Operation of traditional coin telephones

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ABSTRACT

Telephone-company provided coin-operated telephones ("payphones") were at one time ubiquitous around the world, where they were an important part of the culture.

Various schemes of operation were in use over the years in various of the world regions, and the technical aspects were complicated and intricate.

In this article, I identify several "mainstream" modes of service and operation for coin telephones as followed in the US and Canada, generally applicable up through perhaps 1960, and many of its principles beyond that, and explain their operation in some detail.

Emphasis is on operational and circuit principles rather than on the physical construction and appearance of the telephone sets (although there is some attention to those aspects).

Pertinent background is given on the telephone system infrastructure within which these telephones operated.

Appendixes cover in further detail various of the topics.

1 INTRODUCTION

For many years, coin-operated telephones (hereinafter, generally, "coin telephones"), then provided exclusively by the local telephone company, were a ubiquitous fixture on the streets and in the shops of every city around the world (even in some homes). They were, everywhere, an important part of the culture.

Of course today the near-ubiquity of wireless ("cellular") telephones has rendered the "payphone" essentially obsolete, and there are few of them still in service.

A great deal of ingenuity was exercised over the decades in the design of these telephones and the special provisions in the telephone network for supporting their operation. My hope here is to capture some of this and to give some appreciation of it.

In any case, I thought it nice to open with this charming illustration.

Figure 1. "We need a ride home"

It is the frontispiece of the 1912 general catalog of the Gray Telephone Pay Station Company, which essentially developed the "modern" coin telephone and which for many years supplied them to both the Bell Telephone System and non-Bell telephone companies.

2 CAVEAT

Many aspects of the evolution of the different protocols described herein, and the motivations for them, have been lost (at least to me) in the fog of history. This story has largely been reconstructed by the author from myriad historical fragments and clues found in available documents. I may well have gotten some aspects of the story wrong. Readers with knowledge contrary to the story as I present it here are encouraged to contact me with their information.

Further, in this area (like any other in the matter of the telephone network), there were many alternatives and many small (but important) details. My discussion ignores many of those (in many cases I do not even know of them), the objective being to most clearly explain the crucial concepts that apply to almost all situations.

3 SCOPE

3.1 Introduction

The operation of coin telephones is a very complex field, and over the years there have been used many variations on a few basic themes.

My purpose here it not to try to cover this immense waterfront but rather to introduce and illuminate the important principles involved, which in various ways differ from the principles of ordinary telephone operation. In the rest of this section, I will identify that “filter”.

3.2 Geographic range

I will be discussing the practices that were common in the US and Canada. Practices in other countries vary substantially from this.

3.3 Switching mode

Coin telephones operating under the general concept discussed herein were introduced when telephone switching was universally conducted with manual switchboards, and the origins of the protocols discussed herein are from that context. However, with the exception of one short mention, the discussions in the body of this article are all in the context of *machine switching* (“dial”) operation. However, the principles involved in prepay coin telephone operation in manual switching systems are discussed in some detail in Appendix B.

3.4 Ownership of the coin telephone

3.4.1 *By the telephone company*

For the preponderance of the era of interest, it was the universal policy of telephone companies (both Bell Telephone System and non-Bell) that only the telephone company could provide the telephone set(s) on a customer’s line. This applied as well to coin telephones, and the technical working of the coin telephone system depended on an intimate and parochial collaboration of the coin telephones with the telephone company central office equipment. (This is the situation I will discuss.)

3.4.2 *By others*

As part of the policy changes that were eventually fully codified at the breakup of the Bell Telephone System in 1984, it became possible for customers to provide their own telephone sets. These had to conform to an industry standard for their interface with the telephone network. It was an important part of the new policies (and that standard) that the telephone company central offices **would not** support “traditional” coin telephones provided by the customer.

But it was eventually also made clear that a customer could connect to their telephone line a coin telephone that, to the telephone network, looked like a regular telephone set (and meet the interface specification). Thus coin phones were developed that did all the coin management autonomously, under microprocessor control. These would even provide for direct-dialed long distance calls, with the operator's rate table built in.

Such coin telephones were often called "customer owned coin operated telephones" (COCOTs). Entrepreneurs would offer installations of such phones to, for example, the proprietors of stores, perhaps offering a more generous "commission" plan to the "host" store owner than would the telephone company. (The coin phone entrepreneur was sometimes the "customer" of the local telephone company for the line on which the coin telephone operated.)

In fact, AT&T, apparently in the early 1990s, offered, directly to individual "entrepreneurs", their Private Pay Phone *Plus* (let the alliteration go wild!), a very sophisticated "COCOT".

I will not discuss this situation further.

3.5 Bell Telephone System vs. non-Bell coin telephones

In general, the basic principles of coin telephone operation discussed in detail here were followed both by Bell Telephone System and non-Bell telephone companies. But there were at times significant differences in the technical details between the two.

In the body of this article, the detailed description will be predicated on the Bell Telephone System practice. But in Appendix C, which discuses the "postpay" mode of operation, considerable attention is given to both the Bell System implementation and the most popular non-Bell implementation, which differ substantially.

3.6 10¢ vs. 5¢ initial deposit

3.6.1 *5¢ initial deposit*

For much of the overall era of interest, the initial deposit for a coin telephone (which was by definition the initial—maybe entire— charge for a local call) was almost universally 5¢. Of course if the caller did not have a nickel, he could deposit a dime or a quarter, and the system worked the same way. (These phones did not, however, "make change", so the excess payment was wasted!) Much of my discussion will be predicated on the 5¢ initial deposit mode.

3.6.2 *10¢ initial deposit*

Starting in the early 1950's, the telephone companies in most of the US and Canada increased the initial charge for local coin telephone calls to 10¢. Then, a single nickel would no longer satisfy the "initial deposit" requirement; if nickels were used, two had to be deposited before the phone would allow a call to be commenced (or advanced). This required the retrofit of all prepay coin telephones, and in many cases some changes in the supporting central office equipment.

I will discuss this change, and its implications on the coin telephone protocol, in Section 16.

3.7 Multislot vs. single slot coin telephone designs

3.7.1 *Multislot*

In most of the coin telephones made prior to the mid-1960s, there is at the top a stainless steel turret (the *coin gauge*) with separate openings for quarters, dimes, and nickels (in that order, left-to-right). The coins are put into the appropriate opening, "flat-wise", and at the back of the opening fall down a narrow passage into separate "channels" in the *coin chute*.

Once an alternate configuration (having a single intake slot) came onto the scene, these telephones became known as *multislot* (or "3-slot") coin telephones (formally, in the Bell System nomenclature, "multislot *coin collectors*").

Figure 2. Illustrative coin collector (Bell System)

Figure 2 shows a typical example. made by Western Electric for use in the Bell Telephone System.

Very similar ones were made by Automatic Electric Company for use by non-Bell telephone companies.

Almost all of the discussions here will be predicted on the operation of multislot coin collectors of this general type.

3.7.2 *Single slot*

In the mid-1960s, the Bell Telephone System introduced a new line of coin telephones. These featured improved physical security and security against fraudulent operation, and afforded improved flexibility in such matters as the amount of the initial deposit. They also could nicely participate in emerging systems for automatic the payment for user-dialed long distance calls from a coin telephone.

A prominent feature is that they have a single slot into which coins of any of the three denominations can be inserted, edge-wise. The first stage of the coin chute sorts the three denominations of coins into separate channels of the coin chute for further consideration. The coin chute closely followed the norms of the time in vending machines as to the rejection of “bogus” coins.

Not surprisingly, they were known as single slot coin telephones (formally, *coin telephone sets*—note the distinction in formal nomenclature from “coin collector”, as was used for the “multislot” types).

Figure 3. Single slot coin telephone set

Figure 3 shows a typical one of the version intended to be physically interchangeable with the earlier type of coin telephone (for example, in a typical telephone booth).

An alternate version, in a large flat panel (not pictured here), was intended for mounting in the corner of a new type of telephone booth designed for it.

This type of coin telephone is discussed in detail in Appendix E.

3.8 Type of dial

In the 1960s, telephones (including coin telephones) increasingly came to be equipped with "Touch-Tone" (DTMF) dials rather than rotary (pulse) dials used previously. This introduced some circuit changes in coin telephones, but the principles described herein still applied. In any case, the circuit description details herein are predicated on the coin telephone being equipped with a rotary (pulse) dial.

3.9 Prepay vs. postpay operation

3.9.1 *Prepay operation*

3.9.1.1 *General*

In *prepay* operation, the caller must deposit the charge for the initial period of the call (perhaps for a local call that is the entire charge) before the call can proceed. The deposited coins are held in the telephone (sometimes described as being "escrowed") until later (perhaps the end of the call), at which time they are either *collected* (sent to a secure container in the phone, which the telephone company will later collect) or *returned* to the caller in a return chute, depending on whether the call was to be charged for or not.

This is the "mainstream" mode, which was in use other than in small communities (where the alternative "postpay" mode was often used).

There were, however, two important submodes of the prepay mode.

3.9.1.2 *Coin first operation*

In the *coin first* form of the prepay mode the caller must deposit coins for the basic local call charge (the "initial deposit") before "dial tone" was given and thus before any call could be made.

The disadvantage was that "intrinsically free" calls, such as to the local operator (or later, calls to a emergency services bureau), or long distance calls that were to be charged to the called party ("collect calls") or to a credit card, could not be made if the caller had no coins, even though he would ultimately not have to pay for the call (the initially deposited coins ultimately being returned).

3.9.1.3 *Dial tone first operation*

In the *dial tone first* form of the prepay mode the caller could, without depositing any cons, receive dial tone, and place any calls that would, by definition, be “free” (such as to the local operator, long distance operator, or an emergency service bureau). But before a regular local call would be completed by the central office, the minimum deposit had to be made, or before a long distance call through an operator could be advanced, the initial charge for that call would have to be deposited.

3.9.2 *Postpay operation*

In *postpay* operation, mostly confined to smaller community telephone systems, the caller need not deposit any coins to place a call. If the call is completed and answered, the caller then deposits the proper amount (this being required to be able to speak over the connection).

Those coins invariably went directly to the secure collection container. (It is assumed that the caller was smart enough not to deposit any coins if, for example, a busy signal was encountered, or if nobody answered.) There was no provision for returning coins (other than for those that had been “declined” by the coin mechanism as “likely bogus”).

The motivation for this mode is that the coin telephone set and/or the supporting equipment in the central office are less complicated and require less maintenance than for the prepay mode.

I discuss this mode in detail in Appendix C.

3.9.3 *Variations in terminology*

In actual practice, often the *coin first* and *dial tone first* forms of *prepay operation* are called just “coin first” and “dial tone first”, the fact that these were forms of *prepay* operation being implied.

However, in many official documents, these two modes are spoken of as “prepay” and “dial tone first”, respectively. The rationale behind this was that *dial tone first prepay* operation does not fully deserve to be thought of as “prepay”, since for some calls the caller does not need to pay in advance (because for them, he does not ever pay at all).

3.10 Outgoing and incoming calls

The technical features that are unique to coin telephone operation almost all pertain to the operation of the telephone to place calls.

And for many years, generally, it was perfectly possible to place a call **to** a coin station. From a technical aspect, this essentially worked exactly like a call to a regular telephone station..

I do note that in “modern times”, many telephone companies have arranged it so that calls cannot be placed to coin telephones (or perhaps to coin telephones in certain locations), that often being motivated by concern that such calls might be used as a pivotal part of certain illegal enterprises which then might lead to danger to other users.

4 ABOUT WESTERN ELECTRIC AND NORTHERN ELECTRIC

I have spoken already (and will speak in the future) about “Western Electric” (formally, Western Electric Company, Inc. [1]) as the manufacturer of equipment for the Bell Telephone System.

In fact, in Canada, much of the equipment used by the Canadian “arm” of the Bell Telephone System, Bell Canada (to use its popular, and of course, bilingual, name during much of the era of interest) was made by Northern Electric (to use its short name), the Canadian “sibling” of Western Electric. For the most part, the apparatus made by Northern Electric was essentially identical to the comparable Western Electric apparatus.

No slight to Canada is meant by the fact that of these two “parallel” manufacturers, I only mention Western Electric in the remainder of this article. Those references should be taken to usually mean, “Western Electric/Northern Electric”.

5 TAXONOMY

When speaking in a careful technical context, what we may speak of concisely as a “telephone”, viewed as an object, is properly called a “telephone set”. But as a participant in the overall telephone network, it may well be spoken of as a “station”.

When we come to coin telephones, it is tempting to try and be rigorous and call them, as objects, “coin telephone sets”. But, as noted earlier, the formal nomenclature used in the Bell System reserves that precise term specifically for one genre of these objects (the later, “single slot” one), calling the objects of the earlier genre “coin collectors”.

To avoid the linguistic trap awaiting me here, I will refer to all coin telephones, viewed as objects, as “coin telephones”. And as to the entity as seen from a network perspective, I will speak of “coin telephone stations”.

[1] It was commonly spoken of in the Bell System, for short ,as “The Western”, even though there is no “The” in its actual name.

6 JUST A LITTLE HISTORY

6.1 Introduction

This article picks up the story of coin telephones at a certain point in time, not too accurately defined. But I can't help but give a nod to earlier history.

6.2 An early coin collector

An early implementation of a coin telephone station, used with manual telephone service (all connections being made by an operator), is seen in Figure 4.

Figure 4. Early coin collector

It involved a box into which coins could be deposited, the different denominations making different sounds by striking a bell once or twice or a gong once (just as we will learn of in the more modern coin telephones). The coins then went immediately into a locked drawer.

There was no electrical apparatus in the box.

These sounds were heard by the operator by dint of the fact that this box was rigidly connected to the column of the associated telephone set (of the "deskstand" form), where the sounds were picked up by the transmitter (microphone) of the telephone set (also rigidly connected to the column), and so were sent over the line to the operator's switchboard.

The operating mode here was necessarily “postpay”, since the caller was not instructed to deposit any money until the call had been placed and answered (since there was no way that an earlier-deposited coin could be returned should the call reach busy or be unanswered).

Not surprisingly, this box was often called a “coin collector”, which influenced the Bell System nomenclature of the first genre of “modern” coin telephones.

But the direct ancestor of today’s coin telephones (especially of the “coin collector” genre) was introduced in about 1911 by the Gray Telephone Pay Station Company of Hartford, Connecticut, a result of collaboration with Western Electric Company. We see it in figure 55.

Figure 5. Gray 50-A paystation

In fact, for comparison, figure 6 shows the comparable coin collector from a 1963 Bell System Practices section. The transmitter and receiver are of course of more modern types than we see in figure 5.

Figure 6. Western Electric/Gray coin collector

The overall physical construction of the 50-A, the circuit principles by which it operated, and its complex internal mechanism, while indeed benefiting from numerous detailed improvements over the years, were still relatively unchanged over the entire era of the coin collector genre of coin telephones (which we can consider to extend through the mid 1960s). All those coin telephones are sometimes spoken of collectively "50 type", even though their actual Western Electric apparatus codes ("model numbers" to civilians) by 1963 went up into well into the 200s (*e.g.*, 234G) [2].

7 MECHANICAL OPERATION

7.1 Introduction

Here I will describe the overall operation of a "multislot" coin telephone (coin collector) from the standpoint of the mechanical operation of its innards.

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[2] I note that originally, Western Electric apparatus codes had a hyphen between the numeric and alphabetic portions (*e.g.*, "50-A"). But at some point (I don't know the year), the hyphen was eliminated (*e.g.*, "50A"). I follow the form appropriate to the period of the reference.

7.2 The coin chute

The basic nature of the *coin chute*, a key ingredient in this kind of coin telephone, is best seen in an early one (before it took on various complications).

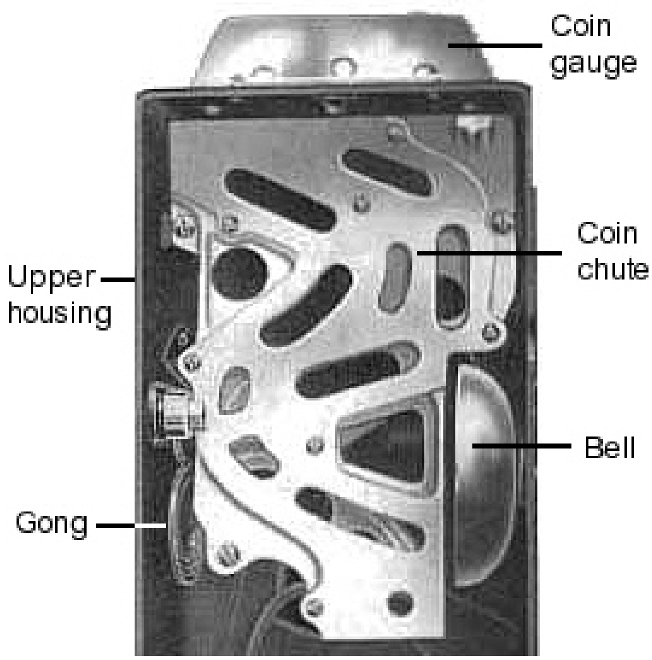

Figure 7. Illustrative basic coin chute

Figure 7 is a rear view of part of the upper housing of a Gray 50-A type coin telephone (*ca*. 1912).

When a coin is deposited into one of the three ingress openings in the *coin gauge*, atop the telephone, it goes into a channel for its specific denomination in the *coin chute*. (The three channels are thin and are in parallel planes.)

The coins traveling through all three channels exit the coin chute at immediately adjacent locations at its bottom and fall into the *coin hopper* (seen later).

As a nickel passes through its channel, it strikes and bounces off the top edge of a bell, here mounted on the upper housing itself (we see it to the right of the coin chute), making a “ding” sound.

Since in this vintage of coin telephone, designed before the advent of the handset, the transmitter is mounted on the upper housing (and the receiver is of the “potato masher” type), the bell sound is acoustically coupled to the transmitter though the upper housing, so the sound is sent into the line (where it can be heard by an operator, for an operator-handled call). The role of this will be discussed later.

As a dime passes through its channel, it first strikes and bounces off the upper edge of the bell and shortly after strikes and bounces off the lower edge of the bell, making a rapid "ding-ding" sound, which as before is sent into the line.

As a quarter passes through its channel, it strikes and bounces off a spiral gong (spoken of as a "cathedral gong"), also here mounted on the upper housing itself (we see it to the left of the coin chute), making a "bong" sound, which as before is sent to the line.

In somewhat more modern coin phones, in an extension at the bottom of the coin gauge and/or in the coin chute are fairly primitive means of blocking or diverting the progress of clearly bogus coins.[3]

7.3 Coin disposal subsystem

7.3.1 *Introduction*

In important (and complex) part of the coin collector is the subsystem that holds the deposited coins ("in escrow") and, at the end of the call (or in some cases earlier) "disposes" of them, meaning releasing them from their "escrow" state and directing them either into a secure collection container or to the return chute.

In this section, I will discuss the two portions of that subsystem, the coin chute and the coin relay.

First, for orientation, Figure 8 shows a Gray 50-A coin collector (albeit recently refurbished [4]) with the upper housing removed so we can see the siting of the players in this chapter of the drama. (Recall that the coin chute is actually in the upper housing.)

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[3] These were however nowhere nearly as effective as what we had in vending machines, as they were even in 1940.

[4] And thus it is equipped with a coin relay or more recent design than the original. albeit almost identical to it.

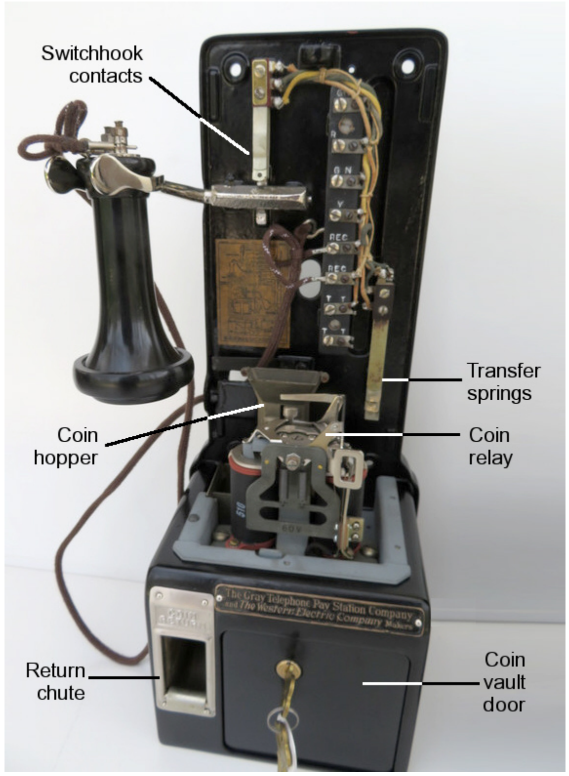

Figure 8. Gray 50-A coin collector

The *transfer springs* are the main unit's part of a set of spring contacts that connect the circuitry of the upper housing, when it is place, into the overall circuitry of the telephone.

The "secure container" for the collected coins is of course behind the locked *coin vault door*.

