The step-by-step telephone switching system: Reverting calls

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ABSTRACT

In a multi-party telephone line (often called by civilians a "party line"), two or more subscribers' stations are connected to the same pair of conductors to the central office (the "line"). The point is to spread the considerable cost of the line over several subscribers' service, allowing service to be given at a lower rate. If a subscriber served by a multi-party line attempts (perhaps unwittingly) to call another subscriber on the same line, the call cannot be completed in the normal way. For one thing, the called line is already busy, and the switching system will not gladly connect to it.

Such a call, if it could somehow be completed, is called a *reverting call*, because the connection "reverts" to the line on which the call originated.

In the step-by-step switching system, two special provisions for completing such calls were in wide use. In this article, we describe their principles and some of the details of their operation. Considerable background is given on pivotal topics..

1 PREFACE

1.1 Reader background

It is assumed that the reader is generally familiar with the operation of the step-by-step switching system. Extensive information on it can be found in the other articles in this series.

1.2 The context

The context of this article is the Bell Telephone System. Non-Bell companies utilized many schemes and details only rarely, if at all, practiced in the Bell System.

1.3 Great diversity

Although "consistency" was a principal tenet of the Bell System's operation, that hardly meant "uniformity". The technical details of the systems and their operation were enormously diverse. In an article like

this, one dare not say “always” or “never” or “there were three different ways such-and-such was done.” The techniques and operational details I describe are intended to give the reader the flavor of the prominent techniques. But consider every statement to be modified by an unseen “Well, not always”.

2 INTRODUCTION

2.1 Multi-party lines

In a multi-party telephone line (often called by civilians a “party line”), two or more telephone subscribers’ telephone stations are connected to the same pair of conductors (the “line”) to the central office. The point is to spread the considerable cost of the line (and the line’s portion of the equipment at the central office) over several subscribers’ service, allowing service to be given at a lower rate.

2.2 Reverting calls

If a subscriber having service over a multi-party line calls a number for a station that, as it turns out, is served by the same line (and the calling subscriber might well have no idea of that), the call cannot be completed in the regular way. For one thing, the switching system will find that the called number is busy (because, of course, its line is in use by our hapless subscriber trying to make a call to that number).

And, if the switching system could get beyond that, it could not ring the called station because there was already a station off hook on its line, namely the station of our hapless calling subscriber. If the system did apply ringing to the line, it would immediately be “tripped”, as normally happens when the called station answers.

A call from one station on a line to another station on the same line (if we could make such a thing happen) is called a *reverting call*, because the telephone “connection” **reverts** to the same line on which it originated.

Of course the telephone industry did not just wish to declare reverting calls “intrinsically doomed”. So, as with every other need in the telephone network, many schemes and systems for actually accomplishing reverting calling were devised.

3 THIS ARTICLE

The overall matter of multi-party lines is unimaginably complicated, and even this “small” aspect of it (reverting calling) is gigantically complicated.

In this article, I will give some background on multi-party line operation, and then I will describe several systems used to make

revertive calling possible. Emphasis will be on the overall principles of operation. I will make no effort to give detailed circuit descriptions of the various circuits involved.

4 MULTI-PARTY LINES

4.1 "Station" and "party"

The "parties" alluded to in the name "multi-party line" are of course the multiple "users" (actually always spoken of "in the day" as "subscribers", but more recently as "customers") given service over the line. Perhaps a four-party line serves Joe, Mary, Bill, and Claire. But of course these four humans are not connected to the line; it is their telephone "stations" that are connected to the line.

But many arbitrary expressions have arisen over the years in this field. And in certain turns of phrase, "party" actually refers to the *station* of one of the parties. Here, I will, wherever possible, consistently refer to "station" when that is meant.

4.2 Ringing signals for multi-party operation

4.2.1 *Introduction*

So that the subscriber at a called station will recognize when a call is coming over the line for that station, different ringing "signals" are used for the different stations. These are distinguished by one or more of the following distinctions:

a. Applying the ringing signal from the ring or tip conductor to ground. (This is spoken of as "divided" ringing.)

b. Using a signal in which the DC component of the voltage is negative or positive. (This is spoken of as "superimposed" ringing.)[1]

c. Sending different patterns (cadences) of ringing. (This is spoken of as "code" ringing.) This was the premise of that old tag line, "That's my ring!" One modern set of ringing codes is shown here.

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[1] The term comes from the fact that this ringing signal has both AC and DC components, and can be thought of as an AC voltage and a DC voltage "superimposed". The irony is that the "ordinary" kind of ringing, used for individual lines and for two-party lines via the distinction in item a, is every bit entitled to the description "superimposed".. But the term "superimposed" is rarely used in connection with that ringing signal, being only used in connection with ringing signals drawing upon the distinction in item b.

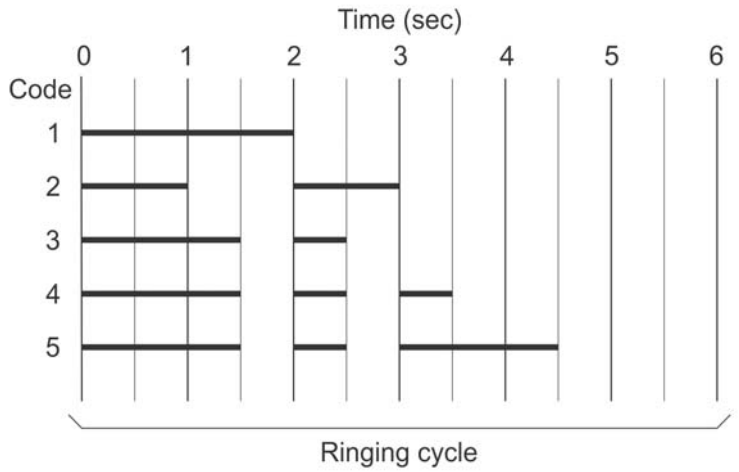

Figure 1.

d. Having the AC component of the ringing signal at different frequencies. This was only very rarely used in the Bell Telephone System, and I will ignore it from here on.

