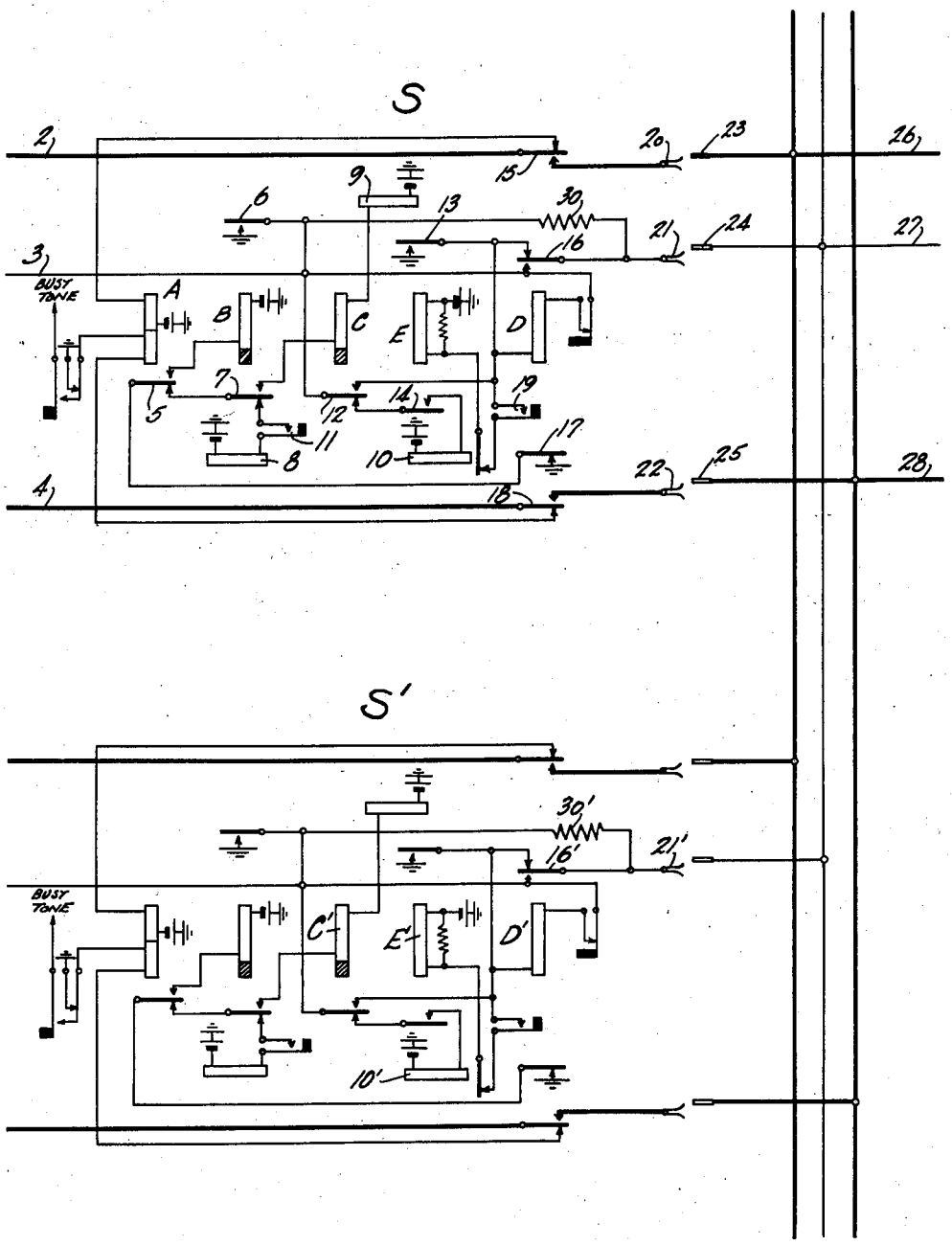
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SELECTOR SWITCH

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## SELECTOR SWITCH

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This invention relates in general to selector switches, and particularly to selector switches of the Strowger step by step type such as are used in automatic telephone systems. These systems as widely used in the past have been arranged so that the trunk lines to which the selector switches have access are made busy by grounding the test conductors, and the selectors in hunting for idle trunks search for absence of ground. The object of the invention is an improved circuit arrangement for selector switches of this type which will largely prevent two selectors from seizing the same idle trunk in the event that they start to hunt simultaneously or substantially so. The improvement consists in adding to each selector switch a resistance which is connected between the incoming test conductor and the test wiper. The addition of these resistances greatly modifies the action of the selectors in testing for idle trunks when two or more of them are testing at the same time. The effect is to substantially eliminate double seizure.