7.3.2 *Coin hopper, coin trigger, and coin vane*

The coin hopper is mostly a cylinder with inside diameter a bit greater than the diameter of a quarter but having at the top a rectangular funnel so that coins exiting from any of the three channels of the coin chute will fall into the hopper.

We see it in Figure 9. Also seen there is a portion of our next player, the coin relay.

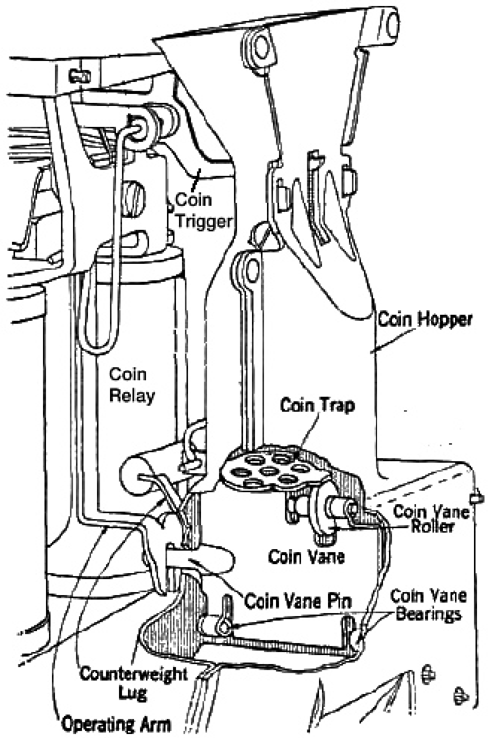

Figure 9. Coin hopper

About halfway down the inside of the hopper tube it is blocked by an initially immovable flap, the *coin trap*. Any coin(s) deposited pile up on top of this. They will stay there ("in escrow") until later (perhaps just after the end of the call).

On the way to the trap, the coins pass and push out of the way a lightly spring loaded finger, the *coin trigger*. When thus deflected, it unlatches a spring loaded lever on the adjacent *coin relay*, which moves so as to close an electrical contact.

Under the trap is a (normally) vertical metal plate, pivoted at its bottom, the *coin vane*. At its top is a small metal roller, which (initially, with the vane centered) supports the coin trap from beneath (which I why I described the trap as initially immovable). We will hear more about it after we hear of the coin relay.

7.3.3 *The coin relay*

The *coin relay* is the real star of this drama. Its name is not really apt, as its main purpose is not to operate electrical contacts, but rather to move a mechanism (although there is an electrical contact involved). It would be better described as an "electromagnetic actuator". We see it in Figure 10.

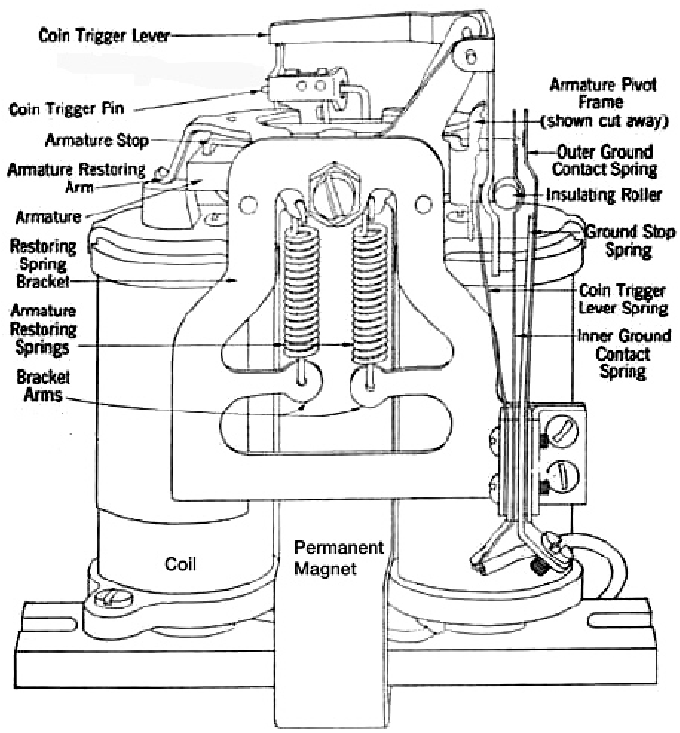

Figure 10. Coin relay (traditional form)

In its traditional form (as seen here)[5], it is built much like the early telephone ringers. Its design is little changed from the original design of this item, dating to the Gray/Western Electric 50-A coin telephone of 1912. It has two coils, each on a steel polepiece, legs of an overall magnetic structure. Nearby is a substantial permanent magnet. Atop the two coils is a pivoting steel armature (operating alongside, rather than against the tips of, the pole pieces).

The two coils are permanently connected in series, and are usually thought of as a single coil in schematic drawings and the like (and I will speak of them here as "the coil").

Two spring loaded *restoring arms* hold the armature in a "centered" position when there is no current through the coil windings. The arrangement is such that there would need to be a non-trivial force on the armature to move it away from its "normal" position.

A current above a certain minimum through the coil will cause the armature to pivot from its centered position in one direction or the

[5] A more recent design has a dramatically different construction and operating principle, but it is nevertheless fully interchangeable (physically and functionally) with what I describe here. It is described in Section 19 and in more detail in Appendix D.

other, the direction depending on the polarity of the current (because of the interaction with the permanent magnet).

The mechanical output of the coin relay (from an forked arm moved by the armature) goes to the coin vane (specifically to a pin on it), so that when the relay operates in one direction or the other, it swings the vane to one side or the other. We actually see that arrangement in Figure 9.

For either direction the vane is moved, a consistent result is that the roller on its top moves out from under the coin trap, allowing it to drop under the weight of the coins and freeing them to continue their journey. After they have left, a small spring or counterweight lifts the trap gently back to its original position across the hopper tube.

A further result is that if the coin vane is moved to the right, it will cause the newly emancipated coins to flow to the left, where they go into a hopper leading to the coin return chute. But if the coin vane is moved to the left, it will cause the coins to flow to the right, where they go into a hopper leading to the secure coin collection container, housed in an armored “vault” at the bottom of the telephone.

A second action of the coin relay is that, when it has been operated in either direction, the coin trigger system is reset, but its electrical contact is held closed until the relay releases, when the contact is opened.

8 GRAPHIC SYMBOLS

In the many schematic circuit sketches to follow, I will use some special conventions, shown on Figure 11.

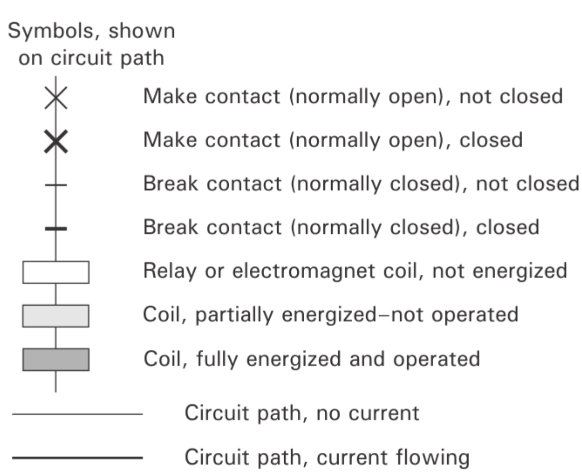

Figure 11. Circuit sketch symbols

These conventions are based on the symbols used in the Bell Telephone Laboratories “detached contact” circuit schematic drawings, but augmented to give insight into the actual present state of the contacts and coils.

9 OPERATION OF REGULAR TELEPHONES

9.1 Introduction

An important aspect of the operation of the "traditional" prepay coin phones operating in an important protocol is a simple but significant difference in the interface between the telephone set and the central office from that used by "regular" telephone service. To put this in context, I will begin by reviewing this area as it pertains to "regular" telephones.

9.2 Line idle

Figure 12 shows the aspects of a regular telephone and its central office interface that are of interest to us. This figure (and others to follow) are intended to illustrate the circuit principles involved, and may not represent the actual wiring. Some liberties have been taken in the interest of continuity in the course of the descriptions.

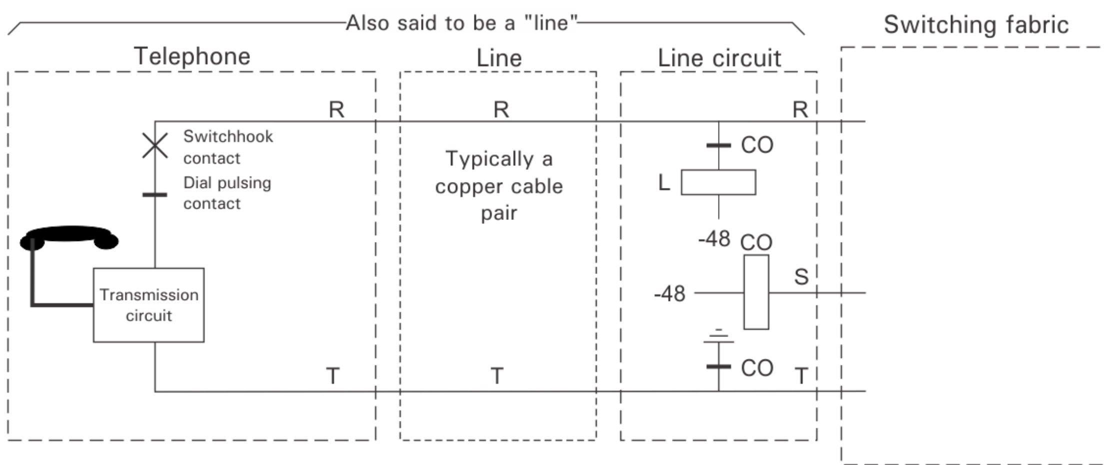

Figure 12. Regular telephone line–idle

At the telephone we see its transmission circuit with a handset attached, and a *make* (normally open) contact on the switchhook, open at the moment since the handset is "on the hook". We see the dial pulsing contact[6], which won't be of importance to us here, but I show it just for continuity with what will follow.

The box labeled "switching fabric" refers to the part of the central office switching system that will eventually provide a path from this

[6] Yes, it would ordinarily be between the switchhook contact and the transmission circuit, but I show it in an unusual location for continuity with what we will see later.

telephone line (as a *calling* line) to the line that is being called (the *called*[7] line), or to a trunk to another central office. This of course differs dramatically over the different types of switching system

The station line terminates at the central office in its *line circuit* (one for each line). There, the ring conductor[8] of the line (R) is connected through a *break* (normally-closed) contact on the cutoff relay (CO), then through a winding of the line relay (L) to a nominally -48 V supply (referred to as "battery"[9]).

The tip conductor (T) is connected through another break contact on the CO relay to ground. Thus a potential of 48 V appears across the telephone line. Since there is no DC continuity at the telephone (the switchhook contact being open), no current flows through the line (nor through the L relay).

9.3 Caller lifts the handset

Now, the caller lifts the handset. We will follow the result on Figure 13.

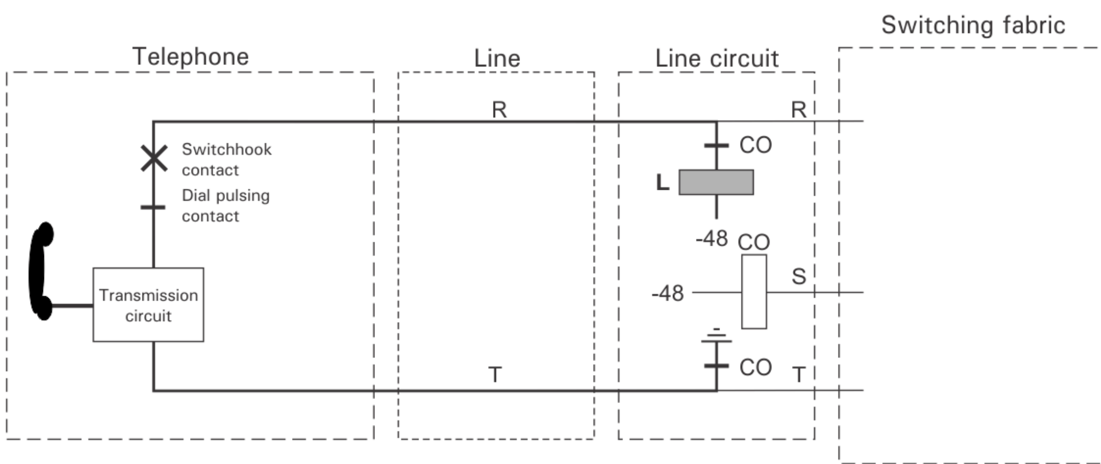

Figure 13. Handset taken off-hook

The lifting of the handset causes the switchhook contact to close, completing the path shown from the -48 V battery ultimately to

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[7] Traditionally spoken in two syllables, as a physicist would do anyway.

[8] The designations "ring" (R) and "tip" (T) for the two conductors of a telephone circuit have nothing to do with "ringing" the telephone, but rather trace back to the two line contacts on a telephone switchboard plug.

[9] So-called because that voltage is normally provided by a "48 V" storage battery continuously "floated" by a DC rectifier operated by commercial power, thus automatically providing for the continuity of operation if the commercial power should fail.

ground at the line circuit. The current in that path energizes the coil of the L relay, which operates.

9.4 Caller gets dial tone

Refer next to Figure 14.

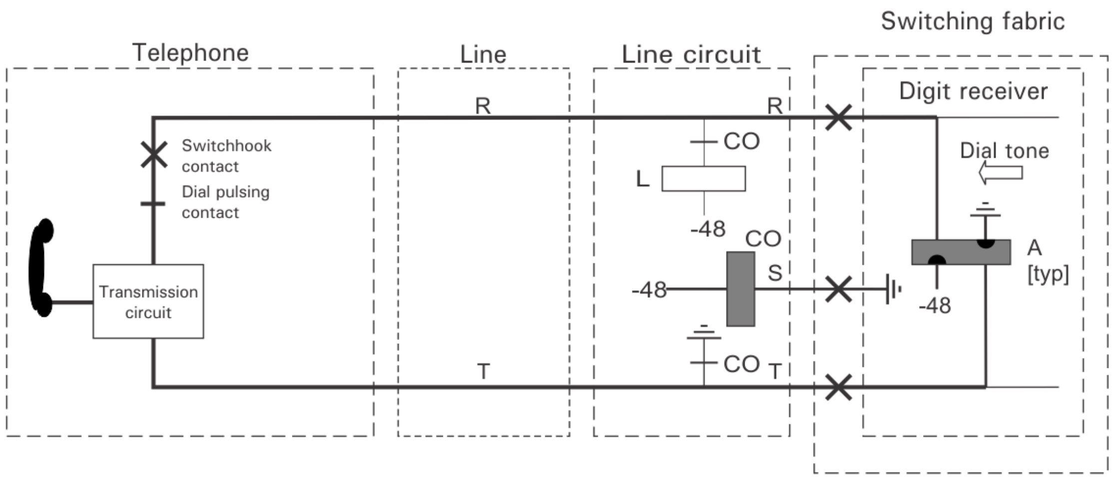

Figure 14. Calling line receives dial tone

In some way (differing greatly between different switching systems), this causes the switching fabric to attach to this line (through the three generic contacts seen) something that will feed “talking battery” (a new path from -48 V to ground) to the line, initially send dial tone back toward the calling station, and prepare to receive the digits dialed by the station. For generality, I call this the *digit receiver*.[10]

Note that “talking battery” is now fed to the station through what I have called here, arbitrarily, the A relay of the digit receiver. [11] The two “half dots” on the relay core symbol indicate comparable ends of the two windings. Thus we can see that the effects of the current through the two windings “aid” toward operating the relay. The A relay operates, indicating to the digit receiver that its “customer” still has the telephone “off hook”.

The L relay in the line circuit is no longer needed. It has done is job in summoning a digit receiver, and its connections to the ring and tip conductors of the line would just interfere with the further working of the switching system. Accordingly, the digit receiver places ground on

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[10] This is not to imply, for example, only a unit such as the *originating register* (or equivalent) found in common control switching systems, but equally embraces the *first selector* of a step-by-step switching system (although it only receives the first of the dialed digits).

[11] The actual details of this circuit vary between systems, but the portrayal here represents them all for our purposes.

the S ("sleeve" lead running to the coil of the CO relay, energizing it, so it operates. Its two break contacts open both sides of the now-unneeded path in the line circuit.[12] The line is now fully in the hands of the digit receiver.

This is as much of the life of a regular telephone line as we need.

9.5 "Loop start"

This type of line circuit (the ordinary kind) is often spoken of, especially when there is need to distinguish it from another kind we will hear about shortly, as a "loop start" line circuit. This of course alludes to the fact that the L relay is operated, to **start** the call, by a circuit that starts with battery though the L relay, then over the ring conductor, through the telephone, over the tip conductor, and to ground at the line circuit–that is, over the **loop** comprising the ring and tip conductors and the telephone itself.

10 COIN TELEPHONE PROTOCOLS

In the following sections I will describe, in moderate detail, various protocols by which coin telephones interoperate with the central office to fulfill the functional and electro-mechanical scenarios discussed above.

11 THE COIN FIRST/GROUND START PROTOCOL

11.1 Introduction

This protocol was the most widely used in (dial) coin telephone operation in areas originally served after 1930 by the *panel dial* ("panel") system, a very complex electromechanical switching system that came into use in larger cities starting in the 1920s, and its successors (the two *crossbar* switching systems).

11.2 Line idle

In Figure 15, we will look at a coin telephone line operating with this protocol, with the telephone idle..

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[12] In some switching systems these two break contacts are not on a CO relay but the same function is provided by contacts on another switching component. But the same principle is followed.

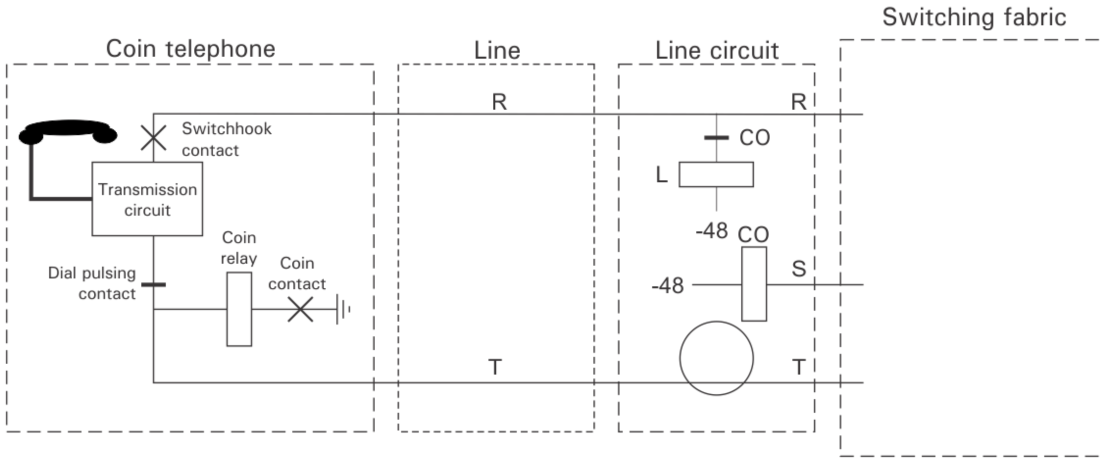

Figure 15. Coin telephone line–idle

We see that. compared to the “regular” telephone we saw earlier, the coin telephone has two new components we heard about earlier, the *coin contact* and the coil of the *coin relay*.

Note that the dial pulsing contact has been moved to the tip side of the transmission circuit. Thus has no effect on circuit operation as we see it, but was seemingly done to facilitate adding a feature we will learn of subsequently.

Also of importance here is a simple but pivotal difference in the line circuit. We note that here, with the line idle, the ring conductor (as expected) is fed battery through the winding of the L relay, but the tip conductor is not connected to ground at the line circuit (the circle calls our attention to this omission).

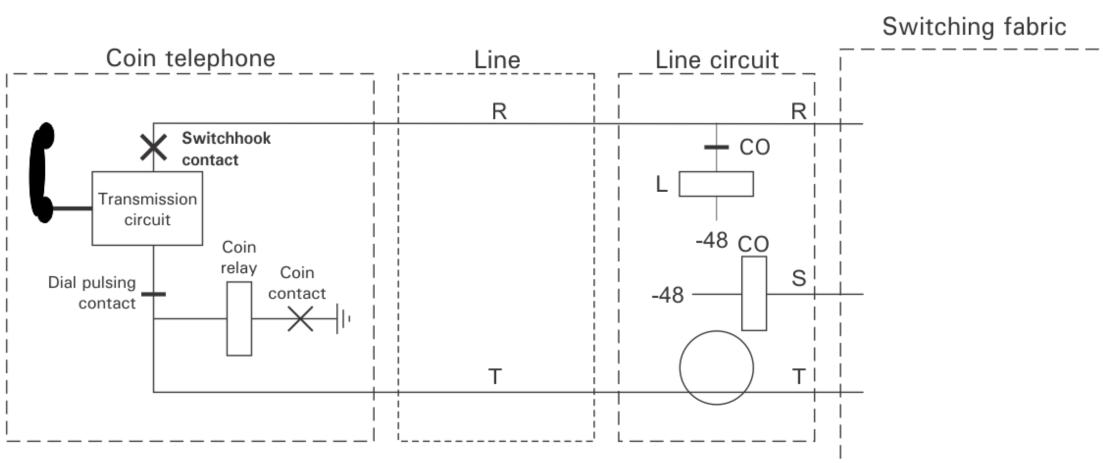

Figure 16. Coin telephone off-hook

11.3 Caller lifts the handset

In Figure 16, we see that the caller has lifted the handset, and thus the switchhook contact has closed.