4.3 Selectivity

This refers to the matter of whether the ringer at a certain station only rings on calls for that station.

In a *full-selective* ringing system, only the ringer at the called station rings.

In a *semi-selective* ringing system, at a given station, the ringer will ring for calls to that station and certain other stations on the same line, but not for all stations. (The distinction to the subscriber between what is heard for a call to his station and what is heard for a call to another station is by way of different ringing codes.)

In a *non-selective* ringing system (although that term is rarely used), the ringers at all stations ring for calls to any stations. Again, the distinction to the subscriber is made by way of different ringing codes.

4.4 Commonly-used services

The following multi-party line services were widely used in the Bell Telephone system.

1. Individual line. (This is a “single party” line, and is included in the list only for completeness.) Ringing can be thought of as on the ring lead and with a negative DC component, but the ringers ignore the latter. The ringing system is not usually named.

2. Two-party line (full selective). This uses distinction **a** (in section 4.2). The ringing system is called “divided”.

3. Four-party line, semi-selective. This uses a combination of distinctions **a** and **b** (two ringing codes used, “one-ring” and “two-ring”). The ringing system is called “divided-code”.

4. Four-party line, full-selective. This uses a combination of distinctions **a** and **b**. The ringing system is called “four-party full selective”.

5. Eight-party line (semi-selective). This uses distinctions **a**, **b**, and **c** (with two ringing codes). The ringing system is called “eight party semi-selective”.

6. Ten-party line (semi-selective). This uses a combination of distinctions **a** and **c** (with five ringing codes). The ringing system is called “ten party semi-selective”.

4.5 Terminal-per-line and terminal-per-station operation

4.5.1 *Introduction*

In step-by-step switching systems, two different basic architectures were used for handling multi-party lines. These cast shadows on the systems used for handling reverting calls, so I will discuss them briefly here.

4.5.2 *Terminal-per-line (TPL) operation*

This was primarily used in smaller offices, typically in rural areas. It was deprecated in later times. In such systems, all the parties on a given line had telephone numbers that were identical except for the last digit. That last digit directly indicated the ringing signal to be used for that party.

In such systems, all the dialed digits except the last three lead the connection to a connector in the group handling that block of 1000 numbers (which embraced 100 lines). The first two of those last three digits move the connector to a certain terminal (just like the last two digits would in the more familiar arrangement). All calls to any station on **that line** went by way of that terminal (thus the name of the arrangement).

The last digit then operates a small stepping switch in the connector. It puts into effect the ringing signal indicated by that digit, which will be used when that line is rung.

4.5.3 *Terminal-per-station (TPS) operation*

This was the more common approach in larger offices and those in metropolitan areas. In such systems, the numbers of the various parties on any given line were essentially independent.

All the digits of the number except the last two lead the connection to a connector in the group handling that block of 100 numbers. The last two digits move the connector to a certain terminal, which corresponds to the telephone number of the **called station** (thus the name of the arrangement).

In one of several ways (in part described in section 4.6), the connector "knows" the ringing signal for the station with that number, which will be used when that line is rung.

4.6 Control of the ringing signal

4.6.1 *Introduction*

In the step-by-step switching system using the terminal-per-line architecture for multi-party lines, with respect to "regular" calls, the proper ringing signal for the called station was most often produced by the application of one or more of the following, as applicable to the ringing plan for a certain line.

4.6.2 *The "side of the line" aspect*

Applying the ringing signal to the ring or tip conductor is often spoken of as applying it to one side of the line or the other.

The connector switch (the last switch in the connection) normally applies the ringing signal to the ring conductor of the terminal for the called number. But for all stations for which the assigned ringing signal is to be sent over the tip conductor, the wiring inside the central office from the connector terminal to the line itself is "turned over"[2]. Thus when, for such a number, the connector applies the ringing signal to what it sees as the ring of the line, that is actually the tip.

4.6.3 *The "DC polarity" aspect*

Commonly different "hundreds blocks" of numbers are reserved for station whose ringing signals involve negative and positive DC components.

The groups of connectors accessing those different hundreds blocks of numbers are wired to either use a ringing signal with a negative or positive DC component (both "waveforms" distributed from the "ringing plant")..

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[2] This is done with the "jumpers," on one or the other of two *distributing frames*, that make semi-permanent connections inside the central office to configure lines for service.

4.6.4 *The "ringing code" aspect—two codes*

When only two codes are involved, commonly different hundreds blocks of numbers are reserved for stations whose ringing signals will include "1-ring" or "2-ring" ringing codes.

The groups of connectors accessing those different hundreds blocks of numbers are wired to either use a ringing signal with a "1-ring" or "2-ring" ringing code.

4.6.5 *Pick up operation*

The "2-ring" connectors include a special feature not normally found in the "1-ring" connectors.

If certain party's ringing code were "2-ring" (two medium-length bursts separated by a short quiet period, the pairs being separated by a longer quiet interval), and the connection was established just as the ringing interrupter for the two ring cadence was between the two bursts of a two ring sequence, the subscribers on the line might first hear a single (perhaps shortened) burst of ringing. If a subscriber not being called had a "one-ring" ringing code, he might think this call was for him, and before hearing the next cycle (in which the two ring pattern was clearly evident) answer the call, which was not for him.