Further details of the operation of the improved selector circuit will be pointed out fully hereinafter, reference being made to the accompanying drawing.

Referring to the drawing, the reference character S indicates a Strowger step by step selector switch having the improved circuit referred to. The mechanism is understood to be of the usual type, and comprises a vertical and rotary shaft controlled by the vertical magnet 9 and the rotary magnet 10. The shaft carries three wipers indicated by the reference numerals 20, 21 and 22. A release magnet 8 is provided for restoring the switch to normal. The switch also has the usual relays for controlling its operation, as will be subsequently described. The resistance which is added in accordance with this invention is indicated by the reference numeral 30.

The selector S' is in all respects like the selector S. It is shown for convenience in describing the operation and effect of the new improved circuit arrangement, which as before stated, deals with the prevention of double seizure by two selectors which start to hunt simultaneously.

At the right of the drawing a trunk line comprising conductors 26, 27 and 28 is indicated. This trunk line is accessible to the selector S as shown and is also accessible by the usual trunk multiple to the selector S' and to other selector switches.

The normal operation of the selector S will first be briefly described. When a calling subscriber seizes the selector S a circuit is completed over the incoming line conductors 2 and 4 for the line relay A. Upon energizing, relay A completes a circuit for the slow acting release relay B at armature 5. Relay B operates and at armature 7 it prepares a circuit for the vertical magnet 9. At armature 6 relay B connects ground to the incoming release or test conductor 3, thereby making the selector S busy and completing a holding circuit for the preceding switch or switches.

When the calling subscriber dials the digit which is to operate the selector S, one or more interruptions are produced in the circuit of line relay A in the well known manner. Assuming that the digit 1 is called, there will be one interruption, and the line relay A will momentarily retract its armature 5 once. An impulse is thereby transmitted to the vertical magnet 9 through the slow-acting series relay C. Magnet 9 steps the switch shaft up so that the wipers 20, 21 and 22 stand opposite the first level, in which it may be assumed that the trunk line comprising the conductors 26, 27 and 28 terminates. Relay C energizes in series with the vertical magnet and is designed to retain its armature retracted throughout a series of impulses. Upon energizing, relay C prepares a circuit for the stepping relay E at armature 12, which circuit is completed upon the closure of the shaft springs 19 when the shaft begins to rise. Relay E energizes and at armature 14 prepares a circuit for the rotary magnet 10. At armature 13 relay E completes a locking circuit for itself.

When relay C falls back upon the cessation of impulses to the vertical magnet 9, it completes a circuit at armature 12 for the rotary magnet 10, and also breaks the initial energizing circuit for the stepping relay E. This relay is, however, locked energized for the time being. The rotary magnet 10 now energizes and rotates the shaft so that the wipers 20, 21 and 22 rotate in on the first level of bank contacts, the said wipers making contact with bank contacts 23, 24 and 25, respectively. The rotary magnet 10 also opens its interrupter contacts and thereby breaks the circuit of the stepping relay E. The relay E therefore falls back and opens the circuit of the rotary magnet and also its own locking circuit.