In the case of a regular telephone and its line, this would have operated the L relay in its line circuit. But here, the lack of a ground on the tip conductor at the line circuit (again, the circle calls our attention to this) means that the path that would do this is incomplete.

So no current flows, the L relay does not operate, and the central office does not know that anything has happened. Needless to say, the caller does not hear dial tone, and if he manipulates the dial, that doesn't do anything (there is nothing for it to do anything to).

11.4 Caller deposits coin

In Figure 17, the caller has deposited a coin—any coin will do (assuming we are still in the 5¢ initial deposit era).

As discussed before, the coin will operate the coin trigger, which results in the coin contact closing.

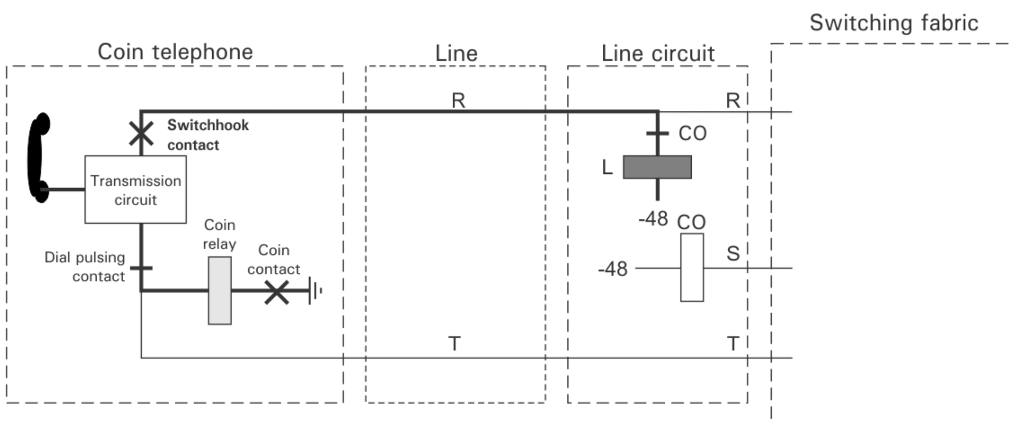

Figure 17. Coin telephone off hook and coin deposited

This closes a path from the tip side of the transmission circuit through the coil of the coin relay to local ground. This completes a path from -48 V battery, through the winding of the L relay, the ring conductor, the switchhook contact, the transmission circuit, the dial pulsing contact, the coil of the coin relay, and the coin contact to ground.

Current flows in the ring conductor of the line, a modest amount, owing to the resistance of the coin relay coil. The current isn't enough to operate the coin relay (which has a well-defined minimum operating current), but it is enough to operate the L relay in the line circuit.

11.5 Caller gets dial tone

The result of the operation of the L relay in the line circuit is, for the most part, just as for the regular telephone and its line, as we see (again in fanciful form) in Figure 18.

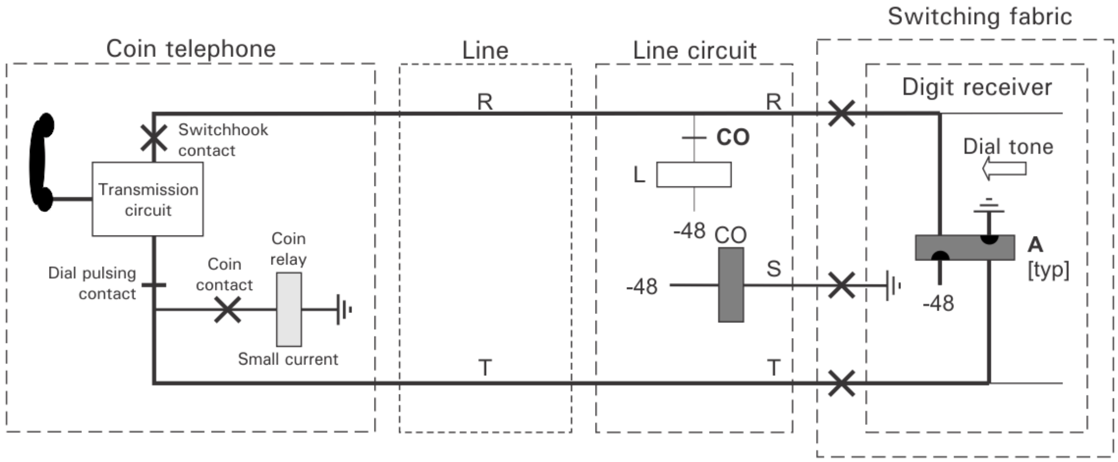

Figure 18. Coin telephone receives dial tone

The switching fabric has established a path from the line to the digit receiver, which returns dial tone to the line. If the caller dials, the digits are received by the digit receiver, and the call is advanced just as for a call from a regular telephone.

As for the case of a regular telephone, the switching fabric grounds the sleeve (S) lead[13] to the line circuit, operating the CO relay, which sheds the L relay from the line (there is no ground on the tip here to be shed).

11.6 "Ground start" line circuit

This type of line circuit (also used in various situations other than coin telephone lines, such as for trunks to the central office from PBXs) is often spoken of as a "ground start" line circuit. This of course alludes to the fact that the L relay is operated, to **start** the call, over a path to **ground** (in this case, through the coil of the coin relay), rather than over the loop comprising the ring and tip conductors (as for the "loop start" type of line circuit we saw earlier).

12 COIN DISPOSAL

12.1 The call is chargeable

First we assume that the caller dials and the system connects him to the desired called line, and a person there answers, and the two converse. The part of the switching system devoted to administering a coin telephone in its "originating" role (*i.e.*, as the calling station) notes that the call was completed and answered, meaning that the call has to be paid for. We will assume that this is a local call (under a

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[13] Again, its name traces back to one contact on the plug used in telephone switchboards,

"flat rate" charge plan) and so the charge will be just the initial deposit. Of course the funds for that are already in the coin telephone, in the coin trap ("escrowed"). They are now owed to the telephone company.

When the caller hangs up the coin phone, the switchhook contact opens and releases whatever relay in the switching fabric is giving the calling line talking battery at the time. If this call were from a regular telephone, the switching fabric would disengage, the CO relay in the line circuit would release, and the line circuit would go back into its idle state.

But this is a coin telephone line, and there is still a task to do before the switching fabric turns the line loose—collecting the "escrowed" coins. We see this in Figure 19.

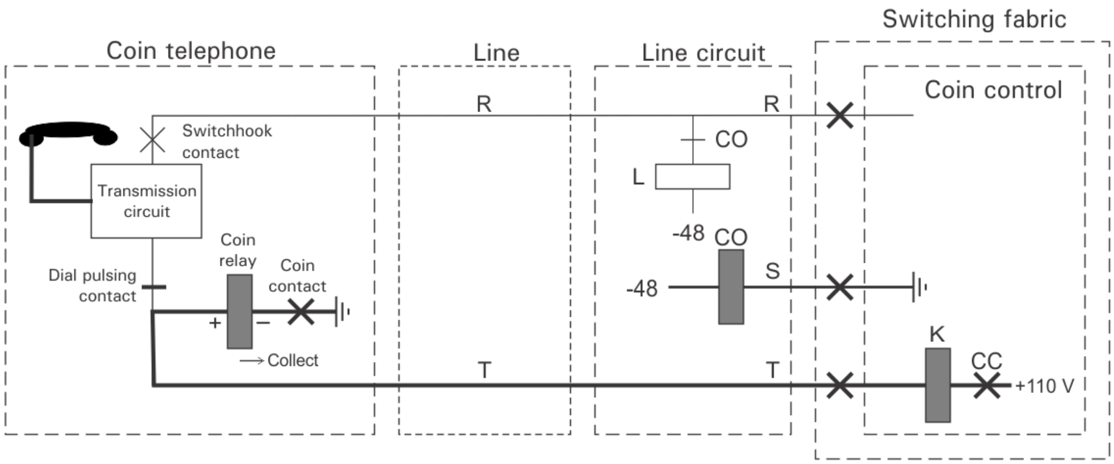

Figure 19. Collecting the coin

The coin control circuit, through a make contact on relay CC (coin collect), applies +110 V to the tip of the line through the winding of relay K. A substantial current flows, and this (by virtue of its polarity) causes the armature of the coin relay in the coin telephone to move from its neutral position to its "collect" position.

As discussed earlier, this moves the *coin vane* to the left, allowing the coin trap to, release the escrowed coin. The *coin vane*, having gone to the left, will steer the released coin to the right, into a secure collection container in a locked coin vault.

The current also operates the K relay in the coin control circuit, which demonstrates to the coin control circuit that current is flowing (presumably to operate the coin relay). If for some reason, no current flows, clearly something has gone wrong, and the failure of the K relay to operate puts something in motion to address that anomaly.

The operation of the coin relay resets the coin trigger (but does not yet allow the coin contact to open). The coin collect voltage is only applied for about 0.5 second. When the voltage is removed, and the current through the coin relay ceases, the coin relay returns to neutral, and this (considering that the coin trigger has been reset) opens the coin contact.

After a further interval of about 0.5 seconds, relay CC closes again. This time no current should flow (because the coin relay should have been reset and thus the coin contact opened). If current does flow (manifest by the operation again of relay K), clearly the coin relay has not reset, another anomaly, and again something is put in motion to address that.

12.2 The call is not chargeable

Now assume that instead the call reaches busy, or there is no answer, or that the call is recognized as a free call (perhaps it was to the telephone company business office). The coin control circuit does not note that this call is to be charged for. Now, when the caller hangs up, the action is almost identical to that just described, except that the coin control circuit now applies −110v to the tip of the line.

We see this in Figure 20.

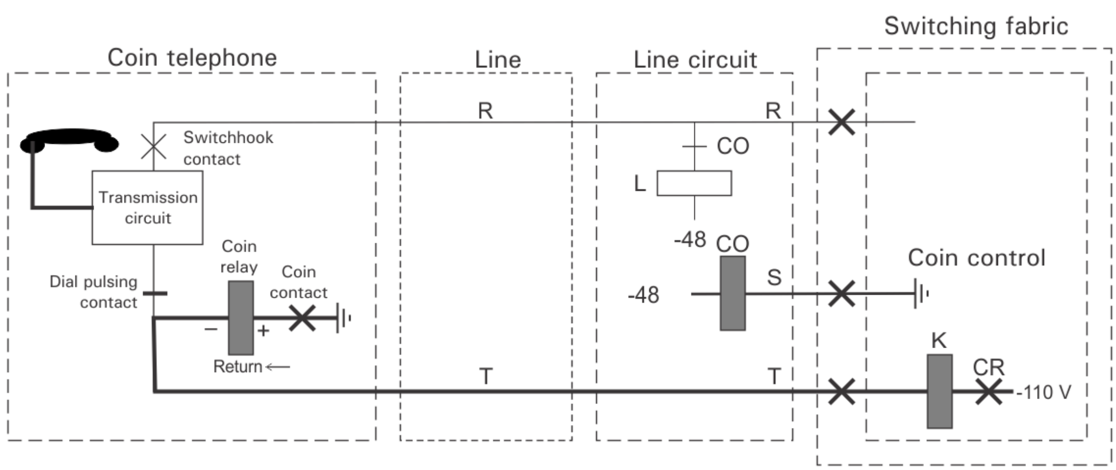

Figure 20. Returning the coin

The operation is exactly as described just above, other than that the coin relay has moved the coin vane to the **right**, so the coin released from the trap goes to the left, into the return chute, from which the caller can retrieve it.

12.3 The coin disposal test

After the pulse of coin control voltage has finished, the coin trigger should have been reset and the coin contact should be open.

If not, it could be that coins have somehow been “stuck” in the trap area, or the coin relay itself might have malfunctioned.

To confirm that everything has worked as expected, at this point the central office checks to see if by any chance there is still a path to ground (presumably through the coin contact and coin relay). If so, there has been come anomaly, and appropriate steps are then taken so this will be looked into.

Electrically, this test may be done in slightly different ways, depending on the type of central office. It may be done by just applying the applicable coin control voltage to the line tip again through a relay that will detect if any current flows. Or it might be done by applying -48 V battery to the tip through a relay.

This is sometimes referred to as the “stuck coin test”.

This general procedure is done for other prepay protocols to be described here, and I won’t repeat this description.

13 THE COIN FIRST/LOOP START PROTOCOL

13.1 Introduction

This protocol was the one most commonly used in areas served by the *step by step* switching system (mostly used in smaller and medium-sized cities) and in some other contexts, but only until the initial deposit was changed from 5¢ to 10¢.

I will describe it in terms of its implementation in the step by step system.

13.2 Operation

The line is served by a *loop start* line circuit. Thus, if the handset is lifted, a linefinder is started to attend to the line, and it brings with it a first selector (which serves as the digit receiver for the first dialed digit). And the first selector sends dial tone in the direction of the calling line.

However, since this call is from a coin line, there is a coin control circuit (a *coin trunk*, formally) interposed between the linefinder and the selector, and in its current state it prevents the dial tone from actually being propagated to the calling line. Also, initially, any dialing is not passed from the calling line to the selector (so the call cannot be advanced).

But the coin trunk almost immediately begins looking continuously for a ground at the station, which we can think of as being done by essentially the circuit of Figure 23. If and when such a ground appears (and so CT operates), the coin trunk lets dial tone, which the selector has been emitting for some while, through to the calling line, and arranges it so that any dialing by the calling line is passed to the selector. Thus the call can be advanced.

At the end of the call, coin disposal is conducted just as described for the protocols described above.

Note that there is no provision for calls of any sort to be made without the initial deposit, as befits a mode described as “coin first”.

13.3 Rationale

One might wonder why, in this form of provision of coin first service, a ground start line circuit was not used, rather than including in the coin trunk the additional complexity to make a coin relay test.

I have no wisdom about that.

13.4 Coin disposal

When the call is finished and the caller hangs up, coin disposal is done exactly as described in Section 12.

14 THE DIAL TONE FIRST/LOOP START PROTOCOL

14.1 Introduction

This protocol is used to provide *dial tone first* prepay operation. This was the norm in the earliest days of the *panel dial* system (used in large cities starting in the early 1920s), but went out of vogue about 1930. It was nevertheless used again in a few areas. It was resurrected, in grand style, in about 1968.

In its early form, it allowed a caller having no coin to reach a local or long distance operator, or perhaps even the telephone company repair service, (which connections, *per se*, would have been free anyway).

A loop start line circuit is used.

The discussion here most accurately applies to the “first coming” of this mode. The more elaborate “second coming” is discussed a bit in Section 22.

14.2 Line idle

In Figure 21 we see a coin line using this protocol, idle.

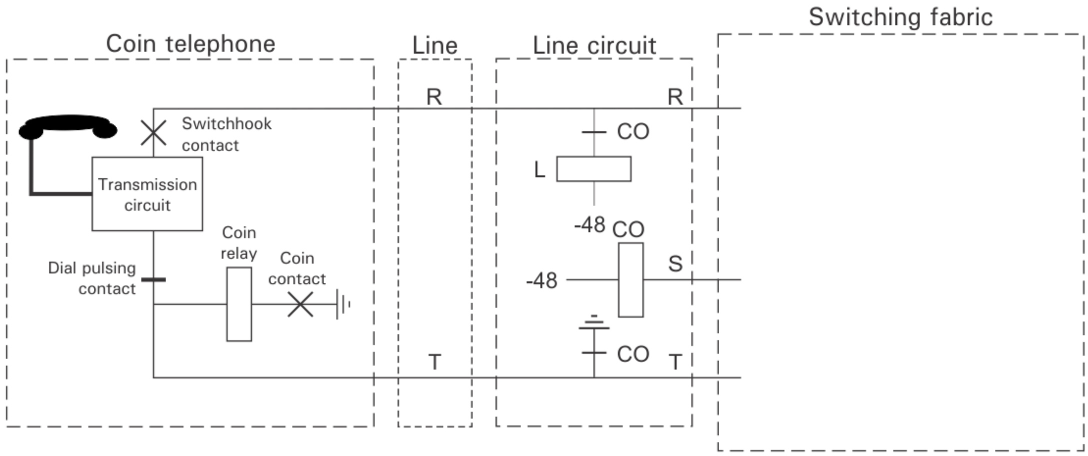

Figure 21. Loop start, dial tone first protocol, line idle

We see that the coin telephone is no different than for the earlier-discussed protocol, but the line circuit is now *loop start*–the tip is connected to ground (just as for a regular telephone line).

14.3 Caller lifts handset

In Figure 22, the caller has lifted the handset. No coin has yet been deposited.

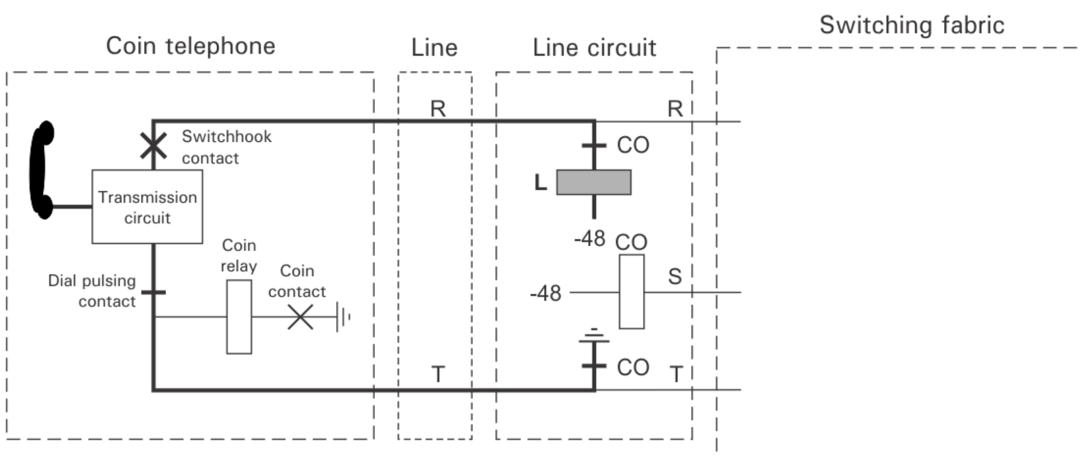

Figure 22. Handset off hook

We see that the L relay is operated, as before summoning the central office to attend to the call.

14.4 Digit receiver attached

In Figure 23, we see that a digit receiver (which includes a coin control circuit) has been attached.

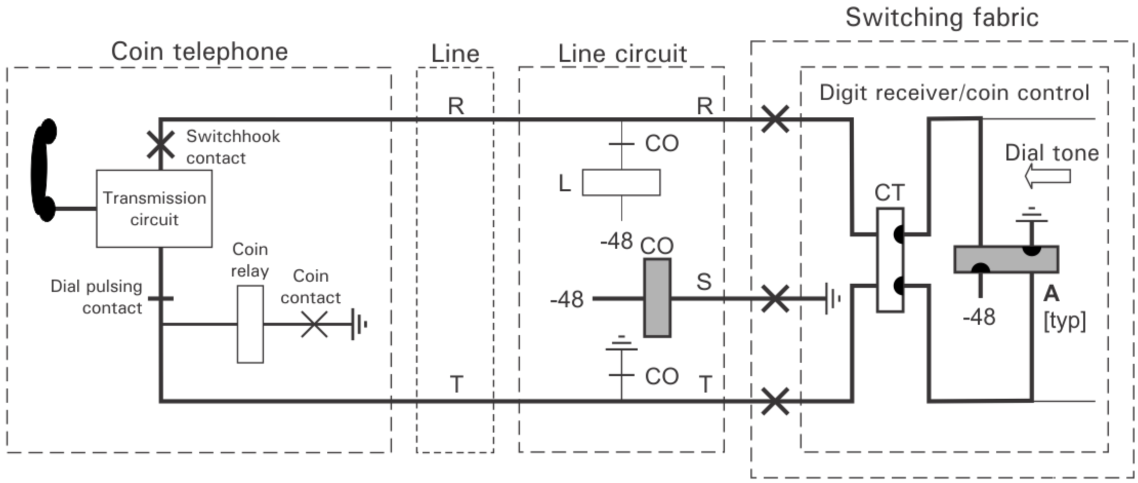

Figure 23. Digit receiver/coin control attached

As we have seen before, talking battery is provided to the calling line through the windings of the A relay in the digit receiver, and the digit receiver returns dial tone to the calling line. This is an invitation to dial but, as we will see shortly, this is a "qualified" invitation.

Note that as part of this fanciful set of circuits we have a new relay, CT ("coin test"), Its job is to determine if and when the initial coin deposit has been made, by looking for the ground then provided at the station through the coil of the coin relay. At the moment, it has not.