To avert this, usually when code ringing is used, and a call will use a code other than "one ring", the connector switch is arranged not to actually apply ringing until the beginning of a ringing cycle. This involves a special lead running from the ringing interrupter system to all connectors. It carries a brief ground pulse just before the beginning of the master ringing cycle. This is called the "pick up" pulse, and the lead is called the "pick up lead".

4.6.6 *The "ringing code" aspect—five codes*

10-party operation (semi-seelctive) usually involves the "side of the line" distinction as well as a set of 5 different ringing codes (perhaps as seen in figure 1). Rather than having five groups of connectors, serving five different sets of number hundreds blocks, with each group of connectors wired to apply a different ringing code, a special connector (a *10-party connector*) is often used. It can apply any of 5 different ringing codes, depending on the station called. (The "side of the line" aspect of the ringing signal is handled as discussed in section 4.6.2.)

In such a connector, at each station terminal, in addition to contacts for the usual tip, ring, and sleeve (T, R, and S) leads, there is a fourth contact (A). This carries, in the form of ground pulses, the actual ringing code cadence for the code assigned to that station. This operates a relay in the connector that "keys" the ringing signal.

Usually, “pick up” control of the start of ringing is used regardless of the code involved.

5 THE ODD NATURE OF REVERTING CALLS

5.1 Introduction

All the revertive call handling scheme we will learn of here revolve around maneuvers that run wholly counter to the general principles of call handling in a telephone system. My challenge here is to teach the details of cricket to people who have only thought about baseball.

To help the reader follow the details of the various schemes, I will first describe models of two of these maneuvers that play a role in all the schemes.

5.2 A model “first maneuver”

Imagine a residential metropolitan area where two-party service is offered.

Suppose Billy (who had two-party service) got Jane’s telephone number in their biology class. After supper, Billy tries to call Jane, but the line is busy. He tries two more times that night, with the same result. “Wow”, he thinks, “she must really be popular.” The next night he tries again several times, with the line always busy.

Billy calls the “operator”. He tells her that he was trying to call BOulevard 0075, but it has always been busy for two days, and he thought the line might be in trouble.

The operator asks Billy for his number, does some checking, and tells Billy, “That is because that number is on the same party line (!) as yours.” (Billy of course would have had no way to know that.) The operator tells Billy how he can complete the call. How that is depends on the scheme that applies. We’ll see the details shortly.

5.3 A model “last maneuver”

After some preliminaries (varying with the system—we’ll see the details shortly), the calling subscriber hangs up. The system then rings both parties. If code ringing is involved, the called party will hear “his” code. The calling party may hear his usual ringing code or the called party’s code, or perhaps a special cadence that is not any station’s code. In any case, this tells the calling subscriber that the revertive ringing is proceeding.

The called subscriber, responding to the ringing at his station (in his code, if code ringing is involved), answers, not realizing that this is not a “regular” call. When he answers, ringing is “tripped” just as for a regular call. The ringing is stopped, and the line is connected to a

source of “talking battery”, which will allow two stations on the line to communicate in a sort of intercom fashion.

When the calling subscriber notices that the ringing (in whatever cadence) has ceased, that tells him that the called party has answered. So he picks up his phone and greets the called subscriber, who has probably earlier said “hello” (which the calling subscriber might well not have heard).

When the conversation is done, and both subscribers hang up, there is no longer any DC current in the line. The battery feed circuit notices this, and causes the connection to be released.

5.4 Good grief!

We can see, from the “model” first and last meneuvers just described, that the handling of reverting calls is, compared to the handling of “regular” calls, pretty clumsy.

The good news, in, for example, a residential metropolitan area, is that it is very unlikely that someone you wanted to call was in fact served on the same line as yours. The other party(ies) on your line probably lived a block or two away. Maybe one of them is a classmate, but you never had any reason to call him.

In rural areas, the story might be quite different. In an extreme case, 15 farms along a certain rural road might all be served by two lines. It would be very likely that you might want to call a neighbor, and there was perhaps a 50% chance that his station was on the same line as yours.

So, clumsy or not, the residents of that road learned how to use the revertive call handling system that was available.

6 THE REVERTING CALL SELECTOR

6.1 Introduction

The *reverting call selector* scheme for handling reverting calls was widely used in step-by-step offices for handling reverting calls on most types of multi-party line.

6.2 In terminal-per-line systems

6.2.1 *Introduction*

This form of the reverting call selector scheme was used in step-by step central offices providing party line operation on a *terminal-per-line* basis (see section 4.5.2).

6.2.2 *Basic operation*

Recall that in such systems, all stations (parties) on a line had the same number except for the last digit. Then last digit of the number indicated the ringing signal for the station (unique as to the side of the line, the polarity of the DC component, and/or the ringing code).

We note that a moderately alert subscriber, wanting to call a certain number, can recognize it is on the same line as his station by the fact that all digits of the two numbers but the last were the same, and may thus recognize that this will be a reverting call. For now we will assume he knows how to do that (perhaps having diligently read the instructions in the front of the directory), and as a consequence, will not end up calling the operator for guidance.

The calling subscriber dials a service code (typically three digits[3]), presumably found in the front of the directory, to reach the reverting call selector (of the type appropriate his type of line).

Note that, unlike the other selectors in the step-by-step system, which advance the emerging connection to the next stage, the reverting call selector is the destination of this connection. (And thus it might better have been called a “reverting call trunk”, but because ii is physically made like a selector, and has the same central mechanism . . .)

In some cases, the caller receives a tone signal (perhaps dial tone or some variant) to confirm that he has reached the revertive call selector.