The switch wipers are now standing on the contacts assigned to the first trunk of the level, and the further operation depends on whether or not this trunk line is busy. If the trunk line is busy, there will be a ground potential on test contact 24, and a new energizing circuit will be completed for the stepping relay E which includes

the test wiper 21. This circuit is also effective to prevent the energization of the switching relay D. Assuming therefore that the first trunk line is busy, the stepping relay E is again energized, and the same series of operations that have just been described occur again, resulting in the rotation of the switch wipers to the set of contacts assigned to the second trunk line. These operations continue to be repeated until the test wiper 21 arrives at an ungrounded test contact similar to contact 24. When this occurs, there will be no circuit for again energizing the stepping relay E, and the rotary movement of the selector will cease. Also, due to absence of ground on the test contact, the switching relay D is no longer short circuited, and it energizes over a circuit which includes the grounded release trunk conductor 3, the winding of relay D, the off normal springs 19, and the winding of relay E. The switching relay D is of relatively high resistance, so that the stepping relay E does not energize in series with it. Upon energizing, relay D makes the selected trunk busy by extending ground to the test wiper and test contact at armature 16. At armatures 15 and 18 relay D disconnects the incoming line conductors from the line relay A and continues them through to the wipers 20 and 22, whence the line circuit extends over contacts 23 and 25 and trunk conductors 26 and 28 to the line relays of the next selector. In the next selector, it will be understood, the line relay now energizes, followed by the energization of the release relay, which places ground on conductor 27 in order to maintain the relay D energized and in order to maintain ground on the release trunk conductor 3 incoming to the selector S. It is noted that when relay D energizes the line relay A and the release relay B both deenergize, the latter disconnecting ground at armature 6 from the release trunk conductor 3. No circuit is closed for the release magnet 8 because ground has been disconnected at armature 17 of relay D.

The foregoing describes the ordinary operation of the selector S in completing a connection in an automatic telephone system. The operation of the other switches involved need not be especially considered. It is understood, of course, that when the connection is to be broken down, the hanging up of the receiver by the calling subscriber results in the removal of ground from the release trunk conductor 27. This brings about the deenergization of relay D, which closes a circuit for the relay magnet 8 at armature 17.

A double seizure is apt to occur when two selector switches having access to the same group of trunks start to hunt for an idle trunk simultaneously or nearly simultaneously. It may be stated that if the two selectors start to hunt exactly together it is almost certain that they will seize the same trunk, provided the first trunk is idle, and unless there is considerable difference in the adjustment of the relays. A double seizure also may occur even though the selectors do not start to hunt exactly together, and the danger is not entirely eliminated until the time interval by which the hunting of one selector is delayed after the hunting of the other one reaches a certain value. The value depends upon the adjustment of the relays and other factors and in any case is exceedingly small.

In order to explain how a double seizure occurs, it may be assumed that the selectors S and S' start to hunt for idle trunks simultaneously. The initiation of the hunting action is caused by the deenergization of the relays C and C'. The rotary magnets 10 and 10' will therefore be energized simultaneously and it will be assumed that the stepping relays E and E' deenergize simultaneously. If the rotary magnets now fall back together, the test circuits including the relay E and the test wiper 21 of the selector S and the relay E' and test wiper 21' of the selector S' will be closed simultaneously. Neither selector finds ground through its test wiper and accordingly, the relays D and D' will start to pull up simultaneously. If there is not too great difference in adjustment of the relays D and D' they will pull up substantially together, and double seizure has taken place.

It will be observed that there are a good many contingencies which may prevent the double connection. If the switches arrive in testing position slightly out of synchronism or if the D relays or the E relays or the rotary magnets are adjusted a little bit differently the double connection may not take place. It should be noted also that there is a possibility for two selectors to start to hunt nearly together and interact and rotate past several idle trunk lines until they get out of step with each other and seize adjacent idle trunk lines. This is due to the fact that each selector arrives at a trunk line with ground on its test wiper. Assume, for instance, that the selector S' has been operated to select the trunk line shown and that the switch has just arrived in testing position, the circuit of the relay E' being closed through the interrupter contacts of the rotary magnet to the test wiper 21'. Assume now that at this instant the selector S is advanced by its rotary magnet to the contacts of the same trunk line. At the moment that the switch S reaches the trunk line, the stepping relay E has not yet deenergized and ground will be placed on the test contact 24 and on its multiple contact in the bank of the selector S'. Although the relay D' has begun to energize in the selector S' it is now shunted down and the relay E' pulls up instead, thus rotating the selector S' off the contact. The energization of relay E' also grounds the test contact of the first trunk at the beginning of the second rotary step of selector S', this operation energizing the stepping relay E of the selector S, which by this time has deenergized. It will be seen that the selectors may interact in this way and pass a number of idle trunk lines provided the relay adjustments are substantially the same on the two selectors. The operation does not take place very often however with standard selectors.