With no path to ground at the station, the current in the ring and tip conductors will be the same in magnitude.

But the relative polarities of the two windings of CT are such that with the two currents being equal in magnitude, their magnetic effect cancels, so the relay is not really energized, and does not operate (revealing that there has not been, so far, an initial deposit made).

Under this protocol, in its usual implementation, the switching system will nevertheless accept dialing of the first few digits, and will then determine whether those digits indicate that the call to be placed will be, by definition, "free".[14] If so, the dialing of further digits will be honored, and the call will be allowed to proceed even though the fact that CT has not operated shows that no initial deposit has been made—such is of course not required, since there unequivocally will be no charge for this call. (Another possibility is that CT is not even inserted in the circuit for this call.)

But if the initial digits do not reveal that this call will unequivocally be "free", then if further digits are dialed, they are not honored. In the

[14] For example, if the first digit dialed is "0", or the first two digits dialed are "11".

early manifestations of this protocol, the result will be that the digit receiver will just "hang", and after a measured time period, the call will be extended to a special local operator, who will remind he caller that a coin deposit must be made for his call to proceed.

In the more recent manifestation of this protocol, in this situation, the digit receiver connects to a recorded announcement reminding the caller that a coin deposit must be made for his call to proceed.

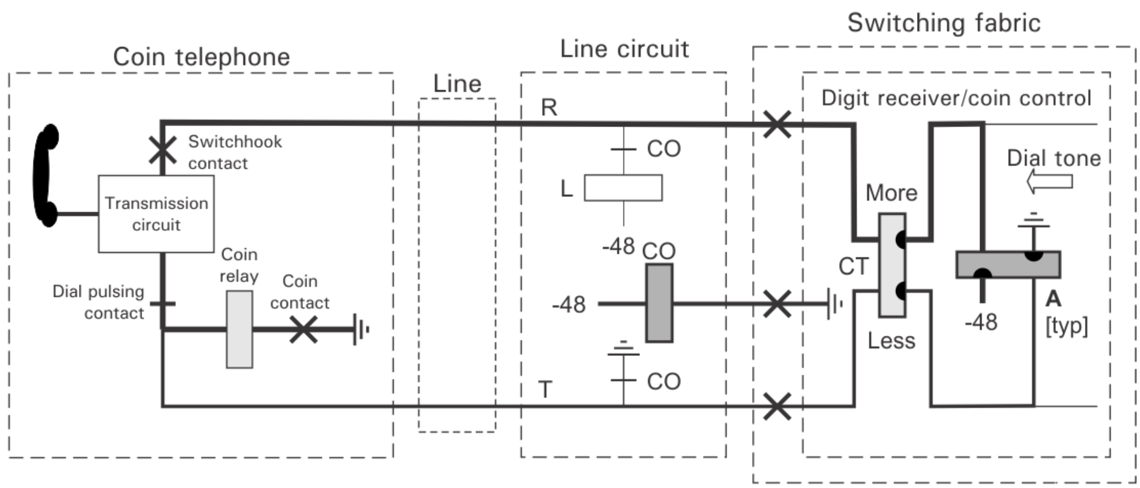

Figure 24. Initial deposit made

14.5 Initial deposit made

In any case, in Figure 24, the initial deposit has been made. This might have happened before the caller dialed, in which case all dialed digits are honored and the call proceeds without further ado.

That deposit has tripped the coin trigger, and the coin contact has closed, connecting the coil of the coin relay from the tip to ground. This increases the current in the ring and decreases it in the tip. (I used different line weights to emphasize this, in this figure only.) Now, the effects of the two currents on CT do not cancel, and CT operates, advising the digit receiver that the initial deposit has been made. The call is them allowed to proceed.

14.6 Coin disposal

At the end of the call, if a coin was in fact deposited, coin disposal (to either collect or return the coin, depending on whether this call is to be charged for or not) proceeds just as described in Section 12.

15 LONG DISTANCE CALLS

Suppose the caller wishes to make an long distance call, and we will assume this must be done through a long distance operator. I will discuss this in the context of coin-first operation

As before, the caller lifts the handset, and must deposit a coin to get dial tone and be able to dial. He dials the code to reach the long distance operator. When the connection is made to a long distance operator position, the coin control circuitry most commonly immediately returns the coin, just as was seen in Figure 20. This is so the caller's "account" is a clean slate as the long distance operator comes into the picture.

The caller tells the operator the wanted number, and the operator, after consulting her Rate and Route guide, advises the caller of the initial charge for that call (which probably covers the first three minutes of a completed call). She advises the caller to deposit that amount in coins. She need not take account of (or even be aware of the presumed amount of) the initial deposit, as that has been automatically refunded to the caller.

We learned in Section 7.2 how a nickel, dime, or quarter will make a "ding", "ding-ding", or "bong" sound as it travels through the coin chute. In that earlier discussion those sounds were conducted acoustically to the telephone transmitter, which in that older type of telephone was mounted on the housing to which the bell and gong were attached.

But in modern coin telephones, a handset is used, so there is no transmitter mounted on the housing. So in such coin telephones, the bell and gong are mounted on a metal plate, isolated by rubber "shock mounts" from the coin chute proper.

Also on the plate is a transmitter (microphone), working much like the one in the handset but operating not from an acoustic wave in the air but rather from the acoustic vibration of the plate on which it is mounted, caused by either instrument. This is connected into the telephone circuit so that its "audio" signal is transmitted into the line. The result is essentially the same as in the original description.

The long distance operator hears these audible cues of the coins being deposited, recognizing each "ding" as worth 5¢ (a dime makes two of them in rapid succession, which is probably recognized by *gestalt* as 10¢, not as 5¢ twice) and each "bong" as 25¢.

If the required amount is heard to have been deposited, the operator advances the call without further ado.

The operator eventually notes if the call was chargeable[15]. When the call is ended, she operates, as appropriate, either the CC (coin collect) or CR (coin return) key on the cord circuit being used for the call.

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[15] Perhaps putting a colored ring on her coin control key to keep track of her finding.

This, either directly or through a coin control circuit, causes either +110 V or -110 V (respectively) to be sent over the tip of the calling line, either collecting or returning the escrowed coins (maybe quite a few) in essentially the same way previously described.

16 INCREASE IN THE INITIAL DEPOSIT FROM 5¢ TO 10¢

16.1 Introduction

Over a few years in the 1950s, in most areas the telephone companies raised the initial deposit for a coin call (which was, by definition, the cost of a local call, or at least for an initial period of it) from 5¢ to 10¢.

Implementing this required retrofitting of every prepay coin telephone as well as, in some cases, making changes in the central office equipment.

We should note that the pace of this unfolding was not just on the basis of the telephone companies making the change as their resources allowed. In almost all states, this change (after all, a change in a telephone "rate") had to first be approved by the state utility regulatory agency[16], and they differed as to when they became "persuaded" that this change was necessary. In particular, Louisiana did not permit that until 1978.

The major change needed in the coin telephones came from the fact that in the original mechanism the deposit of any coin would trip the coin trigger and close the coin contact.

But with a 10¢ initial deposit required, the telephone must not close the coin contact until two nickels had been deposited (or of course, as always, a dime or a quarter). This was arranged for in quite different ways in the Western Electric coin telephones (used in the Bell Telephone System) and the Automatic Electric coin telephones (used by non-Bell telephone companies).

In the remainder of this Section, I will describe the Western Electric implementation. The Automatic Electric implementation is described in detail in Appendix A.

16.1.1 *The basic principle*

Here, for a telephone that could operate with a 10¢ initial deposit, an entirely new coin chute was used. In it, a "first" nickel traveling down the nickel channel would soon encounter an angled flap, the *holding*

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[16] Texas did not have such a body until 1975. Before that, utility rates were regulated by counties or municipalities, if at all.

latch, which was not then free to move out of the way, and which thus prevented that nickel from continuing down the coin chute.

A second nickel would encounter the first nickel, a bit off center, and would roll off to the side of the first nickel and into a "bypass" portion of the nickel channel. Traveling through that part of the channel, the second nickel soon encountered, for a moment, a second angled flap, the *locking latch*, which had been holding the *holding latch* in place. The second nickel pressed the *locking latch* flap briefly outward as it passed, and that second nickel could then continue through the coin chute toward the coin hopper.

The outward movement of the *locking latch* released the *holding latch*, in turn releasing the first nickel, which was now free to also proceed the rest of the way to the coin hopper. Both nickels (the later-deposited one at the fore), traveling through the latter portion of their channel, continued into the hopper, tripping the coin trigger when they arrived (and landing on the coin trap).

The rest of the story would seem to be identical to that we saw earlier. But not quite.

16.1.2 *On a long distance call*

But on a call through a long distance operator, a single nickel had to be able to pass, unimpeded, through the chute, causing the iconic "ding" as it went. For example, perhaps the long distance operator quoted an initial charge of $1.30. The caller might want to pay for this with five quarters and one nickel. The solo nickel must be able to proceed through the coin chute to announce its arrival with a single "ding".

To provide for this, the 10¢ coin chute is equipped with a small electromagnet whose coil is essentially in series with ring side of the line. We can visualize its operation in the context of the protocol where the line operates through a ground start line circuit. After the caller has made the initial deposit, and been connected to a digit receiver, which provides talking battery, there is line current, which operates this electromagnet, and it remains operated after the call is connected to the long distance operator.

With the coil energized, the electromagnet armature moves the tip of a small lever into the nickel chute above where a "first nickel" would be (held by the holding latch), so that, just as if an earlier nickel were there, any nickel deposited would always be deflected into the "bypass" branch of the nickel channel, evading the *holding latch* and freely continuing through the chute, eventually striking the gong (once), and traveling into the coin hopper.

16.1.3 *Return of an orphaned coins*

Suppose a caller deposits one nickel but then (perhaps discovering that he has no further coins) abandons the call and hangs up.

The nickel is so far held by the *holding latch* in the coin chute. But when the caller hangs up, a lever operated by the switchhook causes a small door on the back of the nickel channel in the coin chute, just where the "held" nickel is, to open. The nickel falls out and into a small "hopper" that leads it directly to the return chute, where the caller can retrieve it.

16.1.4 *Cutover*

It of course it took an enormous effort to replace the coin chute mechanisms and make other required changes to the zillion coin telephones in the Bell Telephone System. Most of this was done in the field.

To allow this to be done progressively prior to the date in which service was "cut over" to the 10¢ initial deposit basis (in a given service area, likely an entire state), the new "10¢" coin chutes, as initially installed, had in place a small phosphor-bronze spring clip that held operated the lever of the electromagnet that causes all nickels to evade the "holding latch". Thus a single nickel would go right through the coin chute and trip the coin trigger, etc.

On cutover day, an army of technicians would visit every coin telephone, unlock and remove the upper housing, pull out that little clip, and replace the upper housing. The coin chute would then work as described above to enforce a 10¢ initial deposit.

16.1.5 *With a "loop start" protocol?*

Imagine that, prior to the conversion 10¢ initial deposit, the coin lines in a locale operated under a loop start protocol (perhaps even on an early form of the "dial tone first" basis). That scheme looked to the coin control circuit to ascertain whether an initial deposit had been made.

So, if a caller lifts the handset, the L relay in the line circuit operates, and the line is connected to a digit receiver/coin control circuit. As seen earlier, that will provide talking battery to the line. And thus current will flow through the telephone, on a loop basis.

But that current would also operate the coin chute electromagnet that is essentially in series with the telephone. The result is that the coin chute will be set to allow a solo nickel to pass through.

Now, the caller could deposit a single nickel, which would pass unhindered through the coin chute and into the coin hopper, tripping the coin trigger, and closing the coin contact, in the process.

Then the coin control circuit, looking for evidence of a path to ground, will find it, and will give the caller dial tone, and make it possible to advance a non-free call.

Yet the caller has only deposited 5¢, not the established minimum initial deposit of 10¢. This is not working out well for the telephone company.

The solution is simple, if retrograde. Coin lines converted to a 10¢ minimum deposit, if before then operating with a loop start line circuit, were changed to use a ground start line circuit.

16.2 Effect on the service provided

If, prior to this change, the coin phones in a certain area were operated with the loop start, dial tone first protocol (admittedly not common), the mandatory change to ground start operation meant that dial tone first operation (which allowed the making of some free calls without any coin deposit) was no longer possible. It seems that this might have been very irritating to the subscribers of such systems, as the dial tone first mode was very advantageous to the user. (Although I think most subscribers had not had it.)

But not to worry. Perhaps 15 years later, that capability will come back into being (in grand style) as the ("brand new") "Dial Tone First" feature.

17 "SPOOFING" THE COIN TELEPHONE

17.1 Introduction

Not surprisingly, from the earliest days of coin telephones, various miscreants devised clever schemes for making telephone calls from coin telephones without paying for them.

The history of this, and the incremental changes made in the coin telephone system to thwart these schemes, is a gigantic and very complex area, beyond the scope of this article.

But one aspect of this area had a direct impact on an upcoming topic, so I will give a brief peek into the matter here. It is best understood in the context of a ground start protocol.

Suppose a miscreant could somehow (never mind just how; that quickly gets into the complications of the matter) temporarily apply a ground (picked up "locally")[17] to some point in the circuitry of the coin telephone.

This bogus ground would take the place of the ground through the winding of the coin relay, applied by the coin contact after the initial deposit has been made, that we saw at work in Figure 17. The bogus ground just as well completes the path for the operation of the L relay in the line circuit, and results in the line being connected to the "digit receiver", which gives dial tone and invites dialing of the call.

17.2 A countermeasure

Various measures for thwarting this scheme have been applied over the years. An early (and persistent) one is shown in Figure 25.

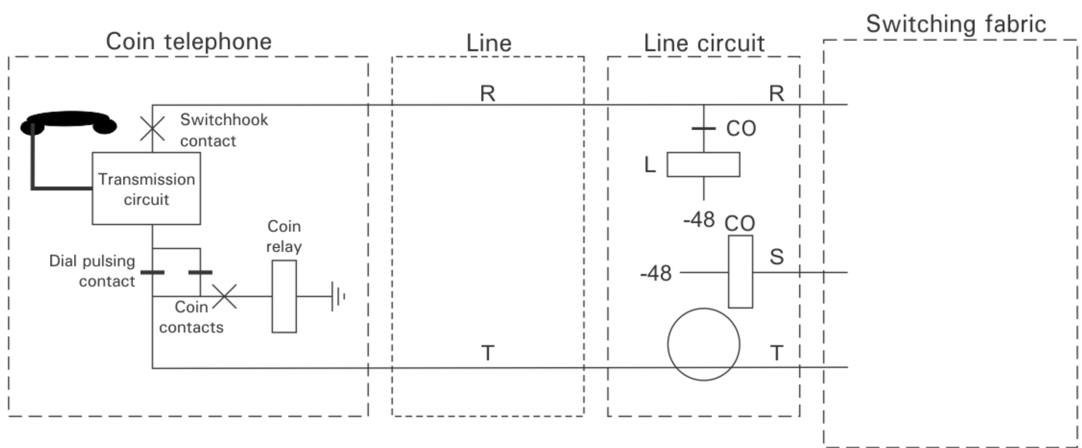

Figure 25. Dial shorting contact

What is new is a second contact in the coin contact set, a break (normally closed) contact, connected across the dial pulsing contact. Note that the sequence of the coin relay coil and coin contact have been reversed so this "dial shorting" contact can be integrated with the coin contact into a single transfer contact set (only 3 springs altogether).

Of course with this dial shorting contact closed, dialing would be ineffectual. But in normal operation, by the time the caller might dial, the initial deposit had been made, the coin trigger had been tripped,

[17] In fact, to frustrate this, for many years the Bell Telephone System insisted that the housing of the coin collector itself and metal parts of telephone booths **not** be grounded (even though AC power entered the booth to operate the light (and perhaps a ventilating fan). But, especially with the arrival of a new design telephone booth, made (by Alcoa, actually) all of aluminum (and glass, of course), the electrical safety authorities pressed heavily for such creatures to be grounded, and the Bell System relented. Thus indeed facilitating the mischief described in this section.

and the coin contacts operated. The dial shorting contact would be open, and the dial would work as expected.

But if dial tone had been "fraudulently obtained" by a bogus ground, the coin trigger would not have been tripped, the coin contacts would not have been operated, and the dial shorting contact would still be closed. Thus dialing by our fraudster would be ineffective.

17.3 Another countermeasure

Next assume that a loop start mode is used, and thus our miscreant would need to maintain the fraudulent ground until the coin test is made at the central office. A countermeasure against this is done in the central office. We see it in fanciful form in Figure 26.

Note the addition of another relay in the coin control circuit, FGT (fraudulent ground test). It works the same as CT (coin test) except it is calibrated to operate at a higher current. The marking "MG" ("marginal") on the relay means that is has a carefully calibrated operate current.

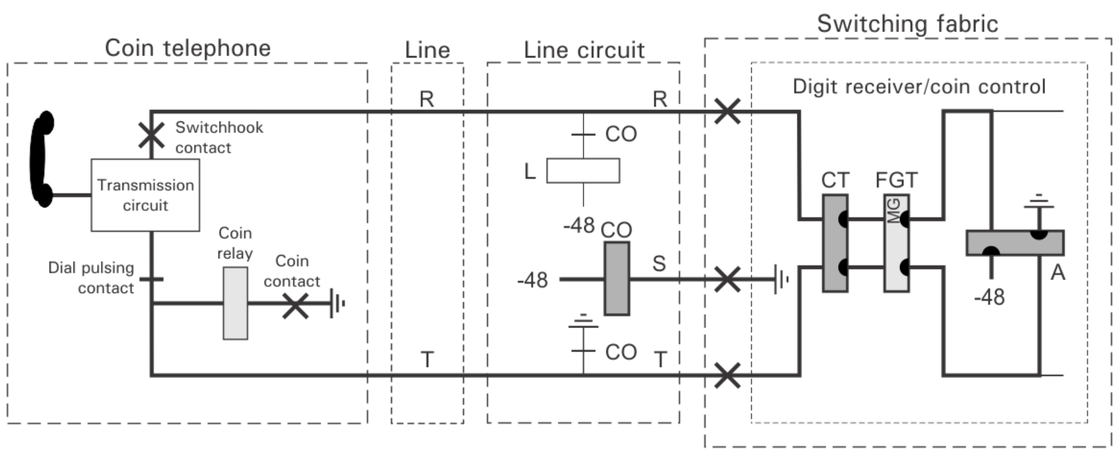

Figure 26. Fraudulent ground test circuit–coin deposited

Here we see the circuit in "normal operation" when a coin has been deposited at the station. The current to ground through the coin relay is not enough to operate the coin relay, is enough to operate CT, and is not enough to operate FGT. This operation of CT and not FGT is taken by the coin control circuit to indicate that the coin trigger had been tripped and presumably a coin has been deposited.

In Figure 27 we see the situation where no coin has been deposited but a miscreant has somehow fraudulently applied a ground to some accessible point of the telephone circuit.

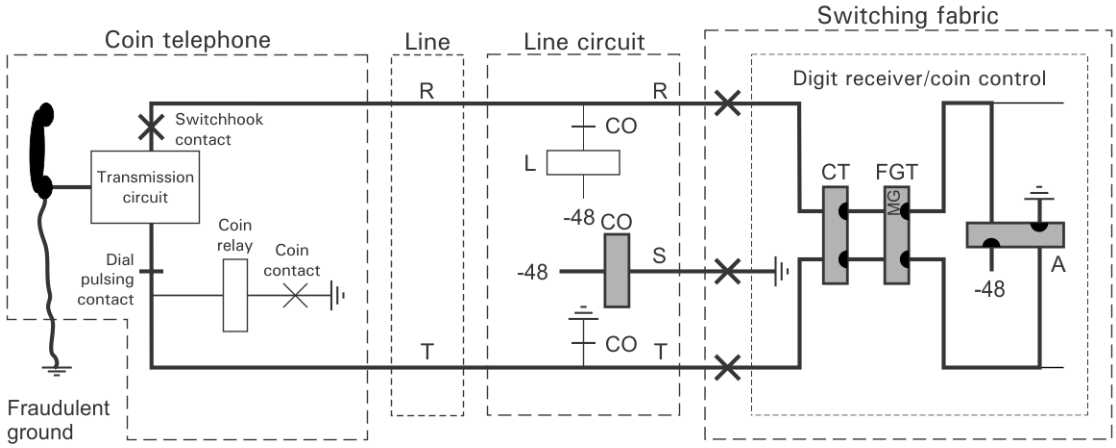

Figure 27. Fraudulent ground test circuit–fraudulent ground applied

Relay CT operates, as we saw just above. But the low resistance of this fraudulent ground, compared to the high resistance of the coin relay coil, allows relay FGT to also operate.

FGT operating overrules the "OK" from relay CT. Typically the circuit just "hangs", and no further call progress is allowed. (As mentioned before for the case in which it seems that no coin had been deposited, in early times the call would have gone to a special local operator, who would "look into" the situation.)