The caller dials the last digit of his number, and then the last digit of the number he wants to reach. These set the two motion switch mechanism in the selector to a position where its wipers set up the selector to apply, on behalf of the calling station, its ringing signal, and, on behalf of the called line, its ringing signal. Then the caller hangs up.

The selector than, back over the connection that brought the calling station to it, rings (alternately) the calling and called stations, using their respective ringing signals.

The subscriber at the called station hears ringing (if coded ringing is involved, with his familiar ringing code), and recognizes this as a call for his station. The calling subscriber hears ringing (if coded ringing is involved, with his familiar ringing code). This tells him that the revertive call is proceeding.

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[3] “In the day”, when step-by-step systems used service codes of the form “11x”, the code for the reverting call selector was often “119”.

When the called subscriber answers, ringing is “tripped”. All ringing is halted, and the line is connected to a “taking battery” supply, which allows both stations on the line to communicate in an “intercom-like” way.

When both parties have hung up, there is no longer any DC current in the line. That is detected by the battery feed relay in the system, causing the selector to release, which in turn releases the connection leading to it.

6.2.3 *But if the subscriber is not that alert*

But suppose that the calling subscriber doesn’t notice that the number he wants to call and his are the same except for the last digit, or notices that and just considers it coincidence, and in any case has not read the description in the front of the directory of what reverting calls are and now to make them.

So after repeatedly getting a busy signal when trying to call that number, like Billy in the parable above, he calls the operator. When she finds he is trying to call 8-6158, and his number is 8-6154, she advises him that this is a reverting call and schools him in how he should make it.

6.2.4 *Ringing the calling party first*

Where possible, when the system begins to ring both stations, the first ringing “burst” that is sent is for the calling station. The reason is that if the first burst were for the called station (and assuming the under the ringing system in use that was not heard by the calling party), and the subscriber there was right by the telephone, and answered right away, ringing would be tripped before the calling party heard any ringing, and so the scenario would fail.

This timing relationship is implemented by way of the pick up functionality described in section 4.6.5.

6.2.5 *Special ringing cadences*

Sometimes, where the multi-party line uses code ringing, this scheme involves the use of ringing cadences that, while sounding like familiar ones, actually had slightly different timing, to make the “interleaving” work out.

In some cases, the ringing sent to the calling party uses a special distinctive cadence, so that the caller realizes that in fact his reverting call is underway (and that he is not, by an accident of timing, receiving an ordinary call from someone else).

6.2.6 *Another wrinkle*

If the ringing signals for the two stations are both on the same side of the line and with the same DC polarity, but differ only in terms of the ringing code, to follow the principle exactly we would have to send, on that side of the line, with that DC polarity, both ringing codes. The resulting cadence would be a mish-mash, and the called subscriber could not be reasonably be expected to recognize his station's code in it and realize that this was a call for him.

So in this situation, the system sends, on that side of the line, with that DC polarity. just the code for the called station. The called station subscriber recognizes that, and will answer. At the calling station, the subscriber hears this and knows this is not his station's code, but he knows that this is a reverting call scenario, and so any ringing (with whatever cadence) will tell him that the reverting call is preceding, and when it stops, will tell him that the called station has answered.

If there are other stations on the line, whose ringing is on that same side of the line and with that same DC polarity (but having a different code), they will also hear this ringing (just as if this were a regular call to this called party), and they will ignore the ringing.

6.3 In terminal-per-station systems

6.3.1 *Introduction*

This form of the reverting call selector scheme was used in step-by step central offices providing multi-party operation on a *terminal-per-station* basis (see section 4.5.3), mostly for 2-party, 4-party (semi-selective of full-selective), or 8-party semi-selective lines. 10-party lines most often made revertive calls by way of a reverting call connector (see section 7).

6.3.2 *General principle of operation*

Imagine that a subscriber, like Billy in the parable above, finds a number he wants to call repeatedly busy. Like Billy, he calls the operator. She gives him the reason for his lack of success, schools him in how to use the reverting call selector, and gives him a specific two-digit number he will need call that specific station. (I will sometimes speak of this jocularly as the "magic number".)

The first digit of that number is an arbitrary digit that identifies the ringing signal for the calling station. The second digit is an arbitrary digit that identifies the ringing signal for desired called number.

So after reaching the reverting all selector, he dials that "magic number". Its two digits set the two motion switch mechanism in the selector to a position where its wipers set up the selector to apply, on

behalf of the calling station, its ringing signal, and, on behalf of the called line, its ringing signal. Then the caller hangs up.

The selector than, back over the connection that brought the calling station to it, rings (alternately) the calling and called stations, using their respective ringing signals.

The subscriber at the called station hears ringing (if coded ringing is involved, with his familiar ringing code), and recognizes this as a call for his station. The calling subscriber hears ringing (if coded ringing is involved, with his familiar ringing code). This tells him that the revertive call is proceeding.

When the called subscriber answers, ringing is “tripped”. All ringing is halted, and the line is connected to a “taking battery” supply, which allows both stations on the line to communicate in an “intercom-like” way.

When both parties have hung up, there is no longer any DC current in the line. That is detected by the battery feed relay in the system, causing the selector to release, which in turn releases the connection leading to it.

Note that once this scenario has played out, the subscriber can use that same pair of digits any later time he wants to call that same number (if he had the presence of mind to write them down someplace); he need not contact the operator again to do so.

6.3.3 *Does this story sound familiar?*

The reader may notice that this story is almost identical to the eralier story for the use of a reverting call selector in a system handling multi-party lines on a terminal-per-line basis. The difference is that, in the former situation, the calling subscriber (if he knows how) can himself determine the equivalent of the “magic number” just from the last digits of his number and the called number.