The effect of adding the resistance according to this invention will now be discussed and the operation thereof will be explained so far as is possible. The resistance should be non-inductive and of a value which depends on the value of the resistance of the E and D relays. Considering the selector S, for example, the value of the resistance 30 should be such that relay E will not pull up in series with it. This is because during the operation of the selector S the test wiper 21 is grounded through the resistance 30. If the resistance 30 is sufficiently low to allow the relay E to pull up, all trunks would obviously test busy. It is desirable, however, that the resistance 30 be sufficiently low so that with two of these resistances in parallel a relay such as relay E will operate. It may be stated further that the value of the resistance 30 should be such that the relay E will not operate in series with the resistance 30 and the relay D in parallel. The condition

of having a relay such as E pull up in series with two resistances such as 30 in parallel occurs when two selectors such as S and S' start to test a trunk line simultaneously or nearly so. Under these conditions ground is supplied to the test conductor of the trunk line through resistances 30 and 30' in parallel. Now, if the interrupter contacts of the rotary magnets do not close exactly simultaneously, only one such relay as E' will have its circuit closed for an instant, and this relay therefore can pull up through the resistances 30 and 30'. The condition of a relay such as E attempting to pull up through the resistance 30 and relay D in parallel occurs in the normal operation of the switch when only one selector tests for an idle trunk. If the trunk is idle the selector should stop and seize it, and the relay E therefore should not energize, notwithstanding the fact that it is being supplied with current through the associated resistance 30 and the relay D in parallel.

Some variation in the value of resistance 30 is possible even though the above conditions must be met. A selector which is in common use has a D relay with a resistance of 1300 ohms, and an E relay with a resistance of 210 ohms. The E relay is shunted by a non-inductive resistance of 1300 ohms. With these resistance values of the D and E relays, it is found that if the resistance 30 has a value of 900 ohms very satisfactory operation takes place. The limits vary with the relay adjustments. Within the range of ordinary adjustments the lower limit is about 500 or 600 ohms, while the upper limit is about 1000 ohms.

The exact way in which the addition of the resistance 30 to the selector circuit prevents double seizure is somewhat obscure. The relay operations take place so fast and there are so many circuits which have to be taken into consideration, and there are so many relay adjustments which alter the conditions that it is difficult to ascribe the improved result to any single factor. It may be that the improved operation is due to a number of different factors, all, however, involving the addition of these resistances. A brief summary of the results shown by repeated tests with and without the resistance will perhaps be informatory.

In testing this circuit arrangement two selectors such as S and S' may be given access to the same group of trunks, as illustrated in the drawing, and a special arrangement may be added for breaking the circuit of the C relays simultaneously in order to start the switches in hunting operation, the switches having been previously raised by hand to the same level. Tests have been made in this way both with and without the resistance 30 and these tests have been made under the condition of releasing both C relays simultaneously and under varying conditions in which the release of one C relay is permitted to lag a varying amount of time behind the other C relay. These tests show that with the resistance 30 included it is very difficult to obtain a double seizure.

Without the resistance 30, when the C relays were released exactly together, both selectors invariably selected the first trunk, that is, a double seizure invariably occurred. Double seizure also occurred frequently when one C relay was permitted to lag behind the other one by as much as 15 milli-seconds, and double seizures were not entirely eliminated until the amount of lag was increased to about 22 milli-seconds. It may be stated that when one C relay is permitted to lag slightly behind, the switches occasionally interact, and this appears to become more frequent until the lag is increased sufficiently so that double seizure is entirely absent.