As you can imagine, the fraudulent ground test was not extremely discriminating, and there were many instances of "false positives". As a result, the use of this test was eventually deprecated.

18 THE SECURE COIN CONTAINER

I had earlier mentioned the "secure coin container", located in a locked "vault" at the bottom of the coin telephone, that receives all the **collected** coins.

This is a clever mechanical system in its own right, and I will discuss it a little here.

Figure 28 shows a typical coin container, with the lid on, as would be the case when it was in the coin telephone, or on its way (empty) to being put in one, or (probably with coins in it) on its way back to the telephone company. Each container has an individual serial number.

Figure 28. Secure coin container with lid

The hasp arrangement that holds the cover closed has provision for a security seal (as seen here). It is in place when the container is sent out with a “collection” employee to be put in a certain coin telephone, and is expected to be intact when the container is returned during the next collection cycle.

The container goes behind a very secure locked door into the “vault” of the coin telephone, with the hasp outward.

As the container is inserted, a feature in the vault engages the lever we see at the left rear of the lid, which rotates as the container is fully inserted, opening a sliding door on the underside of the cover and opening the rectangular “port” we sear near the rear of the cover. This also “cocks” a latch that will later lock the sliding door closed.

That port will align with the “collect” discharge port of the coin hopper so that the collected coins will fall into the container.

When the collection employee next visits the coin telephone, he unlocks the vault door (a different key is required for each telephone, so he has bunch of really big key rings).

As he starts to withdraw the container, pulling it with the wire bail that we see. the lever restores. There is in fact another feature in the vault that forces the lever to restore as the container is withdrawn, and prevents the container from being withdrawn if the lever cannot restore. This closes the door over the rectangular coin port, and the latch, cocked when the door was opened, then locks the door so that it cannot be re-opened.

Back at the telephone company, in a secure room, the containers are opened (the seal being broken) and the coins put into counters and so forth.

In figure 29, we now see the underside of the lid.

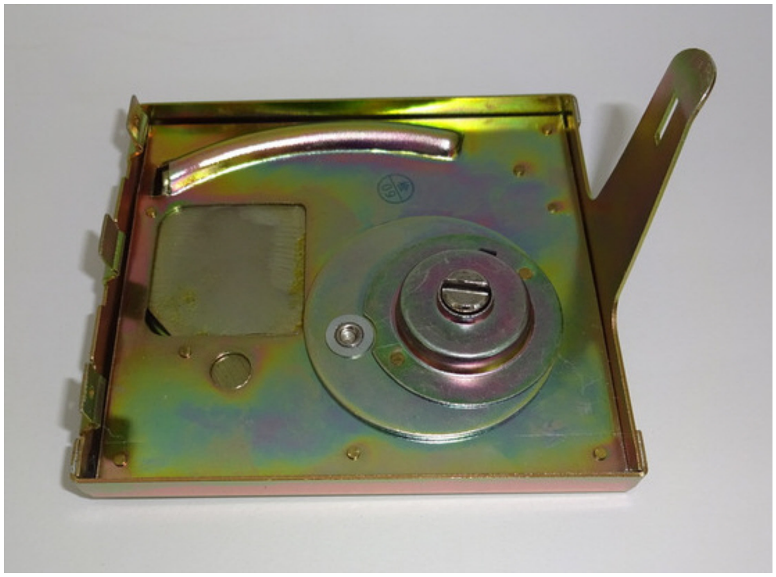

Figure 29. Coin container lid, underside

The door is actually sandwiched between two layers of sheet metal that make up the top of the lid.

The “screwhead” we see is then rotated with a screwdriver-like tool about a quarter turn clockwise. This resets the latch holding the door closed so that, on the lid’s next deployment, the lever will be able to open the door when the container is put into the vault.

19 THE “SINGLE COIL” COIN RELAY

As I began above to discuss the operation of coin telephones, I introduced the *coin relay* with a brief description of its construction. I described it as much like a traditional telephone ringer, permanent magnet and all. Like the traditional ringer, it actually had two coils (on different pole pieces), although they were connected in series and I represented the pair with a single electromagnet symbol on the circuit sketches.

In the late 1950s the Bell System began equipping its (multi-slot) coin phones with a new coin relay of dramatically different design. One obvious feature was that it had only one coil. It was nevertheless functionally, electrically, and essentially mechanically interchangeable with the older type of coin relay. It did require use of a new design of the coin hopper, interchangeable in coin collectors with the earlier one.

Not surprisingly, to distinguish the two kinds of coin relay, this newer type was called a “single coil” coin relay, and the older type was then called a “two coil” coin relay.

This important development is discussed in some detail in Appendix D.

For our purposes here, the introduction of this new type of coin relay had no effect on the operating protocols.

20 IMPLEMENTATION OF TRANSMISSION CIRCUIT AND RINGER

20.1 Background—the *subscriber set*

In early telephone sets, notably the deskstand type (often called by civilians the “candlestick” type), and the early handset desk telephones with a small round or oval base, nether the transmission circuit nor the ringer were in the telephone set itself. Rather they were in a separate box, typically mounted on the wall or desk nearby.

The transmission circuit classically comprised a special type of “audio” transformer (nomenclatured, for historical reasons, as an “induction coil”) and a capacitor, which blocked DC flow where it was not desired and as well formed part of the “anti-sidetone network” of the transmission circuit. The ringer proper was also accompanied by a capacitor, which served to couple it to the telephone line in a way that no DC would flow through it.

The formal nomenclature of this box was originally “subscriber’s set”, now seen as a seemingly nonsensical choice. Later it was changed to “subscriber set”. It is sometimes (but incorrectly) called a “subset”.

20.2 In coin telephones

Of course, the design details of coin collectors varied immensely over the years. In most of the types, neither the transmission circuit nor the ringer were in the coin telephone itself, but rather were in a subscriber set, typically mounted below the coin telephone.

In some of the more modern types, the transmission circuit was in the coin telephone set, but the ringer was still in a subscriber set (this type holding only the ringer and its associated capacitor).

We will see later that in the even more modern “single slot” coin telephone sets, the ringer was finally invited into the telephone proper.

21 THE GROUND NOISE PROBLEM

21.1 The path to ground

We have seen that the prepay coin collector depends in several ways on what we think of as a DC path to ground through the coin relay from what I have so far shown as the tip of the telephone loop.

But it is not at all unlikely that there is a DC and/or AC potential difference between the local ground at the telephone station and the ground to which the DC supply at the central office is referenced.

As to the DC component of this, the overall operation of the system is such that it will operate properly in the face of a certain level of DC potential difference (and that tolerance range is stated in various application planning documents).

21.2 Noise interference implications

The AC component likely has as its fundamental the power line frequency, but might also contain harmonic components further up into the audible range. And thus a current just like that can be "injected" into our coin telephone circuit.

Now if such a spurious AC current were injected into the "AC center" of the transmission circuit (if it had such a node), we can imagine that it would not produce any net effect on the transmission circuit. Half of the current will flow in opposite directions through symmetrical portions of the transmission circuit, the effects ideally canceling out. Thus no audible interference would heard by the user as a result of by this phenomenon.

But (at least in the simplified circuit I have shown), the path for such spurious AC currents would lead not to the "AC center" of the transmission circuit, but rather to one side of it (at the tip). About half of that current will flow into the tip and thus toward the central office. The other about half will flow through the transmission circuit, which will treat it as a signal to be conveyed to the handset receiver. And this will be audible noise.

21.3 Mitigating this phenomenon

Two techniques are available used to minimize the impact of this exposures to noise.

One is to make the impedance of the coin relay high (at the frequencies of interest). This is done by assuring that the relay coil exhibits a high inductance (and that this inductance is not "spoiled" at the higher frequencies by core eddy currents).

And this is in fact done (to the degree practical) in the traditional coin relay.

The second is (duh!) to actually run the path to the coin relay and thence to ground from the AC center of the transmission circuit.

But can we get to that node? Yes, indeed. Because of a parallel problem occurring in two-part telephone line operation, the transformer used in the transmission circuit has (for the older type, in a certain version, and in the newer type, universally) a terminal (typically designated “M”) that is very close to being the “AC center” of the transmission circuit.

And that is done in many coin collectors (especially the “fairly modern” ones, notably those that had the transmission circuit in the coin telephone proper. We see that in figure 30.

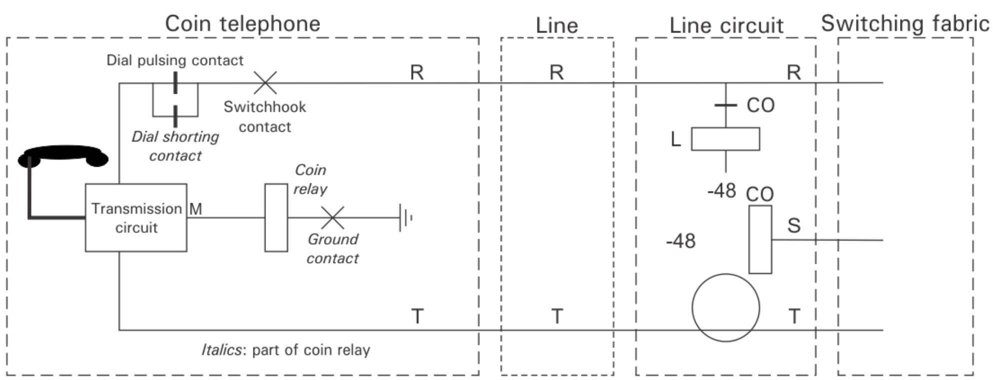

Figure 30. Center of transmission circuit

Note that this has required the relocation of the dial pulsing contact to the ring side of the transmission circuit, and so the dial shorting contact has to be electrically separate from what we now call the *ground contact* of the coin relay, thus making the spring pileup of the coin relay a little more complicated (4 springs altogether).

22 THE SECOND COMING OF “DIAL TONE FIRST” OPERATION

In the late 1950s, there was increasing public pressure to provide (or, in some few areas, restore) the ability to place an emergency call from a coin phone without needing any coins.

The telephone companies also came to realize that there was a market for “800” calls (paid for by the recipient), and calls (even local calls) made on a “collect” basis or charged to a credit card, made by people at a coin phone, but that market could not reach customers who had no coins.

In about 1960, serious planning began for a large initiative in the Bell Telephone System called the Coin Service Improvement Program. Its central feature was the "introduction" of "Dial Tone First" coin service, allowing callers with no coins to place most kinds of free calls (including of course reaching an operator who could arrange for a collect or credit card call). It began to be implemented in 1968.

In due time, regulatory initiatives would mandate this mode of operation for all US and Canadian telephone service, including by non-Bell companies as well.

The whole story of this is very complex, and I will not discuss it here, cutting off the detailed discussion of coin telephone service evolution just before that happened.

But a teaser: As we might properly assume, yes, this necessarily operated on a loop start line circuit basis. So all prepay coin lines, most of which had for many years (almost all of them since the time of conversion to a 10¢ initial deposit) operated on a ground start basis, were now converted to loop start operation.

As an aside, I note that essentially all discussions of this change, whether in the popular press or in such prestigious publications as the Bell Laboratories Record, described this by saying that theretofore, in **all** coin telephones (excluding the postpay mode), a coin had to be deposited to "get dial tone". As you have seen above, that was not exactly always the case (even ignoring the pre-1930 panel office situation).

In any event, I usually write of the "from 1968" mode of dial tone first operation as "Dial Tone First", the initial capitals to give honor to what a big deal this was. But keep in mind that this was actually the "second coming" of this operational concept.

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Appendix A
Operation of the Automatic Electric "two nickel" mechanism

A.1 INTRODUCTION

Certain Automatic Electric Company (AE) coin telephones (actually styled "Payphones" by AE) are equipped to require a 10¢ initial deposit,[18] which can be paid either with a dime or with two nickels. Here, I will discuss how that is provided with an ingenious mechanism.

A.2 ILLUSTRATION CREDIT

The illustrations in this appendix were derived by the author from an illustration originally appearing (among other places) in Automatic Electric Company Technical Bulletin 702-86.

A.3 OBJECTIVE OF THE MECHANISM

The objective of this mechanism is to manage the payment of the 10¢ initial deposit to a prepay mode coin telephone in the form of two nickels, to the end that until the caller has deposited both nickels the call cannot be made.

A.4 SUMMARY OF OPERATION

Simply, when the first nickel is deposited (and that will trip the coin trigger and thus allow the telephone to ask for and get dial tone), a switch is operated (and latched operated) that will disable the telephone's dial pulsing contacts, so the caller (who has so far only paid half of the required initial deposit) cannot yet place a call.

When the second nickel is deposited, the switch is allowed to return to normal, removing the disablement of the dial.

A.5 DETAILED OPERATION

A.5.1 The principal players

Figure 31 represents the major players of the mechanism in their initial states.

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[18] These cleverly have a "55" (the ol' "double nickel") as a suffix to the type code.

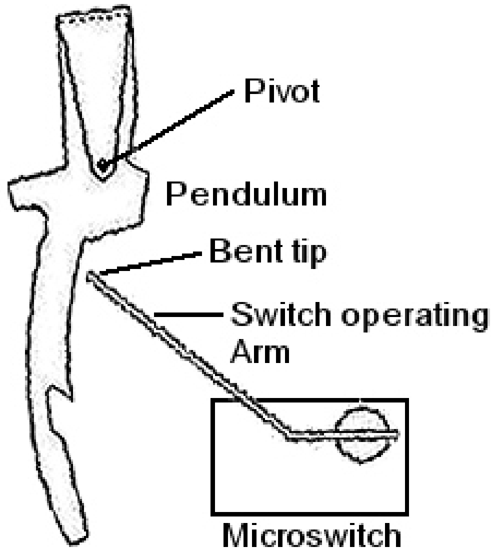

Figure 31. The principal players

"Microswitch" refers to a miniature switch of the "Micro-Switch" style. It has an operating arm (the "arm" or "switch arm") made of hardened steel, with a bent tip that extends (perpendicular to the plane of the drawing) into the nickel channel of the coin chute. The switch has a normally open contact.

The top of the pendulum is bent over, with a bit of a "roof". This allows the pivot axle to keep the pendulum in the desired plane. The mass distribution of the pendulum is such that the top portion is almost a full counterweight for the bottom portion. Thus the gravitational-based force that urges the pendulum to stay "upright" is small.

The substantial mass of the upper part (especially with much of that mass at a fairly great distance from the pivot) gives the pendulum a substantial moment of inertia (sort of the rotational equivalent of mass). The combination of these two parameters means that if the pendulum were to be set free a little way from its equilibrium position, it would oscillate relatively slowly.

As seen in the figure, the pendulum is essentially hanging freely, in its equilibrium ("neutral") position.

A.5.2 The effect of the first nickel

In Figure 32, the (first) nickel, descending through its channel in the coin chute, has struck the tip of the arm and has, so far, pushed it down to the position seen.

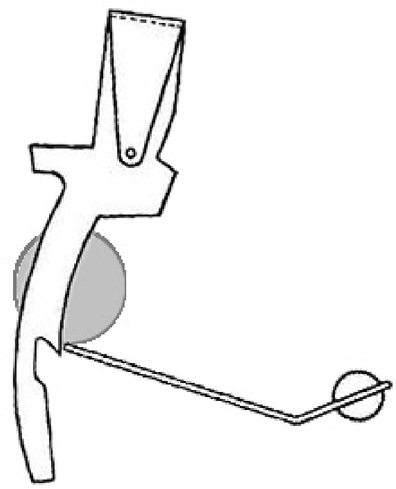

Figure 32. Arm struck by nickel

As a result, the tip of the arm has cammed the pendulum such that its lower portion has been moved to the left. But the movement is slight, and so the pendulum is not given much angular velocity on its way.

As we see the arm, it is just about to slip past the "lip" of the notch in the pendulum.

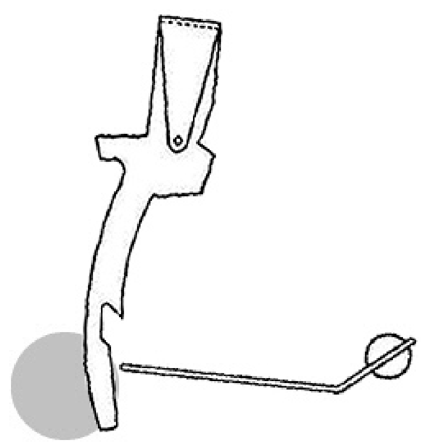

Figure 33. Arm pushed past the notch

In Figure 33 we see the arm having been pushed down by the nickel as far as it will go, past the latching notch. The nickel rolls off the tip of the arm and continues its journey down its channel in the coin chute. It exists the coin chute and goes into the coin hopper, where it trips the coin trigger, closing the coin contacts. This closes the path from the tip of the line through the coil of the coin relay to ground, operating the L relay in the line circuit. This causes a digit receiver to be attached, and the caller hears dial tone.

Our intrepid switch arm, now freed from the force of the falling nickel, begins to move upward under the restoring force of a spring in the microswitch.

But as soon as the arm passed the lip of the notch in the pendulum, the bottom of the pendulum was free to move to the right (toward its equilibrium position) under the influence of the gravitational-based force on it. We can imagine it moving into contact with the tip of the switch arm, as seen in Figure 34

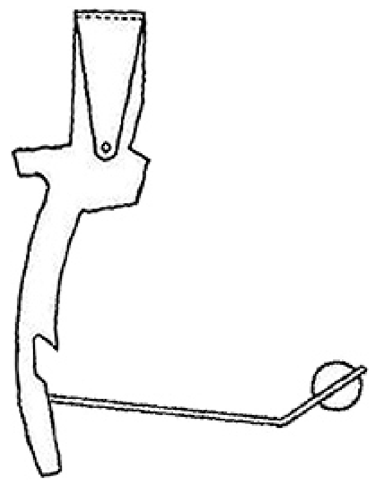

Figure 34. Pendulum swings into contact with the switch arm

With the pendulum in that position, the lip of the notch is where it would catch the switch arm as it rises.

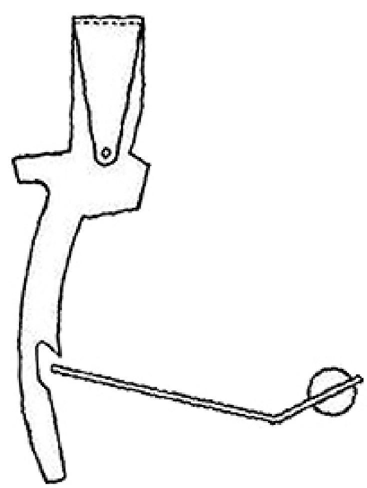

Figure 35. Arm rises and is caught by the lip of the notch

We see that in Figure 35. The switch arm is indeed about to be caught by the notch lip and thus will be forced fully into the notch.

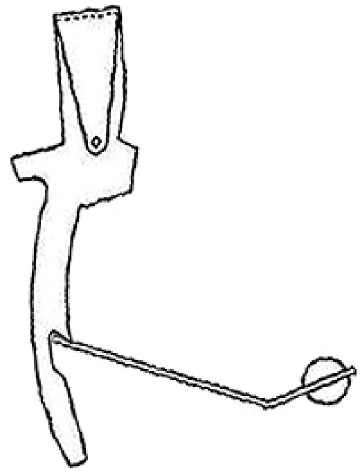

Figure 36. Arm in repose in the notch

In Figure 36 we see the arm fully caught and in peaceful repose in the latching notch.

At this moment, the telephone line has received dial tone, heard by the caller (rather a tease at this point), but the microswitch is operated, and its contact has closed and shorted out the dial pulsing contact. Thus the caller (having only yet paid half the price of admission) cannot dial.

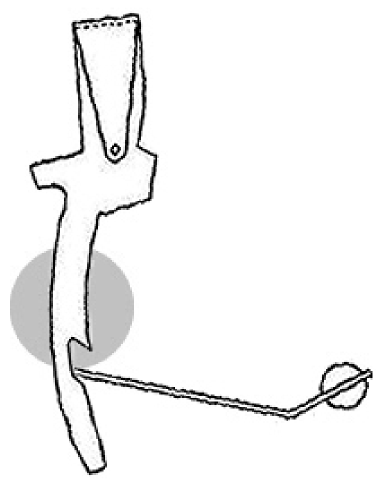

Figure 37. Arm struck by second nickel

A.5.3 The effect of the second nickel

Now the caller deposits a second nickel. We see the beginning of the result in Figure 37.

The second nickel has struck the tip of the arm and, so far, has driven it to the bottom of the notch. Further downward movement of the arm will cam the lower end of the pendulum smartly to the left ("smartly" owing to the steep slope of the bottom of the notch), imparting a substantial amount of angular momentum (in the clockwise direction) to it.

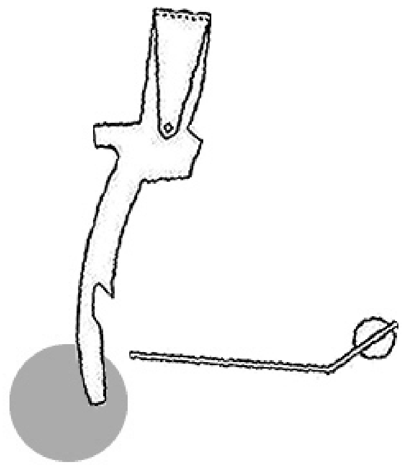

Figure 38. Arm kicked out

In Figure 38 we see the arm as far down as this nickel could push it, and we also see that the lower end of the pendulum has been kicked substantially to the left.