6.3.4 *For 4-party semi-selective ringing*

When the lines involved use 4-party semi-selective ringing, only a one-digit “magic number” is needed to define the ringing for both stations.

Accordingly, the mechanism of the selector is a degenerate form of the regular step-by-step two motion switch mechanism, only able to step in the rotary direction, that done in response to the one dialed digit.

It might seem at first that there would be 12 possible combinations of (two different ones of) the four distinct ringing signals for the two

stations,[4] and those combinations could not all be separately invoked by a single digit.

But an interesting wrinkle means that we need not need be able to choose among that many different combinations.

First imagine the case in which the two stations' ringing are on different sides of the line). There are four possibilities for that[5].

In such a case, the reverting call selector sends the normal ringing signal for each of the two stations on the appropriate side of the line. (the ringing bursts are interleaved in time) Each party will hear his familiar code, the called party to realize that this is a call for him, the calling party so that he knows that the reverting call is proceeding, and so he can tell (when the ringing stops) that the called party has answered.

Next imagine the case in which the two stations' ringing are on the same side of the line, of necessity with different codes. We cannot (in any reasonable way) send both ringing codes on that side of the line. If we tried to, the stations would hear a mish-mash, and the called subscriber could not be expected to recognize his code in it and realize that this was a call for him.

So we send only the called station's signal on that side of the line. There are four possibilities for that[6].

That way the called party will recognize the ringing as being for a call to him. The calling party will of course hear that code, which is not his familiar one.

But the calling party knows that this is a revertive call scenario, and in such a situation, for the calling party all that is really needed is that he hear some ringing, so he knows that the reverting call is proceeding, and so he can tell (when the ringing stops) that the called party has answered. So this action will perfectly well serve that purpose.

Under this scheme, there are only eight different combinations overall of ringing signal that ever need to be sent, which of course can be distinguished with a single "magic digit".

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[4] The signal for the calling station could be any of four, and for each of those cases, for the called line (which by definition has a different signal) the signal could be any of the remaining three, a total of $4 \times 3 = 12$ possibilities.

[5] One or two-ring cadence on one side of the line, along with one- or two-ring cadence on the other side of the line.

[6] One- or two-ring cadence, on one side of the line or the other..

This scheme does not support the luxury of always having the first burst be for the called station.

6.3.5 *For two-party ringing*

For a two-party line, only a single ring cadence (1-ring) is used, sent on one side of the line or the other for the two stations. Thus, in a reverting call, the ringing signals for the two stations are the same except for being on opposite sides of the line.

There is no need for the calling subscriber to acquire, and dial, any “magic number”. In the ringing phase of a reverting call, the selector always sends bursts of the basic ringing signal on the two sides of the line (alternating in time). Each station hears its familiar ringing cadence (always “1-ring”).

7 THE REVERTING CALL CONNECTOR

7.1 Introduction

This system is primarily used for 10-party service, but the basic principle would be equally applicable to other multi-party line types. It is mostly more convenient for the calling subscriber than the reverting call selector method.

This system does not require the calling party to, in advance, be aware that the number he wishes to reach is in fact served on his line, or to deduce that from getting a lot of busy signals. Nor does he need to contact an operator to get a “magic number” to use in the process. He does, however, need to know how to work the reverting call system. (There will usually be a tutorial in the front of the directory.)

7.2 Some basics

A reverting call connector is not only used for reverting calls. The terminal reached on a certain connection might be on the same line as the calling station, but most often would not. Thus, on each connection where the called line is found busy, the switch must ascertain whether this will be a reverting call or not, and behave quite differently in the two cases.

The way it does that depends on the fact that, if the called number is for a station on the same line as the calling station, the sleeve lead of the called station (reached by the connector wipers) is in fact the same lead as the sleeve lead of the calling station (brought to the connector over the connection through the earlier switches); it is the single sleeve lead for the line on which both stations are served.

On every call, the connector, in effect, makes a “continuity check” between those two sleeve leads. If that reveals that they are indeed the same lead, the connector goes into its “reverting call” mode.

We will see in some detail how that is done in the two following sections.

7.3 Call to a number whose station is not on the same line as the calling station (not a reverting call)

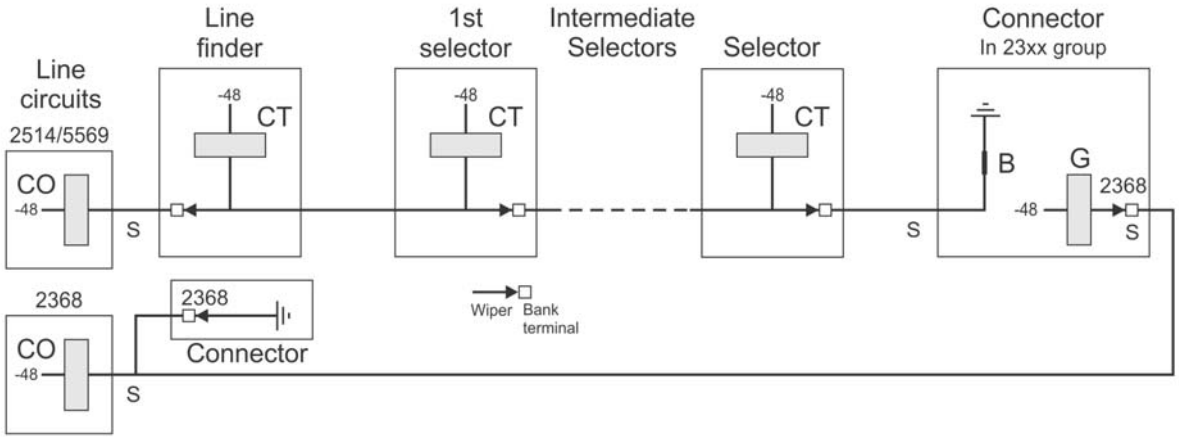

Figure 2.

