251 to move to their back positions. As a result of the armature 242 moving to its back position, the interposed relay 202, for opening the circuit breaker, is now connected to the contact of the control bank C—2. When the armature 251 moves to its back position, the original energizing circuit for the relay 212 is opened and the series locking circuit for the relays 212 and 211 is now closed.

As a result of the energization of relay 211, the normally closed circuit for the relays 210 and 4 is now opened at armature 220. Relays 210 and 4 are now deenergized and function to close the circuit for the drive relays in a manner similar to that already described. When the wipers reach the contact connected to the power mechanism which has changed its condition, in this case circuit breaker B, a circuit will be closed from negative battery, armature 248, second contact of the bank S—2 to the indicator at the dispatcher's office, in a circuit as already traced.

It is understood, of course, that any one of numerous operations may be performed by connecting the mechanism which is desired to be controlled to the contacts of the control and supervisory banks. A Kelvin balance 260 merely illustrates one such additional use. By causing the wipers to stop on their third contact, a circuit shunting the relay 287 will be completed from positive battery, wiper of the bank B—2 and its third contact to negative battery.

If the wipers remain on this contact a sufficient length of time, slow-release relay 287 will be deenergized to cause its armature to drop to its back position to close the energizing circuit for the relay 272. Energization of relay 272 places the Kelvin balance 260 across the power line through the transformer 273. The Kelvin balance is arranged to translate the power of the line into current variations by means of the resistance element 274 whose graduations have been predesigned for this purpose. These current variations are then transmitted over the line 290 and fourth contact of the control bank C—2 conductor C, fourth contact of

bank C—1 to the meter 51, to give an indication to the dispatcher of the power on the trunk line at the sub-station.

Following either the control or supervisory operation the stop key is returned to normal and the wipers C—1 to D—1 and C—2 to D—2 continue to be stepped around by the operation of the drive relays, as already described, until the wipers reach their twenty-fifth or last contact. At this point a circuit is completed from positive battery at the substation winding of relay 275, the last contact of the bank C—2, its wiper, control line C, wiper of bank C—1 and its last contact, winding of relay 8 to negative battery.

Energization of relay 8 closes an energizing circuit to shunt the relay 13 over a circuit from positive battery, armature 87 and its front contact, the last contact of the bank B—1, its wiper, armature 34 and its back contact, armature 35 and its back contact, and element 33 to negative battery. The relay 13 is shunted over this circuit and is deenergized. After an interval of time it permits its armature 70 to retract, to close an energizing circuit for the relay 11, which in turn, as already described, opens the locking circuit for the relay 10 and the drive circuit is closed to in turn energize the stepping magnets 9 and 216 in a manner already described. The stepping magnets will, in turn, deenergize and step the wipers at each station to their first or normal position.

Another result of the energization of relay 8 is to open the locking circuit for the relays 6 and 5, thereby restoring the armature of these relays to normal.

At the substation, energization of relay 275 opens the locking circuit for the relays 211 and 212, previously described, thereby restoring the armatures of these relays to their normal position. When the relays 211 and 212 are deenergized, the original energizing circuit over the control line for the relays 4 and 210 is completed as heretofore described. The starting circuit is prepared at the armatures 23 and 223 and the mechanism is in condition for subsequent operation or supervision.

The relays 46 and 50 disclose one particular form of supervisory receiver signalling device. Similarly, the lamps associated with the key 2 may be employed if so desired for supervisory signalling. The detailed description above of the operations which take place in connection with the circuit breaker on the second contact of the switch banks are the same as those which would take place upon operation of any apparatus unit located on any of the other contacts. Thus, for example, an operation of a unit connected to the third contact of the switches would change the potential at the substation on the supervisory line from positive potential to negative potential and a circuit would thereupon

be completed over the switch wiper of the bank S—1 at the office through the third contact, the armature 135, and its back contact, and through the winding of the relay 136 to the battery. The energization of the relay 136 operates its armature to release the latch at armatures 137 and 138. Armature 137 upon closing its back contact, opens the circuit for the lamp 3 and completes a circuit for the lamp 2 from positive battery over armature 137 and its back contact through the lamp 2 to negative battery. At the same time, the relay 137 is energized over a circuit including armature 138 and its back contact and armature 136 closes its front contact preparatory to energizing the relay 148 in response to the next supervisory signal.