Again the nickel rolls off the tip of the arm, which is again now free to rise under the influence of the restoring spring in the switch.

The pendulum, under force of gravity, begins to move its lower portion to the right, but only slowly (as the gravitational torque on it is so slight).

As a result, this time, when the arm tip rises to the altitude of the lip of the notch, the lip is still left of the tip of the arm. We see that in Figure 39.

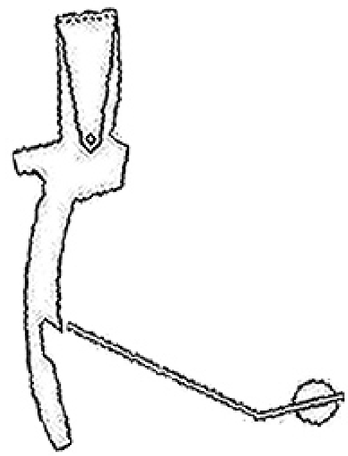

Figure 39. Arm misses the tip of the notch

The arm misses the notch completely. The arm continues to rise, until it returns to its original position, as shown in Figure 40.

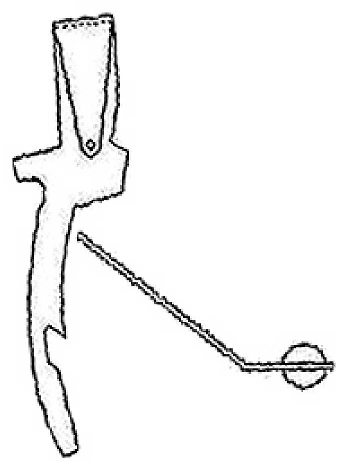

Figure 40. Arm returned to normal

With the arm here, the switch contacts are open, and the shunt they provided across the dial pulsing contacts is no more. The caller can dial his call.

A.5.4 The restoring magnet

Whenever coil control voltage (of either polarity) is applied to the tip of the line, and assuming that the coin contacts are closed, the current that flows through the coin relay coil also flows through the coil of the *restoring magnet*. We see it in Figure 41.

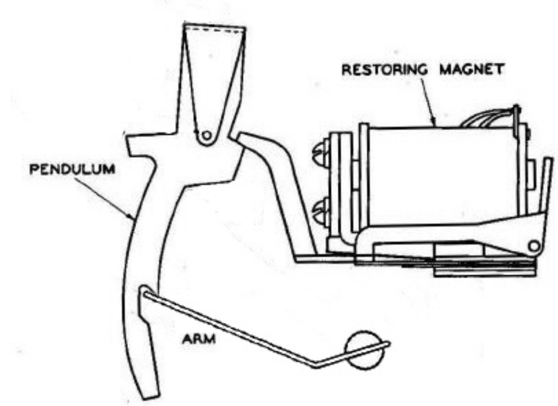

Figure 41. Restoring magnet

We see that when the restoring magnet operates, its arm presses on the pendulum so as to rotate it clockwise, moving its lower end to the left (not pictured). Thus, if the switch arm had been latched by the notch in the pendulum, the arm would be released and would return to its “normal” position (as seen in Figure 40), readying the mechanism for its next outing. When the magnet releases, the pendulum returns to its idle position (again as seen in Figure 40). The mechanism is ready for the next call.

22.1.1 *An anti-fraud feature*

Imagine that a coin telephone with this mechanism is not mounted rigidly to a wall, but rather is on a wood bracket sitting on a table.

Now imagine that after a caller has deposited a single nickel, and the switch arm is latched into the notch in the pendulum, so the microswitch is operated and the dial disabled, the caller gives the coin phone a hard blow to its left side, making it jump to the right.

The asymmetry of the first moments of the top and bottom portions of the pendulum means this would tend to rotate the pendulum clockwise (so its lower portion moved to the left). And this could disengage the switch arm so it could rise to its normal position, causing the switch to open its contacts, removing the shunt from the dial pulsing contacts.

The dial would then be functional, and the caller could then make his call, only having paid 5¢ to do so (plus perhaps a sore left hand).

[I did not make this up.]

To thwart this ploy is the job of the *shock lever*, seen in Figure 42.

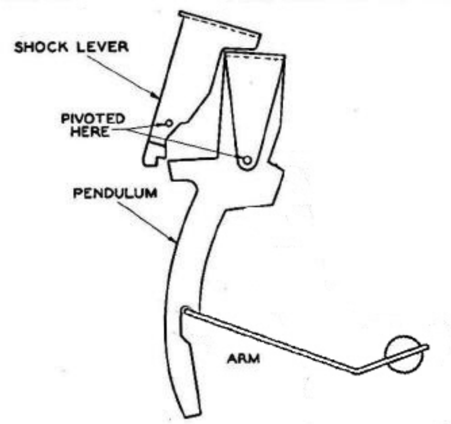

Figure 42. Shock lever

Note that its top “leans against” the top of the pendulum. When the pendulum is in the position shown, This puts the shock lever in a position where its toe almost engages an extension of the pendulum, but not quite.

Recall that when our miscreant smites a mighty blow on the left side of the coin telephone, making it jump to the right, this will tend to rotate the pendulum clockwise.

But the shock lever, with almost all its mass above the pivot, will rotate counterclockwise, moving the toe at its bottom. Even a small such motion will make the toe engage the pendulum extension, blocking any clockwise rotation of the pendulum. Thus the switch arm will not be released.

The problem (if it really existed) has been solved.

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Appendix B
Prepay coin operation in manual offices

B.1 INTRODUCTION

The basic principles of prepay coin telephone operation, discussed in detail in the body of this article in the context of "dial" operation, were first developed and deployed in the context of manual switching. Here I discuss that context.

There is an interesting (if small-seeming) difference between the protocol used here and the corresponding protocols used for dial operation. That is a major motivation for including this discussion.

B.2 REGULAR STATION OPERATION IN A MANUAL SWITCHBOARD

As I did in the body of this article for "dial" operation, to establish the technical context I will begin by reviewing the pertinent features of manual telephone service for a "regular" (non-coin) line.

In Figure 43 we see the pertinent features of a "regular" manual telephone line, with the line idle.

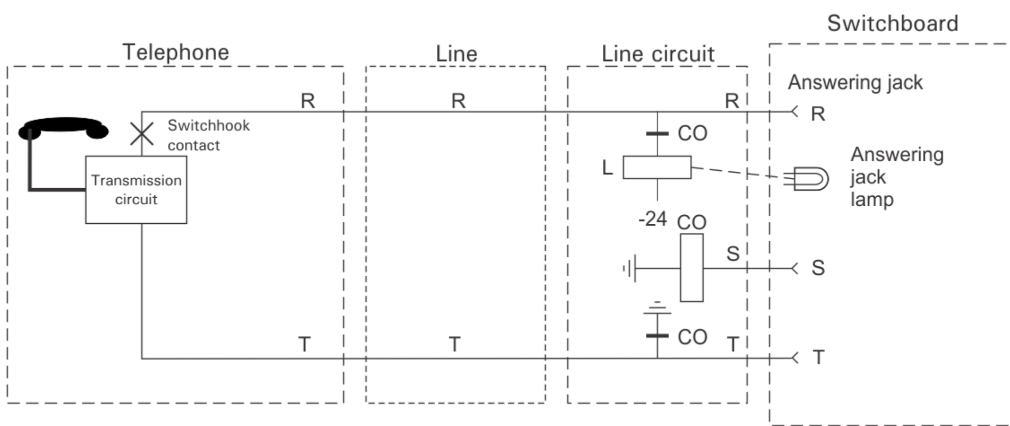

Figure 43. Regular line with manual service, idle

The parallels between this and the corresponding figure for dial service are obvious. The differences are:

- Operation is on a 24 volt basis[19] (not of any real consequence to this story).
- The cutoff relay is fed from ground rather than battery (not of any real consequence to this story).

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[19] 48 volts was later adopted for "machine switching" (dial) systems because of the greater amount of energy used in those.

- The "switching fabric" here is the manual switchboard, and we recognize that the line appears there on several jacks. I use the generic "connector" symbol here rather than the more illustrative "jack symbol" just for the sake of simplicity.
- When the L relay in the line circuit operates, it lights a lamp at the "answering jack" associated with the line to alert the operator that this line wants service. I did not show the actual circuit (simple though it is) to save congestion on the figure.

In Figure 44 we see the situation after the user takes the telephone off-hook to initiate a call.

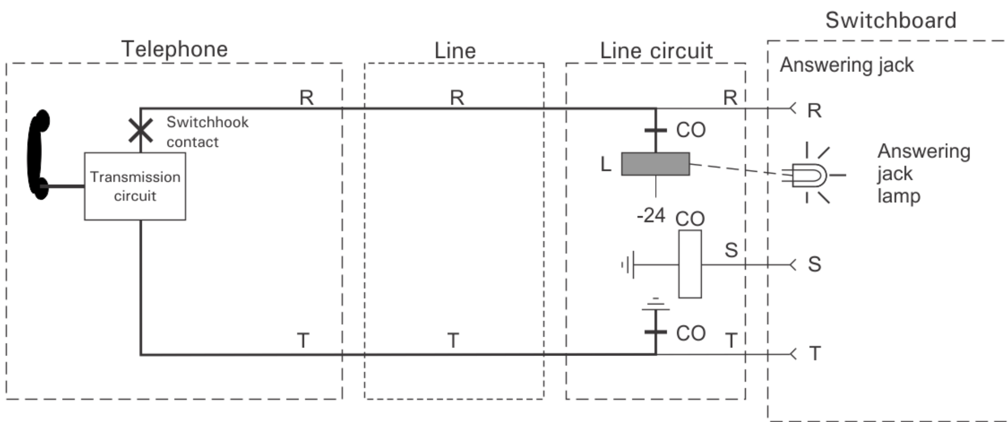

Figure 44. Caller goes off-hook

The operation of the L relay in the line circuit lights the answering jack lamp.

In Figure 45 we see the situation when the operator has responded to the lamp by plugging the "answering" cord of an idle cord circuit into the answering jack.

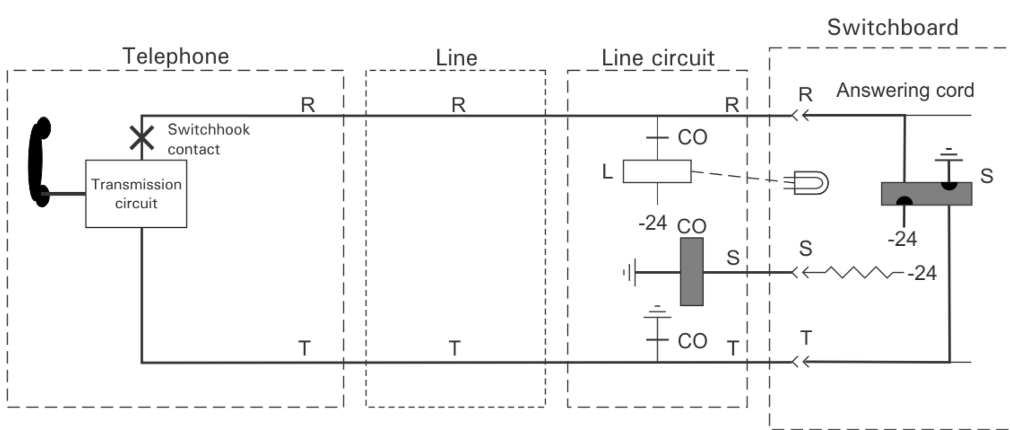

Figure 45. Operator answers the line lamp

In reality, the circuit that feeds battery to the calling line is not that shown here, but I drew it the same way I did for the dial case for ease in comparison.

The sleeve of the answering cord carries battery through a resistance, and that operates the CO relay in the line circuit, which (just as in the dial case) removes the path involving battery through the L relay on the ring and the ground on the tip.

This completes this review of manual switchboard operation for "regular" stations, as it covers all that will be pertinent here.

B.3 PREPAY COIN SERVICE—GROUND START COIN FIRST PROTOCOL

B.3.1 Basic operation

Prepay operation with manual switching was essentially universally on the basis of coin first operation with a ground station line circuit. We see the line circuit with the station dial in Figure 46.

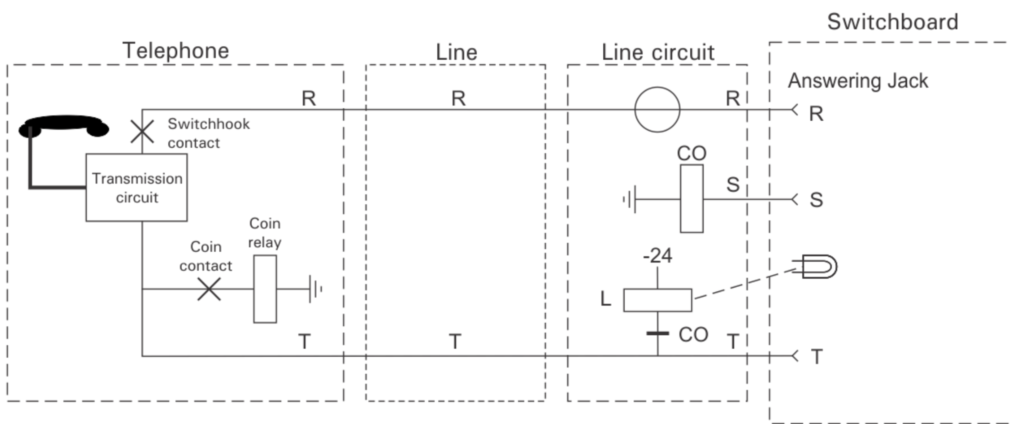

Figure 46. Manual coin line

We see the differences from dial operation noted in the previous section. But there is a further difference when the line circuit is used for a coin station. Battery through the L relay is applied to the tip conductor (not the ring, as for dial operation). And, since this is a ground start line circuit, the other conductor (ring) is open at the line circuit (again I use a circle to highlight this).

In Figure 47 we see the situation when the user of the coin station has lifted the handset but not yet deposited a coin.

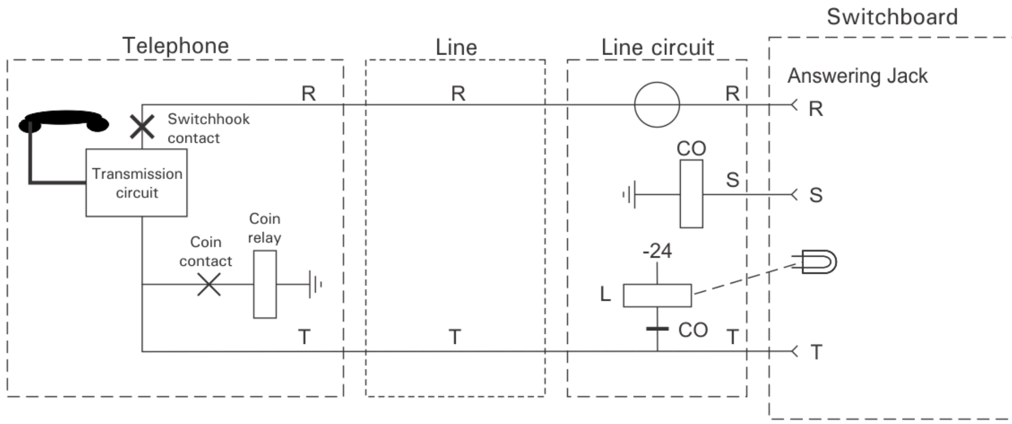

Figure 47. Use lifts handset

As we have come to expect, nothing happen at the central office.

In Figure 48, the user; having already lifted the handset, deposits a coin or coins (depending on the initial deposit amount).

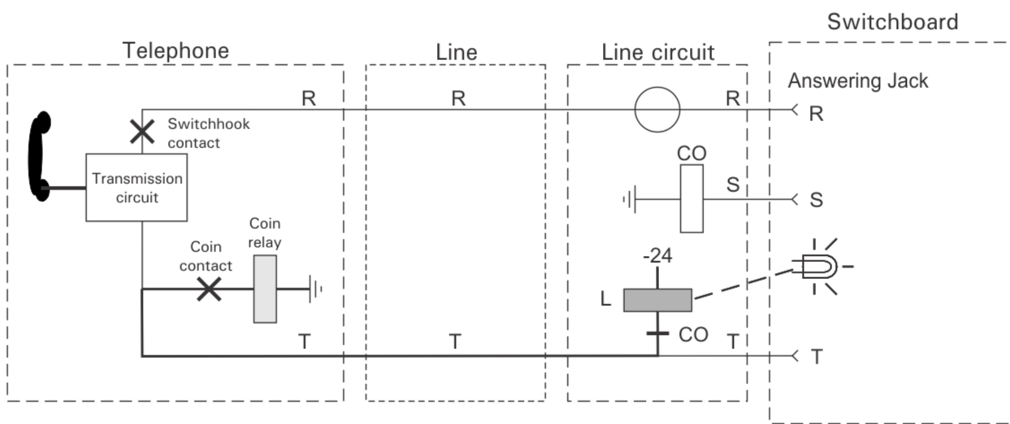

Figure 48. User deposits coin (or coins)

The coin contact closes, completing a path from the tip to ground through the coin relay coil.

The current through the tip conductor operates the L relay in the line circuit, lighting the lamp at the station's answering jacks at the switchboard. The current is far less than would operate the coin relay.

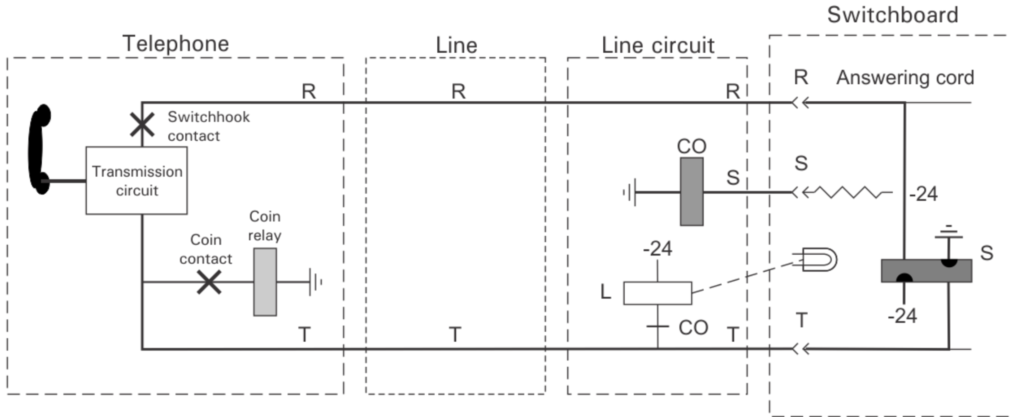

Figure 49. Operator answers

In Figure 49, the operator has answered this signal by plugging the answering cord of an idle cord circuit into the line's answering jack.

No surprises here.

At the end of the call, the operator, by operating a "coin collect" (CC) or "coin return" (CR) key associated with this cord causes +110 V or -110 V (respectively) to be applied to the tip, operating the coin relay in the familiar way. We see this in Figure 50 for the collect operation.

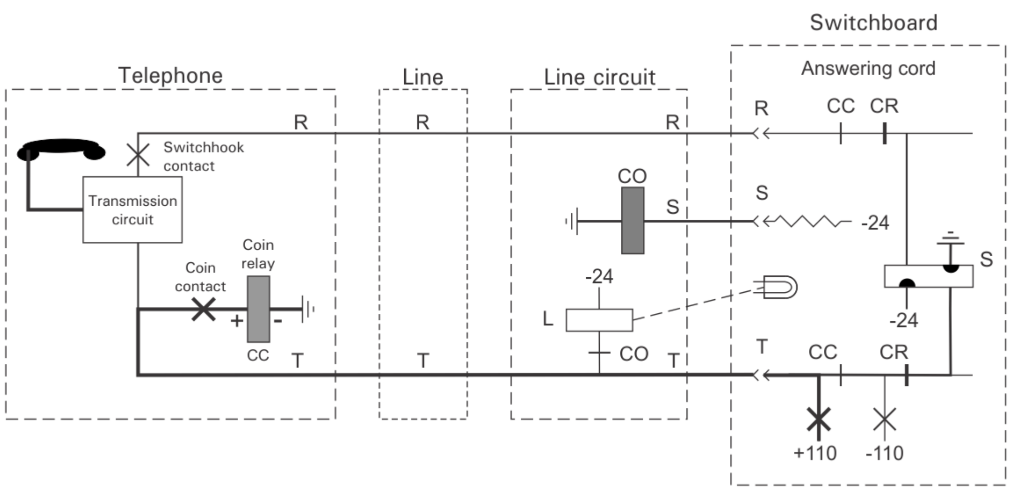

Figure 50. Coin collect

Note that the ring conductor is opened during the application of the coin control voltage to the tip.