7.3.1 *Conventions*

In this figure and those to follow, a relay core shown shaded indicates that the relay is operated. The relays in the line finder and selectors I have arbitrarily designated CT in the figures are the *cut through* relays. They extend the connection to the next switch, and, when operated, prevent their switch from releasing. They hold to the S (sleeve) lead.

7.3.2 *Connection completed*

This figure shows a connection that has been established from a certain multi-party line (its numbers are 2415 and 5569) to the number 2368. Although it doesn’t really matter here, imagine that the station calling is the one whose number is 2514.

The path we see through the earlier is that for the sleeve (S) lead of the calling line, which plays a critical role in this story. Of course it is accompanied by the matching ring (R) and tip (T) leads, which we don’t see yet, and which don’t really figure in this story.

CO is the designation for the cutoff relay in a line circuit. When operated it frees the line from the L (line) relay in the line circuit (not shown), which detects when an idle line has some off hook to request service.

In this figure, the connection has been built up through the line finder and several selectors to a connector in the proper group (the one accessing 23xx numbers). When the connection reaches the connector, the A relay (not seen) operates and it operates the B relay. The B relay grounds the incoming sleeve lead, which holds operated the CT relays in the line finder and the various selectors, which in turn hold the respective switches operated, and holds operated the CO relay in the line circuit.

The last two digits have then been dialed into the connector, driving it to terminal 2368 (not the number of a station on the same line as our calling station). The connector tests the sleeve of that terminal through the winding of the G relay to battery, to ascertain if that sleeve is grounded, which would indicate that the called station is busy. And in the example, we assume that the called number's line is indeed busy, by way of a wholly-unrelated existing call through another connector.

That other connector has grounded the sleeve of the line serving that number. This operates the CO (cutoff) relay in the line circuit for that line, freeing that line from its L relay, and the ground on the sleeve "marks" the line as busy, so no other connector will attempt to connect to it if another caller dials that number.

7.3.3 *The called number tests busy*

So "our" connector finds that the sleeve of the line for the called number is indeed grounded; it finds this out when its G relay operates.

The immediate result is that the connector returns busy tone back though the connection to the caller. The calling subscriber, believing that the called number is busy (and in this case it is) will soon) hang up. And if our connector did not have reverting call capability, that would be almost the end of the story. The A and then B relays in the connector would be released, the connector would take ground off the sleeve lead, the CT relays we see in the line finder and selectors would release, and all the switches themselves (including the connector) and the CO relay would release.

7.3.4 *Is this a reverting call?*

But "our" connector does have reverting call capability, and so when the called number is found busy, and the calling station hangs up, it proceeds with some further work before releasing the connection. We see the next stage of that work here.

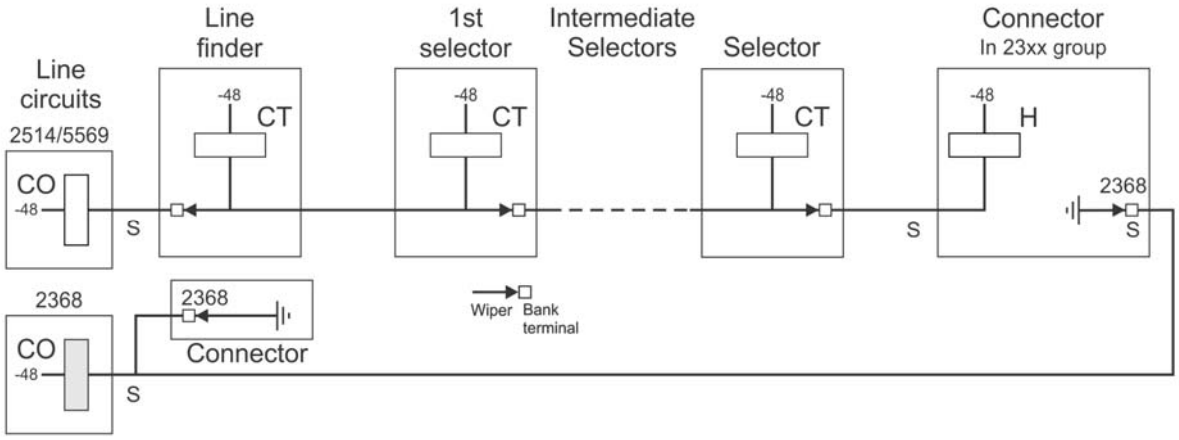

Figure 3.

In this stage, the connector:

- Removes ground from the incoming sleeve lead and connects the sleeve through the winding of relay H to battery.
- Grounds the sleeve wiper and thus the sleeve of the called number.

The called number sleeve is already grounded (because 2368's line is already busy elsewhere), so the ground applied by our connector does nothing. And it will only remain in place for a very short time.

But now there is no ground on the sleeve through the connection to hold the CT relays and the CO relay operated, or to operate the H relay in the connector.

7.3.5 *Release of the connection*

The result, just as if the connector did not have the reverting call feature, is that the CT relays and the CO relay release, and all the earlier switches release.

The fact that the H relay does not operate tells the connector that this is not a call to a number on the same line as the calling station. So the connector does not go into the reverting call mode, but just releases. That removes the "redundant" ground on the sleeve of number 2368.

7.4 Call to a number served on the same line as the calling station (a reverting call)

7.4.1 *Connection completed*

After all the digits of the called station (5569) have been dialed, we have the situation seen here.