In the event that an apparatus unit is automatically operated while the switches are in an off-normal position, a condition will be set up and stored for restarting the switches, after they have been restored to normal in the manner described above.

Assuming, for example, that an automatic operation of breaker B occurs when the switches at the two stations are on some position other than normal. As was described above, after the switches have left their normal position, relay 210, which is normally energized, is deenergized and armature 223 then engages its back contact. When circuit breaker B operates from the position shown to its closed position and the relay 209 is deenergized by reason of its circuit being open at the pallet contacts 246 and 247, a circuit is completed from positive side of battery over the armature 250 and its back contact, the front contact and armature 251, armature 223 and its back contact, through the armature and back contact of the relay 213 and through the winding of relay 214 to negative battery. Relay 214 is energized over this circuit and prepares a locking circuit for itself and the relay 213 in series over the front contact and armature of relay 214 and the front contact and armature of relay 215 to positive battery. This circuit, however, is not effective at this time due to the bypass circuit of the relay 213 traced above through the back contact and armature 250.

The relay 208, a circuit for which is opened at the same contact as relay 209, being a slow-to-release relay, deenergizes after an interval following the deenergization of relay 209 and, in turn, opens the energizing circuit of relay 207, which, after an interval, also deenergizes and, at armature 248 and its back contact, prepares the supervisory indication to be transmitted when the selector switches have reached the position individual to that circuit breaker.

At armature 251, the bypassing or original energizing circuit for the relay 214 is opened when the armature moves to its back contact and the relays 214 and 213 are then energized

in series and, at armature 242, a circuit is prepared for the trip relay 202 in the event that the dispatcher desires to trip the breaker.

A circuit is now prepared, at armature 276 and its back contact and armature 289 and its front contact, for the relay 212, which is not effective, however, at this time, inasmuch as the relay 210 is deenergized and armature 223 engages its back contact.

When the selecting apparatus has gone through a complete cycle, however, and been restored to normal, in a manner described in detail above, and the wipers are on their first contact, the holding circuit for relay 210 at the substation is again completed, and relay 210 is energized. Upon energization of relay 210 at this time, a circuit is completed for the relay 212, as described above, and relay 212 is energized. Energization of relay 212 prepares, as described above, an energizing circuit for relays 212 and 211 in series and also completes a shunt circuit for the negative side of the battery at relay 215, through the front contact and upper armature of the relay 212, the front contact and lowest armature of relay 210, to positive battery. Relay 215 is deenergized and, at its armature, opens the locking circuit of relays 214 and 213, which relays are thereupon deenergized, opening the original energizing circuit for the relay 212 at armature 289. This opens the bypass circuit for the winding 211, and relays 212 and 211 are now energized in series. As a result of the energization of relay 211, the switches are again started into operation, in the manner described in detail above, until the particular breaker which has operated is reached, whereupon a supervisory signal is transmitted over the line, indicating the change in operation.

The system herein disclosed is shown as applied to supervisory control. Applicant has, however, invented a novel selecting and synchronizing system. It is apparent, therefore, that the invention is applicable to any system wherein selection is required. Applicant is, therefore, not to be considered as limited to the particular application of the system disclosed.

I claim as my invention:

1. In a signalling system, a first station, a second station, a rotating switch at each of said stations comprising a wiper and a set of bank contacts, the alternate odd numbered contacts of the switch being connected together and the alternate even numbered contacts of the switch being connected together, a drive line connecting the wipers of said switches, means for alternately opening and closing said drive line, while switches at each station are on either the odd or even contacts simultaneously, means responsive to the closing of said drive line for conditioning said wipers for stepping to the succeeding contact, said means being operative re-

sponsive to the opening of said drive line for stepping said wipers to the succeeding contact, said first mentioned means being responsive to said conditioning means for opening said drive line.