We can also see on this figure how the matching coin return operation would work.

There is no monitoring of the current in this path to be certain that a coin relay is indeed present.

After applying this voltage for some period (hopefully about 0.5 second), the operator releases the coin key and pulls the cord out of the line jack. There is no test made as part of this process itself to confirm that the coin relay has indeed reset.

B.3.2 "Stuck coin"

Suppose that for some reason the coin relay does not properly reset the coin contact (referred to as a "stuck coin" situation, not really an apt description). The caller has hung up, and the operator has disconnected from the line. The situation will be that seen in Figure 51.

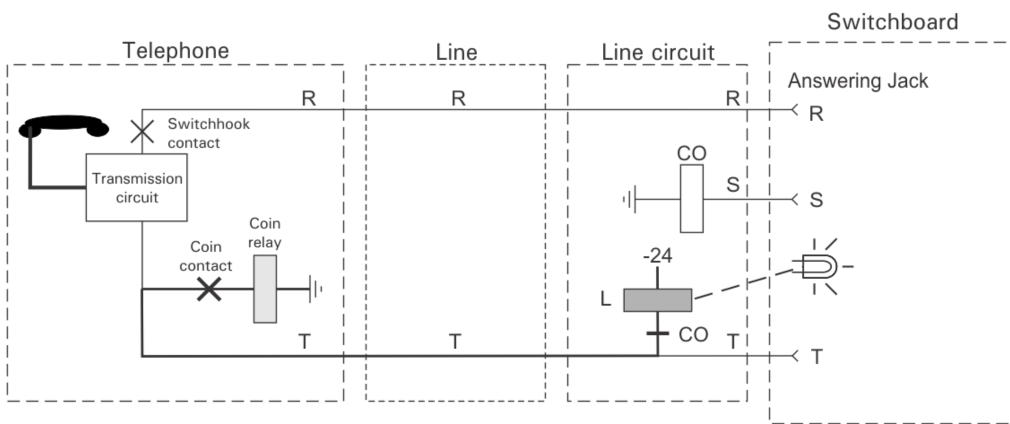

Figure 51. "Stuck coin" situation

Once CO is released, the path through the coin contact and the coin relay to ground operates the L relay in the line circuit, in turn lighting the lamp at the line's answering jack.

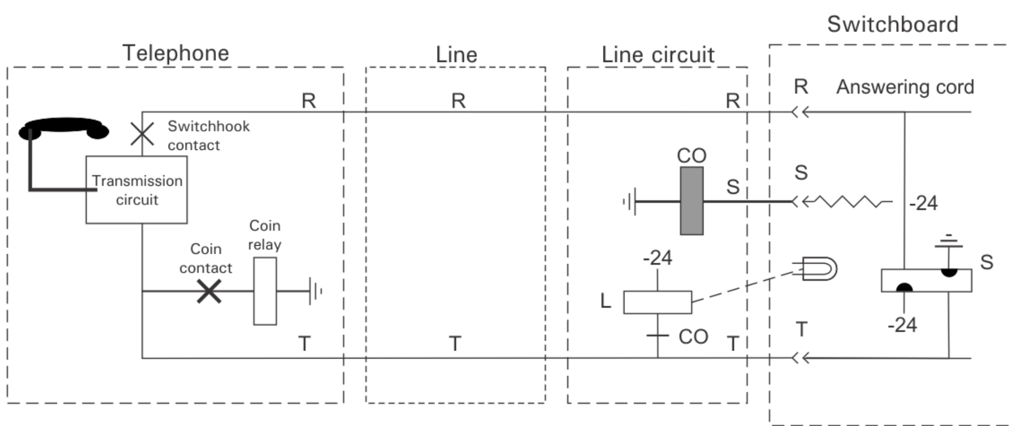

Figure 52. Operator answers "stuck coin" signal

The operator, thinking that perhaps the caller has immediately wanted to place another call, again plugs an answering cord into the line jack. Now the situation is as seen in Figure 52.

We see that the S relay does not operate. With the cord plugged in but S not operated, the cord supervisory lamp lights, telling the operator that the station associated with the cord is on-hook.

But since the answering jack lamp was lit, for the calling station to be on-hook is clearly anomalous, and, since this is marked as a coin line, this tells the operator that she is probably dealing with a “stuck coin” situation, which she will refer to the proper office for attention.

It is to make this part of this scenario work that in a manual coin line circuit the L relay is connected to the tip, not the ring as for a “regular” manual service line.

-#-

Appendix C
Postpay coin telephone operation

C.1 INTRODUCTION

C.1.1 The concept

The “postpay” mode of coin telephone operation was primarily used in small, step by step dial offices, often those called, in the Bell Telephone System, “community dial offices” (CDOs). (Essentially the same scheme was earlier used with manual service in small towns, but here I will only describe the operation for dial service.)

In this mode, the caller would lift the receiver/handset and get dial tone. No coin deposit was needed at this point nor should any have been made.

For a local call, the caller would dial in the usual way. If the called line was busy, or if the called subscriber did not answer, or if the call went to recorded intercept because the dialed number was not currently valid, the user would just hang up.

If and when the called subscriber answered, he was not able to speak with other party (the details of this differ between Bell System and non-Bell implementations). The caller makes the initial coin deposit into the phone, which them made it possible to speak with the other party.

In the coin telephone, the hopper led directly to the coin vault (there being no trap or vane), so any coin(s) deposited were immediately “collected”. There was no provision to return to the caller valid coins that had been deposited. The return chute was only used to return coins that were rejected by the coin chute as bogus.

C.1.2 The motivation

The principal motivations for the use of this mode, rather than the “prepay” mode generally used, were:

- In the implementation used by the Bell Telephone System, the coin telephone was somewhat simpler, both an initial cost and maintenance advantage.

- In the implementation used by non-Bell telephone companies, there was essentially no special circuitry needed at the central office to handle coin telephone lines and service. And in the Bell System’s implementation of this mode, there was special central office equipment required, but it was not as complex as for prepay service.

C.2 THE COIN TELEPHONES

The coin telephones used for postpay service during the era of interest were in general of the multi-slot coin collector variety, and for the most part were externally indistinguishable from the telephones used for prepay service.

Inside, the coin chute was not essentially different from that used in the prepay coin collectors (to use the Bell System nomenclature). But there was no coin relay. Rather, the coin hopper (different from that used in prepay coin collectors) led directly to the coin vault, so any (legitimate) coin(s) deposited were immediately collected. The return chute was only used for the return of coins rejected as bogus by the coin chute.

The hopper did not contain the trap and vane arrangement found in prepay coin phones. Instead there was indeed a trigger lever that was operated by the passage of any coin through the hopper. Exactly what that did varied between Bell System and non-Bell implementations, so that will be discussed separately in sections for each of those situations.

C.3 TWO RATHER DIFFERENT IMPLEMENTATIONS

As suggested at the end of the above section, unlike the situation for prepay operation, where the operating scheme was essentially identical for Bell Telephone System and non-bell contexts, here there was a significant difference between the two implementations of the postpay mode. I will discuss them both in some detail.

C.4 THE BELL TELEPHONE SYSTEM IMPLEMENTATION

C.4.1 Introduction

In the Bell Telephone System, the implementation of postpay coin telephone involved special *coin trunks* in the central office though which all coin telephone calls were routed. These were however considerably simpler than the coin trunks used for prepay coin service. Notably, they needed to have no provision for effecting the collection or return of the “escrowed” coins at the end of the call.

C.4.2 The coin telephone

The coin telephones used here are almost identical to those described for the non-Bell implementation except that there is no coin relay of any sort. But again there is, in the hopper, a coin trigger arm momentarily operated by the passage of any coin. What that does will be seen shortly.

In any case, the most tricky and potentially troublesome mechanism of the prepay coin telephone (the coin relay) is completely absent here, presumably an advantage from a maintenance standpoint.

C.4.3 At the central office

At the central office, all coin telephone traffic was handled by a group of linefinders whose path to the associated first selector was though a *postpay coin trunk*. This was a complex circuit, but not as complex as the coin trunks used for prepay coin service. As mentioned just above, for one thing, it did not have to deal with the collection or return of coins, which, especially with all the provisions for dealing with anomalous conditions, was a major complexity

If and when the calling line answers, the reverse battery supervision returned through the connection operates a polar (polarity sensitive) relay in the trunk, which causes the trunk to “split” the connection from a transmission standpoint (both ways, of course). It also causes the trunk to send to the calling line (steadily) the “deposit coin” tone (the same tone as used for busy tone). This indicates to the calling party that the called line has answered and he should deposit the required coin(s).

With the connection “split”, loop battery is supplied to the calling line by the coin trunk. If and when the caller deposited a coin, as it momentarily operates the trigger lever, the lever’s contact momentarily (for 100-300 ms) puts a 4450 ohm resistor in series with the loop.

The resulting momentary decrease in loop current (but not to zero) is discerned by a marginal relay circuit in the coin trunk. This causes the trunk to remove the “deposit coin” tone and “put the connection back together”. The rest of the call proceeds in the usual way.

C.5 NON-BELL IMPLEMENTATION

C.5.1 Method of operation

What I aptly describe as the “non-Bell” implementation actually arises from Automatic Electric Company (AE) (later part of GTE), the principal manufacturer of coin telephones for non-Bell telephone companies. To them, this mode was spoken of as “semi-postpay”.[20]

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[20] L. L. Ruggles, then Chief Telephone Engineer for Automatic Electric Company, in a 1954 article in the Automatic Electric Technical Journal, explains that thus: “Semi-post pay paystations were designed for service in a dial system. The term "semi-postpay" is applied to distinguish a dial postpay paystation from a manual postpay paystation.” I do not claim to fully understand that.

This scheme depends on the premise that, when the called party answers, reverse battery supervision is returned all the way to the calling line and thus to the calling coin telephone. Since, in the era of this mode, the small central offices in which it was used almost invariably were of the step-by-step type (actually referred to, outside the Bell System, as "Strowger" offices), which in fact followed that signaling convention, this worked out fine.

This protocol involved a coin telephone that was essentially identical in complexity to that used for prepay service (albeit different in operation), but did not for the most part require any special central office circuitry.

At the calling coin telephone, the reversal of battery when the calling station answers is detected by a polarity-sensitive "coin relay". This is made very much like the coin relay used in prepay coin telephones, and is mounted in the same place (in front of the hopper). But its operation is quite different. For one thing, it has a fairly low resistance (typically 150 ohms), and is in series with the loop. And of course there is no trap and vane mechanism for it to actuate.

We see it in Figure 53.[21]

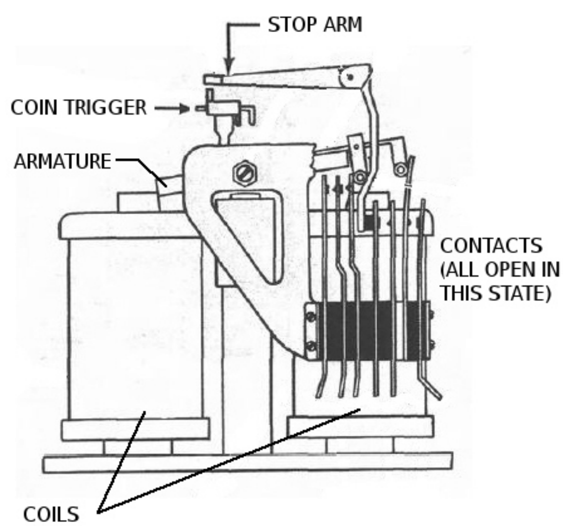

Figure 53. Automatic Electric postpay coin relay—idle

It only has two positions, which we will, as for a conventional relay, consider to be *non-operated* and *operated*. With current through its windings in the initial direction in the loop, it is non-operated. With the

[21] This figure and the two following are adapted from figures in a technical bulletin of Automatic Electric Company, dated 1957, and presumably copyright by that company. They are used here under the doctrine of fair use.

loop current reversed, it is operated. With little or no current, it will remain in the present position.

We see it in the idle (non-operated) state in Figure 54.

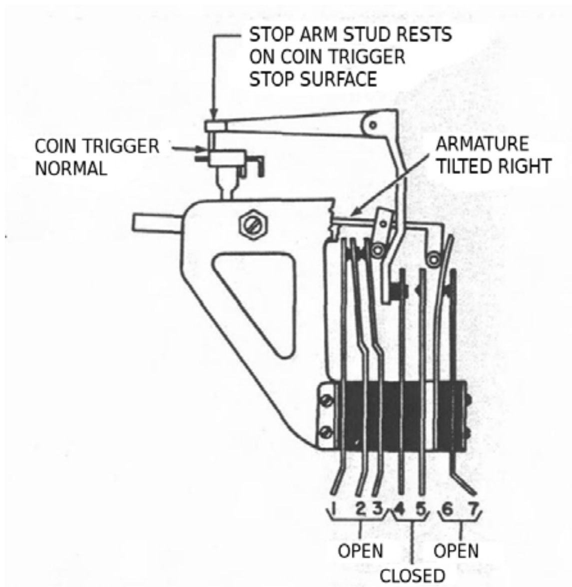

Figure 54. AE postpay coin relay—operated

Contacts 1-2 close to short out the transmitter so it would be impossible for the calling party to speak to the called party. Contacts 2-3 shunt the receiver through a resistor, so as to substantially reduce the volume of any speech from the distant party, although such could still be heard faintly. Contacts 6-7 are now closed; this performs a circuit function I will not describe here.

When any coin is deposited, as it passes through the hopper, it operates a coin trigger which releases the stop arm, which lowers and, at its vertical limb, moves right and changes the contact situation, The trigger and stop arm are latched in the position even after the coin has passed the trigger, We see the relay in that state in Figure 55.

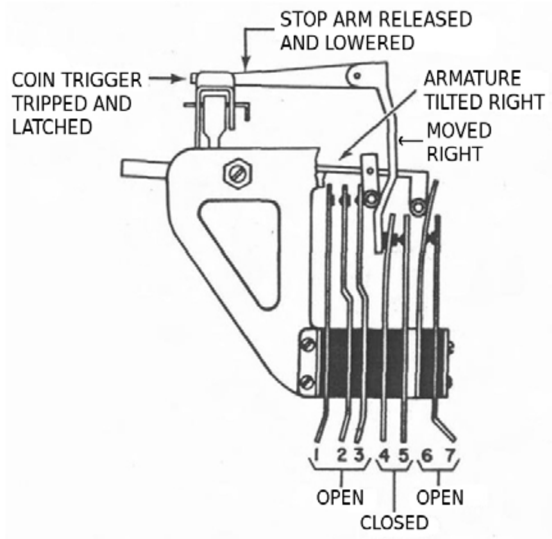

Figure 55. AE postpay coin relay—operated and trigger tripped

We see that contacts 1-2-3 are now again open, relieving the short circuit on the transmitter and the shunting of the receiver. Contacts 4-5 are now closed; this performs a circuit function I will not describe here.

At the end of the call, circuit arrangements not described here, involving an additional high-resistance winding on one of the relay coils, forces the relay to the non-operated state (as seen in Figure 53). This allows one of the contract springs (fourth from the left, numbered "4" on later drawings) to force the stop arm to its uppermost position, in turn allowing the coin trigger to reset, so the mechanism will be ready for the next call.

Note that contacts 1-2-3 will then be open, so the transmitter and receiver will initially operate normally on that subsequent call.

C.5.2 An interesting advantage

An advantage of this implementation to certain users was this: Suppose that a young man called his girlfriend's house to speak to her, but her father answered, to whom he certainly did not wish to speak.

He would just not deposit any coin, hang up, and go about his business, not having wasted any money on this misadventure.

C.5.3 One more mode

Automatic Electric also offered coin telephones and the associated central office equipment for a mode they called "Local Prepay Service". From the user's viewpoint, the mode operated essentially in the prepay mode for local calls but the postpay mode for long distance calls (as discussed in Section C.6). The former aspect was intended to avoid problems for users unfamiliar with the postpay mode (see Section C.7). The latter aspect was intended to avoid the need, for toll calls, to provide for the control of coin collect or return by the long distance operator.

It used a line protocol different from any discussed here. The coin telephone included a very elaborate coin relay mechanism.

In local (thus prepay) operation, when and if the call is answered, the central office applies reverse battery, which causes the coin relay to go into the “collect” state, so the escrowed coins immediately go into the coin vault.

If the call is not answered, when the caller hangs up, the central office a -110 V DC “coin return” signal to both tip and ring line conductors. This operates the coin relay to the “return” position, and the escrowed coins are returned.

On a call to the long distance operator, the central office immediately sends the coin action signal (-110 V DC), which causes the initially deposited coins to be returned.

But then, reverse battery is applied, which cause the coin mechanism to go into the “collect” mode, which persists. Thus any coins subsequently deposited are sent to the coin vault.

No +110 V DC “coin collect” signal is ever used in this scheme, so the central office need not have such a supply.

The coin telephone includes the “dial pulse shorting” provision described earlier (Section 17.2), and as well, when used with a 10¢ initial deposit, the Automatic Electric “nickel counting” mechanism described in Appendix A.

C.6 CALLS TO A LOCAL OPERATOR OR “FREE” NUMBERS

On a call to the local operator, or to a “free” number (typically the telephone company business office), no reverse battery supervision is returned when the operator (or called line) answered.

Thus, in either the non-Bell or Bell System implementation, nothing happened to prevent the caller from conversing with the distant end.

If the local operator completed the call to a local number (that operator is advised that the call was from a coin telephone station in various ways), she “split” the connection while waiting for the called line to answer. If and when the calling line answered, the operator advises the party there that there was a call from a “payphone” and asks them to hold the line for a moment.

The operator then tells the calling party to make the deposit for the local call. The operator would know that the coin was deposited from the sound made by the coin(s) as it (they) traversed the coin chute, and then unsplits the connection so the conversation could proceed.

C.7 CALLS THROUGH A LONG DISTANCE OPERATOR

A connection initially made to the long distance operator proceeds in much this same way. Typically the operator is advised that the call was from a coin telephone station by a burst of tone sent when she answered the trunk.

Here, after the called line answers (or if the call was "person to person", the desired person was on the line), the operator advises that party to "hold the line" and asks the caller for the proper deposit for the initial period for that call.

Again, she can identify the coin(s) deposited by the bell or gong sounds that this made, and after the proper amount was deposited, would unsplit the connection. The rest of the call would proceed in the usual way.

C.8 CHANGE IN THE INITIAL DEPOSIT FROM 5¢ TO 10¢

When the initial deposit (and thus the charge for a local call, at least for the initial period) was raided from 5¢ to 10¢ in a service area using postpay operation of the coin telephones, all the coin telephones had to be modified (just as for prepay coin telephones).

This modification was essentially the same used in prepay coin telephones, and the operation of the modified coin handling mechanism (differing substantially between the non-Bell and Bell system applications) was essentially the same as described in Section 16 of the body of this article.[22] There were a few "wrinkles" of difference in the postpay telephones, but those are beyond the scope of this appendix.

C.9 A "PROMPT" FOR OUT-OF-TOWN USERS

Most telephone subscribers lived and worked in areas where coin telephone service was on a "prepay" basis. When they would be in a small town with postpay coin telephone service, and wished to use a

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[22] That scheme allowed the initial deposit to be made with two nickels or a dime (or of course a quarter. There were also models that would only allow the initial deposit to be made with a dime. Any nickels deposited in the initial state were rejected in the coin chute and returned. After the connection was made, the reverse battery supervision operated a polarity-sensitive electromagnet, which changed the coin chute path so that nickels could pass through in the normal way. These cleverly had"10" as a suffix to the type code.

public coin phone, their instinct was to lift the receiver/handset and immediately deposit a coin.

That coin of course immediately went into the coffers of the telephone company. If the line was busy, or if the called party did not answer, the caller was just out of luck—his coin could not be returned.

Of course, to minimize the chance of this, the instruction signs on postpay coin telephones had a prominent alert to not deposit any coins until the call had been successfully competed.

Figure 56 shows an example (apologies for the poor image). The reference to "again hear dial tone" may have been a simplification, or in this system dial tone might have actually been used for the "deposit coin" signal.

Figure 56. Postpay instruction sign

But of course few users would actually read that sign.

To reduce the likelihood of such gaffes, a clever accessory was developed (shown in Figure 57).

Figure 57. Gauge guard on postpay coin collector

It was a small hinged transparent plastic flap that, in its normal position, covered the round slots into which the coins were inserted [23]. It had imprinted on it a bold “READ” with an arrow pointing to the instruction sign that warned to not deposit any coins until the called party had answered.

Since the user would have to lift that flap to deposit a coin (there being a nice tab on it to press to do that), it was hoped that this would force attention to the notice explaining how this coin telephone worked.

C.10 POSTPAY OPERATION IN MANUAL CENTRAL OFFICES

Postpay operation was also used in manual central offices (again typically in smaller cities). The coin telephone (in both Bell System and non-Bell contexts) had the familiar coin chute with the bell and gong (and a bell and gong transmitter if the set used a handset). There was no coin relay of any sort.