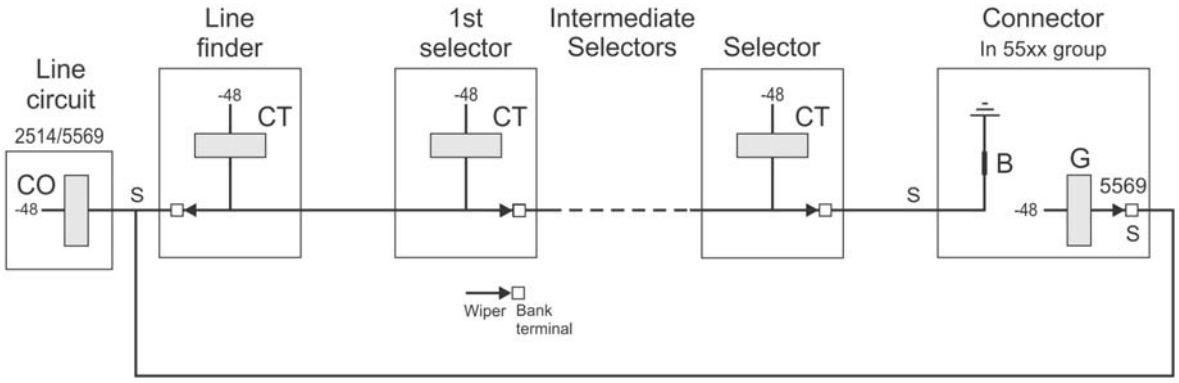

Figure 4.

We note, for future reference, that, as was described in section 4.6.6, the "A" wiper of the connector is now receiving a sequence of ground pulses carrying the ringing cadence assigned to that called station.

So far as the situation on our connector is concerned, this is the same as we saw for the earlier case. But the difference is that the sleeve lead found grounded by the connector, on terminal 5569, is in fact the same sleeve lead as is coming forward through the connection (on behalf of calling station 2514).

7.4.2 *The called number tests busy–is this a reverting call?*

As before, G operated causes busy tone to be sent to the calling station. Again we assume that the calling subscriber shortly hangs up. (He presumably has no idea he has dialed the number of another station on the same line as his station. But, as before, since this connector has the reverting call feature, it does some more work before it releases. We see the first stage of this here.

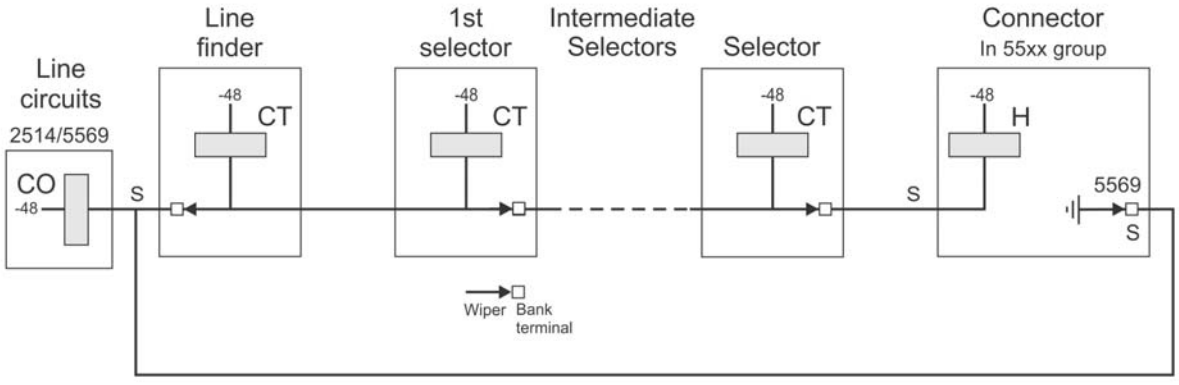

Figure 5.

As in the earlier case, the connector removes ground from the incoming sleeve lead and connects the lead through a winding of the H relay to battery. And it grounds the sleeve wiper.

But now, because the sleeve that the wiper is on is in fact the sleeve of the calling line, the sleeve running through the switch train is still grounded (now from its "line finder end"), the CT relays remain operated, keeping their switches "up", and the H relay operates.

7.4.3 *It is a reverting call*

The H relay being operated tells the connector that this must be a reverting call. So the connector "shifts into the reverting call mode". It removes the ground from its the sleeve wiper. Then the situation is this:

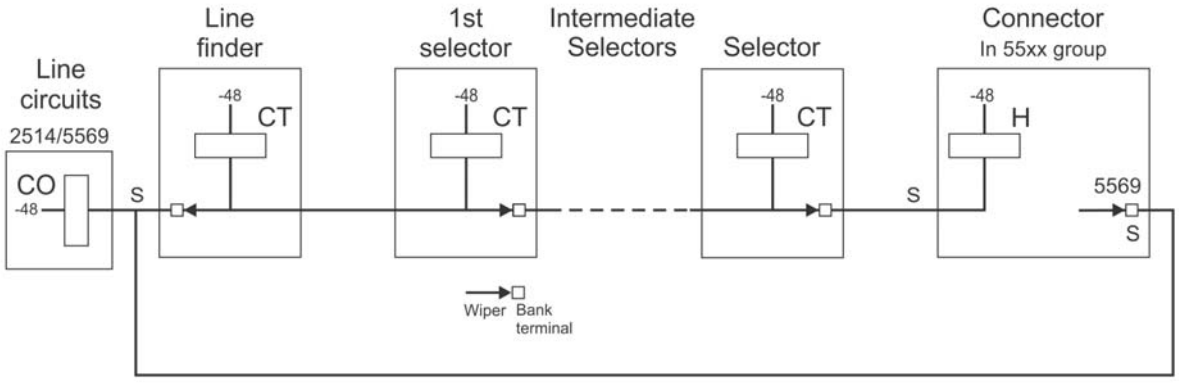

Figure 6.