2. In a signalling system, a first station, a second station, a switch bank at each of said stations, each switch bank comprising a set of bank contacts and a wiper moving thereover, the odd numbered contacts of each switch at each station being connected together and the even numbered contacts being connected together, a drive line connecting said wipers, circuit connections to said odd numbered and even numbered contacts such that an energizing circuit for said drive line is completed only when said wipers at each station are both either on the even or odd numbered contacts, electromagnetic means for opening and closing said drive line, a stepping magnet at each of said stations conditioned for operation upon the closing of said drive line for stepping the wipers of said switches to their succeeding contacts upon the closing of said drive line and for operating said wipers to their succeeding contacts upon the opening of said drive line, said first mentioned electromagnetic means being responsive to the conditioning of said first station stepping magnet for opening said drive line.

3. In a signalling system, a first station, a second station, a rotating switch at each of said stations, each of said switches comprising a bank of contacts and wipers, a drive line connecting said stations, electromagnetic means for alternately opening and closing said drive line, a driving means for stepping said wipers from contact to contact at each of said stations, drive line means responsive to the closing of said drive line for conditioning said driving means for stepping said wipers, said electromagnetic means being responsive to the conditioning of said driving means for opening said drive line, said drive line means being responsive to the opening of said drive line for operating said driving means to move said switches to their succeeding contacts.

4. In a signalling system, a first station, a second station, a rotating switch at each of said stations comprising a set of bank contacts and a wiper, a drive line connecting said wipers, electromagnetic means for alternately opening and closing said drive line, a stepping magnet for stepping one of said wipers from contact to contact, drive line electromagnetic means responsive to the closing of said drive line for conditioning said stepping magnet to operate said wipers to their succeeding contacts, electromagnetic means responsive to the conditioning of said stepping magnet for opening said drive line, said drive line means being responsive to the opening of said drive line for operating said stepping magnet to operate its wipers to their

succeeding contacts, means for releasing said first mentioned electromagnetic means to again close said drive line following the operation of said stepping magnet, a second stepping magnet for the other of said wipers and means responsive to the opening and closing of said drive line for operating said second stepping magnet.

5. In a signalling system, a first station, a second station, a rotating switch at each of said stations, comprising a bank of contacts, a switch wiper, stepping magnets for each wiper, a drive line connecting said stations, electromagnetic means for opening and closing said drive line, drive line electromagnetic means responsive to the closing of said drive line for operating said stepping magnets, means responsive to the operation of said stepping magnets for conditioning said switch wipers for operation, said first mentioned electromagnetic means being responsive to the operation of one of said stepping magnets for opening said drive line, said drive line electromagnetic means being responsive to the opening of said drive line for releasing said stepping magnets, said switch wiper conditioning means being responsive to the release of said stepping magnets for stepping their wipers to succeeding contacts.

6. In a signalling system, a first station, a second station, a rotating switch at each of said stations comprising a bank of contacts and a switch wiper, a stepping magnet for each wiper, a drive line connecting said stations, electro-magnetic means for opening and closing said drive line, electro-magnetic means responsive to the closing of said drive line for operating said stepping magnets, means responsive to the operation of said stepping magnets for conditioning said switch wipers for operation, said drive line controlling electromagnetic means being responsive to the operation of said first station stepping magnet for opening said drive line, said stepping magnet operating electromagnetic means being responsive to the opening of said drive line for releasing said stepping magnets, said switch wiper operating means being responsive to the release of said stepping magnets for stepping said wipers to their succeeding contacts, and means operated as said switch wipers move from contact to contact for releasing said drive line controlling means to again close said drive line.