In testing the selectors with a resistance such as 30 included in their circuits, double seizure occurred only infrequently even under the condition of releasing the C relays exactly together. It would appear that this double connection should occur even with the improved circuit, if the C relays are released exactly at the same time. It is probable, however, that there was some slight difference in the adjustment of the relays and the rotary magnets of the selectors. By introducing only a slight delay in the release of one of the C relays so that this relay lagged behind the other one, double connections were practically all eliminated. A time lag of 7½ milli-seconds was sufficient to produce this result. The interaction between the switches is much more marked and frequently results in stepping both the switches past all of the idle trunks. This interaction was observed until the lag was increased to as much as 36 milli-seconds, which appears to be about the point at which normal operation entirely replaces interaction.

As intimated hereinbefore, it is hard to tell just why the circuit works the way it does. It appears to be certain, however, that the addition of the resistance, which is in shunt of the D relay at the time this relay is trying to pull up to seize a trunk, renders the D relay slightly slower to operate, which will delay seizure slightly and perhaps give other factors which tend to prevent a double seizure time to be more effective. The E relay has more chance to operate also, and drive the switch on to another trunk, because of the additional circuit which may be established through two of the resistances in parallel. This latter is undoubtedly at least partly responsible for the increased amount of interaction which is observed.

A fair estimate of the results secured by the improved circuit is that approximately 85% of the double seizures which would normally occur are prevented by the improved circuit arrangement. As noted, a considerable number of double seizures are prevented by an increased frequency of interaction between two selectors hunting simultaneously, and by an increase in the extent of such interaction, so that both selectors are frequently rotated past all of the trunk lines. Of course, this means that some calls are lost, but it is much better to have the calls lost in this way than to have them lost because of the double seizure of a trunk. When the selectors rotate past all the trunk lines they arrive in the eleventh position, in which position the rotation ceases and the subscribers are given a busy signal. Such calls, therefore, do not become a source of complaint.

The invention having been described, that which is considered to be new and for which the protection of Letters Patent is desired will be pointed out more specifically in the appended claims:

1. In a selector switch, an incoming test conductor, a test wiper, a switching relay connected between said conductor and wiper, and a non-inductive resistance normally connected between said conductor and wiper in shunt of said relay.

2. In a selector switch, an incoming test conductor, a test wiper, a switching relay normally connected between said conductor and wiper, contacts on said relay for shifting the connec-

tion of the wiper from the relay to said conductor, and a resistance connected in shunt of said relay until said contacts are operated.

3. In a selector switch, a test wiper, a stepping relay operated over said wiper when the same finds a grounded contact, and means in said selector for applying ground to said wiper through a resistance while the selector is operating, said resistance being high enough so that the ground placed on the test wiper thereby will not operate said relay, being low enough, however, so that said relay will operate if connected to ground through said resistance in parallel with a similar resistance in another selector.

4. In a selector switch, a switching relay having a resistance of about 1300 ohms, a stepping relay having a resistance of about 210 ohms, and a resistance which is more than 500 ohms and less than 1000 ohms connected between the incoming test conductor and the test wiper.

5. In a selector switch, a stepping relay which is operated over the test wiper of the switch when the wiper engages grounded contacts, a switching relay which is shunted by the engagement of grounded contacts by said wiper, said switching relay operating in series with said stepping relay when an ungrounded contact is engaged, and a resistance connected between said test wiper and ground during the hunting operation of the selector, the value of the said resistance being such that the stepping relay will not operate when supplied with current through said resistance and the switching relay in parallel but will operate when supplied with current through said resistance in parallel with a similar resistance in another switch.

6. In combination, a plurality of selector switches, trunk lines accessible to said switches, means for causing said selectors to hunt for idle trunk lines, and means in each selector whereby two selectors which started to hunt simultaneously are caused to interact and rotate over said trunk lines whether idle or not.

7. In combination, a plurality of selector switches, trunk lines accessible to said switches, means for causing said selectors to hunt for idle trunk lines, and means in each selector whereby two selectors which start to hunt simultaneously are prevented from seizing the same idle trunk line, said means operating by rendering such selectors capable of readily interacting with each other so that they will rotate past idle or busy trunks until all the trunks are passed over or one of them seizes an idle trunk to the exclusion of the other.

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