7.4.4 *Releasing the connection except for the connector*

With no ground now (from either end) on the sleeve lead running through the switch train, the CT relays and CO release, the line finder and all selectors release, and H releases. But the connector, **being in the reverting call mode**, does not itself release. It waits to do the revertive call ringing operation. The situation is now this (we see now the ring and tip leads, which soon will deserve more attention.)

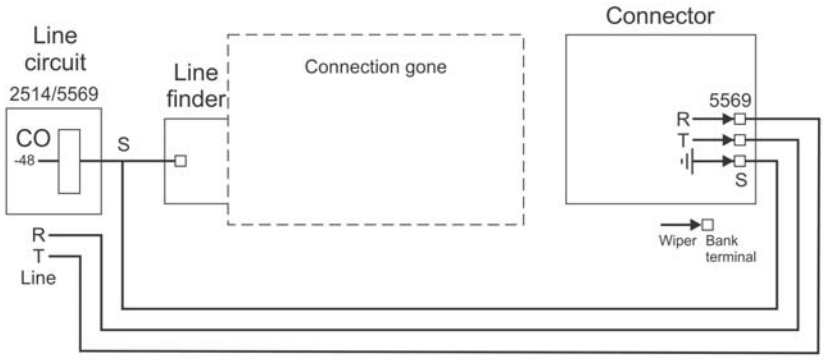

Figure 7.

The fact that the sleeve lead for the line is not now grounded gives the possibility that another call to either of the numbers on the line would find the line apparently idle and make an improvident connection to it. But this situation will be eliminated very shortly.

The release of the CO relay reconnects the L relay of the line circuit to the line. But at this moment, there is no station off hook on the line, so the L relay does not operate. (If it did operate, it would start some line finder looking for the line to give it service!)

If the connector tried to ring the two stations on the line when things are in this state, the L relay would provide a DC path to prematurely "trip" the ringing. But stay tuned—all will be well.

As soon as the connector confirms that the earlier part of the switch train has released (from the release of its A and then B relays), it re-grounds its sleeve wiper, again marking the line busy (hopefully before any other call has "dropped in"). The CO relay in the line circuit re-operates to again free the line from any encumbrance from the L relay in the line circuit. The situation is now this:

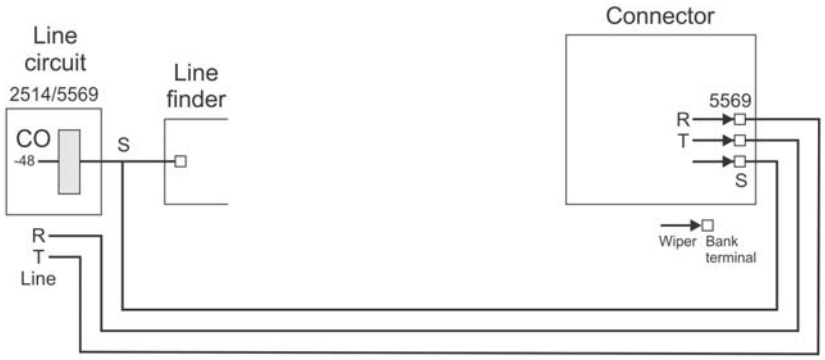

Figure 8.

7.4.5 *The reverting ringing process*

The connector then applies the ringing code for the called station (generated by the relay following the A lead on the called station terminal) to what the connector sees as the ring conductor of the line (via the ring contact on the wiper). (Of course, if the called station is assigned ringing on its tip conductor, the jumper from the connector terminal to the line is "turned over", so that ringing is actually applied to the tip of the line.)

If the calling station has its ringing assigned to the same side of the line as the called station, both those stations hear ringing. It of course is the code for the called station. The subscriber at the called station recognizes this code, and knows this is a call for him. For the subscriber at the calling station, all that is important is that he hear some ringing, so he knows that revertive ringing is proceeding, and, when it stops, he will know that the called station has answered.

But what if the calling station has its ringing assigned to the opposite side of the line as the called station (and the connector doesn't know if this is so or not).

Twice in every full 6-second ringing cycle (during what is a gap between ringing bursts for all five codes), a relay in the connector applies, for about one-half second, ringing voltage to what the connector sees as the tip of the line.

So, if in fact the calling station has its ringing on the opposite side from the called station, the calling station hears only this odd cadence of short ringing bursts (the “revertive ringing signal”), but that is sufficient to advise the calling subscriber that revertive ringing is happening, and when it stops.

In any case, when the called subscriber answers, ringing is “tripped”. All ringing is halted, and the line is connected to a “taking battery” supply, which allows both stations on the line to communicate in an “intercom-like” way.

The calling subscriber recognizes that the ringing he has been hearing (whatever cadence it has) has stopped, so he picks up the phone and the two parties converse.

When both parties have hung up, there is no longer any DC current in the line. That is detected by the talking battery feed relay in the connector, causing the selector to release, which in turn releases the connection leading to it.

8 IN MODERN TIMES

In modern times, the role of true multi-party lines has greatly diminished.

Nevertheless, modern switching systems can support multi-party lines of various kinds, and generally can provide a less clumsy way of dealing with reverting calls that the schemes described above. Sometimes, if the caller dials a number served by the same line, a voice announcement will advise of the situation, and advise the caller how to proceed.

Still, the scenarios generally follow the core concept described in the body of this article, albeit implemented in a much different way.

But this is well beyond the announced scope of this article.

9 RELEASE RECORD

Issue 1, October 29, 2020 (this issue). Initial issue.