7. In a signalling system, a first station, a second station, a rotating switch at each of said stations comprising a bank of contacts and a switch wiper, a stepping magnet for each wiper, a drive line connecting said stations, electro-magnetic means for opening and closing said drive line, electromagnetic means responsive to the closing of said drive line for operating said stepping magnets, means responsive to the operation of said stepping magnets for conditioning said switch

wipers for operation, said drive line controlling electromagnetic means being responsive to the operation of said first station stepping magnet for opening said drive line, said stepping magnet controlling electromagnetic means being responsive to the opening of said drive line for releasing said stepping magnets, said switch wipers conditioning means being responsive to the release of said stepping magnets for stepping said wipers to succeeding contacts, means successively operated as said switch wipers move from contact to contact for releasing said drive line controlling means to close said drive line, a key individual to each of said switch contacts, said successively operating means being controlled by any one of said keys when the switch wipers have reached a contact position individual to said key for preventing the release of said drive line controlling electromagnetic means whereby said switches are brought to a stop at any desired position.

8. In a signalling system, a first station, a second station, a switch at each of said stations comprising a bank of contacts and a rotating wiper therefor, a drive line connecting said switches, means for opening and closing said drive line, means responsive to the closing of said drive line for conditioning said wipers to be operated to their succeeding contacts, said means being responsive to the opening of said drive line for moving said wipers to their succeeding contacts, operating means individual to each of the contacts of one of said switches and means controlled by said individual means and directly from one of said switches for controlling said opening whereby said switches are brought to a stop at any desired position.

9. In a signalling system, a first station, a second station, a switch bank at each of said stations, each of said switch banks comprising a set of bank contacts and a wiper moving thereover, the odd numbered contacts of each switch at each station being connected together and the even numbered contacts of each station being connected together, a drive line connecting said wipers, circuit connections at each station to said odd and even numbered contacts such that a circuit for said drive line, including a source of energy, is completed only when said wipers at each station are both either on the even or odd numbered contacts, electro-magnetic means for transmitting impulses over said drive line, a stepping magnet at each of said stations, electro-magnetic means connected in said drive line and responsive to said impulses for operating said stepping magnets for stepping the wipers of said switches to the succeeding contacts, and means whereby said first mentioned means is controlled by one of said stepping magnets to transmit said impulses.

10. In a signalling system, a first station, a second station, a switch bank at each of

said stations, each switch bank comprising a set of bank contacts and a wiper moving thereover, the odd numbered contacts of each switch at each station being connected together and the even numbered contacts of each switch being connected together, a drive line connecting said wipers, circuit connections to said odd numbered and even numbered contacts such that an energizing circuit for said drive line is completed only when said wipers at each station are both on either the even or odd numbered contacts, electro-magnetic means for opening and closing said drive line, a stepping magnet at each of said stations for actuating said wipers from contact to contact, electro-magnetic means connected in said drive line and responsive to the opening and closing thereof for operating said stepping magnets, and means whereby said first mentioned electro-magnetic means is operated in response to the operation of said stepping magnets.

11. In a signalling system, a first station, a second station, a step by step switch at each of said stations, each of said switches comprising a set of bank contacts and a wiper moving thereover, a drive line connecting said wipers, a source of energy at each of said stations, means connecting the positive side of the source of energy at the first station to the even contacts of the switch thereat and the odd contacts of said switch to the negative side of said source, means connecting the negative side of the source at the second station to the even contacts of the switch thereat and the positive side to the odd contacts thereof, means connecting similar sides of the two sources together whereby an energizing circuit including the drive line, the wipers and said sources is completed only when said wipers at each station are both on either the even or odd numbered contacts, electro-magnetic means for controlling the effectiveness of said circuit, stepping magnets for said wipers, means included in said circuit and responsive to the control thereof for operating the stepping magnets to move the wipers from contact to contact and means whereby said circuit control means is controlled by one of said stepping magnets.

In testimony whereof, I have hereunto subscribed my name this 7th day of November, 1925.

THOMAS U. WHITE.