Electrically, the coin telephone was essentially like a regular telephone. It operated with a regular loop start line circuit (as seen earlier in Figures 43-45). There was no special circuitry needed at the central office, except that maybe the switchboard cord circuits had provision for splitting the connection.

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[23] It was formally called a “gauge guard”, since the stainless steel “turret” that has the three coin intake slots was formally called the “coin gauge”

In any case, at the central office, the answering jacks for coin lines were marked distinctively so that when the operator answered she knew she was dealing with a coin station.

Assuming the call was local, when the operator got the number from the caller she put up the call (with the cord circuit split if there was that provision). If and when the called line was answered, the operator would ask the called party to “hold the line” and the asked the caller to deposit the coin(s) for the local call rate.

When the operator heard that the appropriate amount had been deposited, she “unsplit” the connection (if it had been split) and the conversation could commence. The rest of the call proceeded in the regular way.

If the switchboard was not equipped with provision for splitting the cord circuit, the called party heard the discussion between the operator and the caller as well as the coin sounds—part of the charm of small town life.

If the called line was busy, or if there was no answer, the operator advised the caller accordingly. He presumably just hung up and went on about his business. The operator pulled the answering cord and was done with this call.

C.11 DEPRECATION OF POSTPAY COIN TELEPHONE OPERATION

Postpay operation for coin telephone was a “odd duck” in the telephone network, and as new services emerged, they could not always be handily accommodated by the postpay mode. And that mode (with the prominent visual reminder provided by the helpful “gauge guard”) was a continuing reminder to the denizens of town served that way that they somehow had “a second-rate kind of telephone service”, a matter of great political concern at one time.

As a result, there emerged a relatively low-key initiative to replace postpay operation with prepay operation. This was of course not simple, nor easy, but it proceeded, Eventually, only a few cities remained served with postpay coin telephones.

C.12 SINGLE SLOT POSTPAY COIN TELEPHONES

In Section 3.7.2 of the body of this article, I mentioned the introduction in the Bell Telephone System, in the 1960s, of the “single slot coin telephone set”, with a physical and circuit design greatly different from the existing family of “coin collectors”. There were nomenclatured as “Coin Telephone Sets” rather than “Coin Collectors”.

One subseries of these (the 1E1 Coin Telephone Set) could indeed replace the existing postpay coin telephone sets.

This family of coin telephone is discussed in some detail in Appendix E.

C.13 THE ONSET OF DIAL TONE FIRST COIN TELEPHONE SERVICE (THE SECOND COMING)

In the late 1960s there was a powerful initiative to convert all coin telephone service in the Bell Telephone System to Dial Tone First operation (and regulatory initiatives eventually effectively mandated this for most non-Bell telephone service as well). This is discussed in Section 22 of this article.

I use the name with all caps to differentiate this fancy new modality from the "dial tone first" mode. of coin telephone operation that was sometimes used in earlier times (that being handily ignored in the hoopla surrounding the new initiative), and I often jokingly speak of this as the "second coming" of this service concept.

Ironically enough, postpay coin telephone service (in dial offices) was always "dial tone first", but of course without all the collateral implications of Dial Tone First operation.

But there was of course no version of Dial Tone First operation that corresponded to the concept of postpay operation. And so the Dial Tone First initiative helped hasten the effective demise of postpay operation from the US and Canadian telephone network scene.

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Appendix D
The "single coil" coin relay

D.1 INTRODUCTION

In the body of this article, I introduced the *coin relay* with a brief description of its construction. I described its construction as much like that of a traditional telephone ringer, permanent magnet and all. Like the traditional ringer, it actually has two coils (on different pole pieces), although they are connected in series, and I represent the pair with a single electromagnet symbol on the circuit sketches.

I also mentioned that, in the late 1950s, Bell telephone Laboratories completed, the design of a new coin relay of dramatically-different design. One obvious feature was that it had only one coil. It was nevertheless essentially functionally and electrically interchangeable with the older type of coin relay.

An initial premise of this development was that the coin relay would be used in the new line of coin telephones, the "single slot" coin telephone sets, then also in development (see Appendix E). But there would also be a slightly different form suitable for retrofit (with a new coin hopper that worked with it) in existing coin collectors. And from then on, coin collectors then being manufactured (or refurbished) were equipped with this "retrofit" version of the new coin relay.

Not surprisingly, to distinguish the two kinds of coin relay, this newer type was called a "single coil" coin relay, and the older type was then called a "two coil" coin relay.

For our purposes here, the introduction of this new type of coin relay *per se* had no effect on the operating protocols.

D.2 OBJECTIVES

The new coin relay is intended to avert the "tricky" adjustments required in the field for the older style relay, to allow reliable operation over longer loops, to provide more reliable operation in the face of variations in the duration of the coin control signal, to work with a larger number of coins "in escrow", and to have an increased impedance so as to reduce the "ground noise" problem, among other advantages.

D.3 CONSTRUCTION AND BASIC PRINCIPLE OF OPERATION

We see a single coil coin relay and its associated hopper *in situ* in Figure 58.

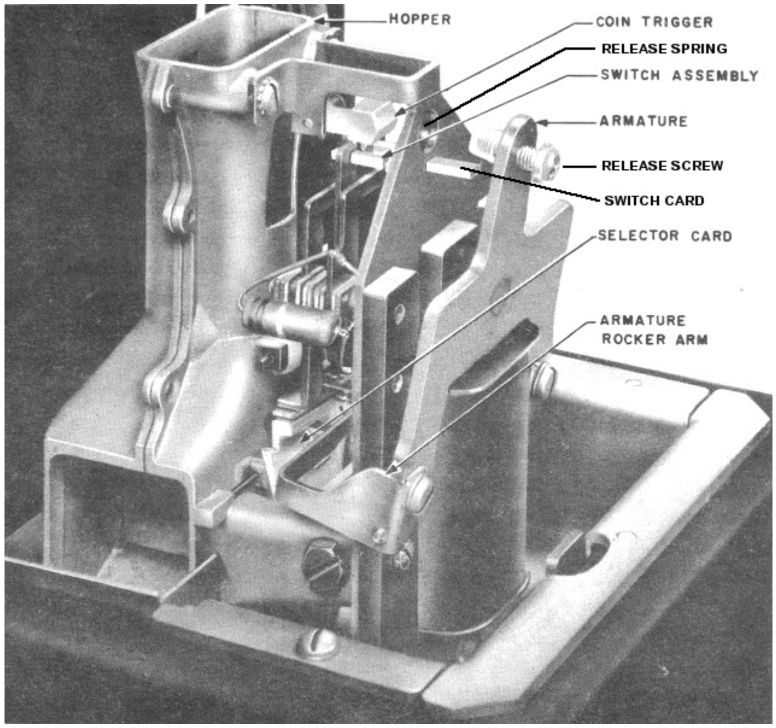

Figure 58. Single coil coin relay and associated hopper

The hopper used with the new relay is a bit different in construction that the hopper used with the two coil coin relay. For one thing, the hopper is made of two die-cast components (riveted together), rather than being formed of sheet metal as in the older design. The trap and vane are made of molded nylon rather than metal. Importantly, the trap is not released by the movement of the vane but rather directly by the coin relay, as we will see in some detail later.

In Figure 58 we see the single coil and the armature, much like those on a typical “wire spring” type telephone relay (but larger). This part of the mechanism operates the same for either polarity of current through the coil—its is not of itself polarity-sensitive.

In Figure 59, we see the coin relay, separated from the hopper assembly, from the rear (but the hopper from the front).

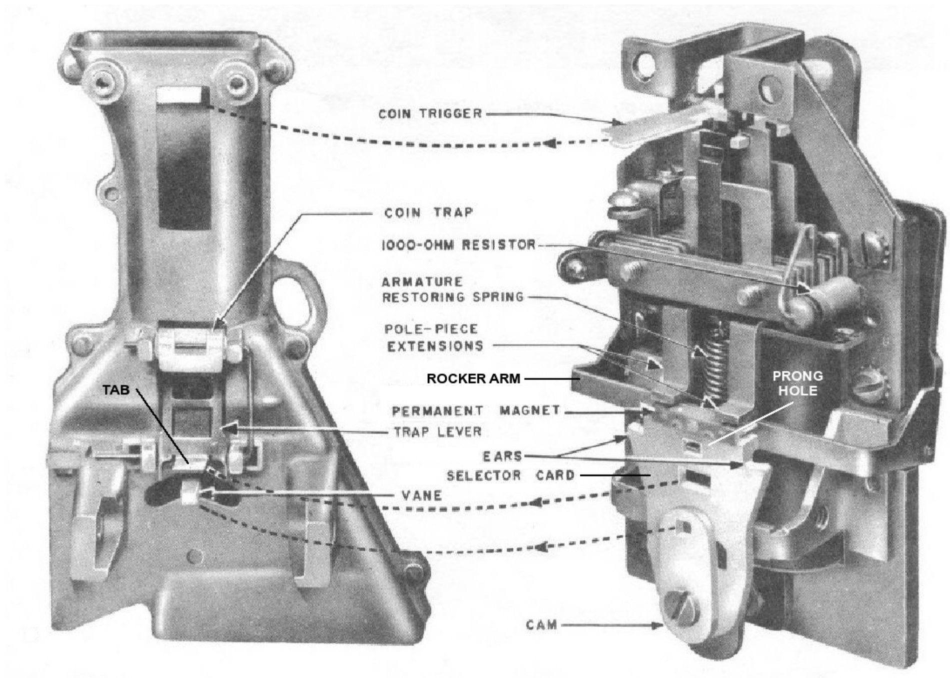

Figure 59. Single coil coin relay and associated hopper—separated

When any coin enters the hopper, it will press down the coin trigger. This unlatches one contact spring in the contact assembly, which itself makes contact to close the ground path through the relay coil, (in the version used in the multi-slot coin collectors) moves another spring to open the dial shorting contact, and holds the trigger in its tripped position.

Fastened rigidly to the armature is the *rocker arm* (in fact, the armature actually pivots on a shaft passing through holes in the rocker arm). With the relay not energized, a coil spring operating on the rocker arm holds the armature in its released position.

When the armature operates, it pushes a notched phenolic (or molded nylon) *switch card* (best seen on Figure 58) [24] which moves the contact springs in such a way that the coin trigger is reset but the ground path contact remains closed (until the coin relay releases). The card also operates contacts involved in the "slow release" aspect of the coin relay (discussed in Section D.4). (The contact system is described in detail in Section D.6).

When the armature operates, it tilts the rocker arm downward. A prong on the rocker arm presses down a nylon *selector card*, which can move vertically and also swing about that prong.

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[24] Yes, it doesn't seem very "cardlike". As for the *selector card* we will hear of shortly, the name was likely taken (not too aptly, in my opinion) from the notched phenolic "card" that moves the contacts in the "wire spring" type of telephone relay.

The card bears at its top a small permanent magnet. The two ends of the magnet are under the influence of two legs of an extension of the coin relay magnetic circuit (the *pole piece extension arm*), just above the magnet. Initially, the magnet lays just a small distance beneath them.

When the relay is energized, one end of the magnet is attracted (upward), and the other repelled (downward) by the magnetic forces. Which end does which of course depends on the polarity of the current though the coin relay winding.

Thus, when the rocker arm moves down, as the selector card descends, and becomes mechanically free to swing about the prong, the net torque due to these unbalanced forces causes it to swing to one side or the other.

As the card descends, it rotates the *cam* one way or another (depending on which way the card has swung). The further motion of the card locks the cam in its new position.

> How this seemingly minor part of the scenario happens is the result of a very clever mechanism. The details of how this works are given in Section D.5 of this Appendix (sort of an appendix to the Appendix).

The cam is directly coupled to the vane and moves it in the corresponding direction (which of course depends on the polarity of the current in the relay coil at the start of this chapter of the story).

Additionally, as the cam moves down, an opening on it presses a tab on the lever that has held the trap up, tipping it (against a spring that has been holding it in the engaged position) so it releases the trap. The trapped coins are released to go on their way (their ultimate route of course dependent on the direction in which the vane was moved).

When the relay (and thus the card) has returned to normal, the spring moves the trap locking lever back toward the engaged position. The arrangement is such that this pushes the trap back up before the lever settles into the engaged position.

Also, as the card returns to its idle position, it releases and ultimately centers itself, and the cam (and thus the vane), so the entire assembly will be ready for the next operation of the coin relay.

The "ears" of the card are used by a technician, working on the coin relay, to tilt the card during various mechanical testing and reassembly maneuvers.

D.4 TIMING CONTROL

Especially when the coin control voltage is applied directly by an operator, the duration of the voltage pulse may not be long enough that, with the original mechanism, the vane is moved for enough time for all the escrowed coins to be sent to their destination. The result can be a jamming of the mechanism. And even some dial central offices did not consistently generate a pulse of such length that reliable operation is assured.

With the single coil coin relay, a sufficient period of operation is insured within the relay itself, which is in effect made “slow release”.

When the armature fully operates, the contact operating card operates a contact which short circuits the relay coil. Although this ultimately results in the release of the relay, the inductance of the coil allows the current flow to decay only slowly, sustaining the magnetic force, so the armature remains operated long enough for reliable coin disposal (typically about 400 ms).

While the coin relay coil itself is thus short-circuited, another contact inserts a 1000-ohm resistor in its place in the path to ground so that the coin telephone set looks to the central office circuitry as if the coin relay coil was still in place. Among other things, with a “zero resistance” path to ground, for a short loop, the coin control limiting circuit in the central office (typically using a resistance lamp) would be continually “stressed” more than was originally expected. The insertion of the resistor avoids that.

Normally, the pulse of coin control voltage from the central office will finish before the coin relay releases, so there is little risk that the relay coil will be energized a second time in the same coin disposal operation.

The *armature release screw*, with a plastic tip (see on Figure 58) works through a hole against a flat *release spring*, pretensioned against the back of the plate through which the screw tip passes. A dimple on the armature is the armature stop, which assures a specific operated gap.

Adjusting the screw changes the amount of deflection of the release spring when the armature is fully operated and thus its reaction force on the screw (and thence to the armature), which adds to the force of the coil spring trying to move the armature away from the pole pieces.

That affects the current in the coil at which the armature actually begins to move away. Therefore adjusting this screw allows the release time of the relay to be finely adjusted.

D.5 THE INTERACTION OF THE SELECTOR CARD AND THE CAM

How the selector card, having been slightly tipped by the magnetic system, in a direction dependent on the polarity of the current through the coin relay system, gives the cam (and thence the vane) a significant deflection is a fascinating story. I have a sort of cartoon series that shows how it works.

In figure 60 we see the players as they will appear in the cartoon. These are adapted from photographs of the actual parts.

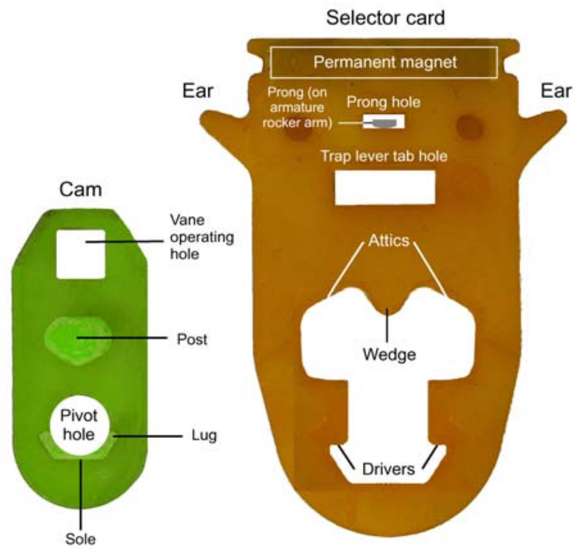

Figure 60. Selector card and cam

Many of the terms there are my own (some admittedly fanciful).

Figure 61 shows the cam "in person" to help clarify its construction.

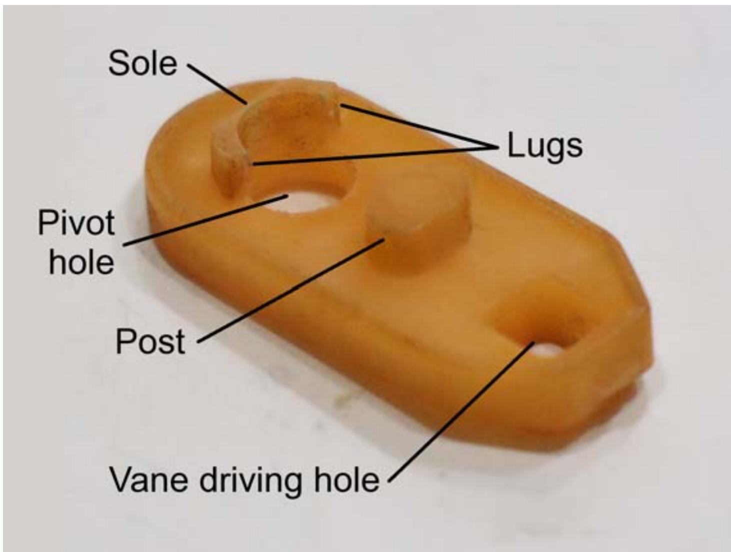

Figure 61. Cam

In figure 62, we see the system with the relay idle.

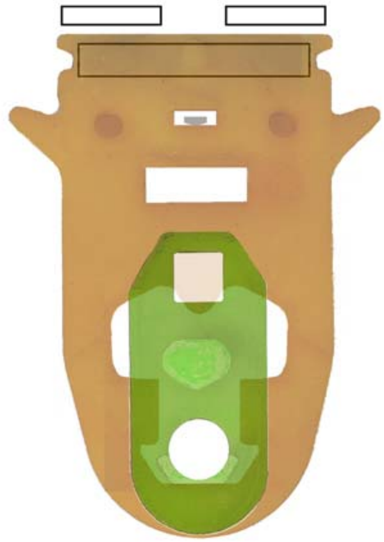

Figure 62. Relay idle

We see the selector card and cam as is from the rear, as if seen from the hopper. The cam is essentially turned over from the way we see it in figure 60. The lugs/sole and post of the cam are thus on its far side, but are seen in “phantom” view. (Please excuse that the card as seen through the vane driving hole of the cam appears light brown, an artifact of a flaw in the way these figures were made, and not easily changed!)

At the top we see the two extension pole tips.

The cam pivots on a stationary shoulder screw passing through what I have labeled as the “pivot hole”

The armature return spring pulls the rocker arm up, and the prong on that pushes the selector card up as far as it will go.

Note that the (straight) floor of the window in the selector card has pushed up against the (flat) sole of the cam, centering the cam (and the card somewhat as well).

In Figure 63, the relay coil has been energized.

Figure 63. Relay energized, card moves down a little and swings

The armature has started to move, the prong on the rocker arm starting to move the card down. The green shading is meant to suggest that, for this particular polarity of the coil current, that side of the magnet at the top of the card is magnetically **attracted** to the extension pole above it. The red suggests that on that end the magnet is **repelled** away from that extension pole. And as a result, we see that the selector card has stated to tip, its lower end moving to the right.

In figure 64, the armature rocker arm tang has moved the card a bit farther down.

Figure 64. Card moves down a little more

We also see now that one of the "driver" edges of the window in the card has contacted the leftmost of the two lugs on the cam.

In figure 65, the card has moved down more yet.

Figure 65. Card moves down more yet

Now that “driver” edge has actually pressed down the leftmost lug on the cam, which had thus been rotated just a bit counterclockwise.

In figure 66, the card has descended farther.

Figure 66. Card moves down farther

As a result, the cam has been rotated a bit farther.

In figure 67. the card has moved down farther yet.

Figure 67. Card moves down farther yet

Now, the feature on the card window I call the “wedge” moves alongside the post on the cam, helping to complete the rotation of the cam.

Finally, in figure 68, we see the end of the maneuver.

Figure 68. The end of the maneuver

The post on the cam has settled into an “attic” of the card window, holding the cam (and thus the vane that it moves) fully in the leftward position. (That would in fact be the “return” position–remember we are seeing these parts from the rear.)

When the relay releases, the selector card moves upward (dragged by the prong on the rocker arm, the latter pulled up by the return spring). The result is that the system returns to the state seen in Figure 62.

D.6 THE CONTACT SYSTEM

D.6.1 Introduction

The contact system of the single coil coin relay is very clever.

I will first speak of the version intended for use in a multislot coin collector. There is a slight difference in the version used in the single slot coin telephone sets (which will be explained a little later).

D.6.2 The multislot coin collector version

As we heard earlier, there are three contact sets in the contact system of this coin relay:

- The ground contact. This completes the path from the tip through the coin relay to ground once a coin has passed into the hopper and tripped the coin trigger (it is sometimes labeled the "hopper trigger contact")
- The dial shorting contact. This short circuits the dial pulsing contacts until the coin trigger has been tripped, to resist a certain fraud technique (as described in Section 17.2).
- The relay-resistor contact set. When the relay fully operates, this short-circuits the relay winding and puts a 1K resistor into the path to ground in its place. This is part of the scheme by which the armature is operated for a predictable time period regardless of the duration of the coin control voltage pulse (as described in Section D.4).

Figure 70 shows how these contacts figure into the overall coin telephone circuit.

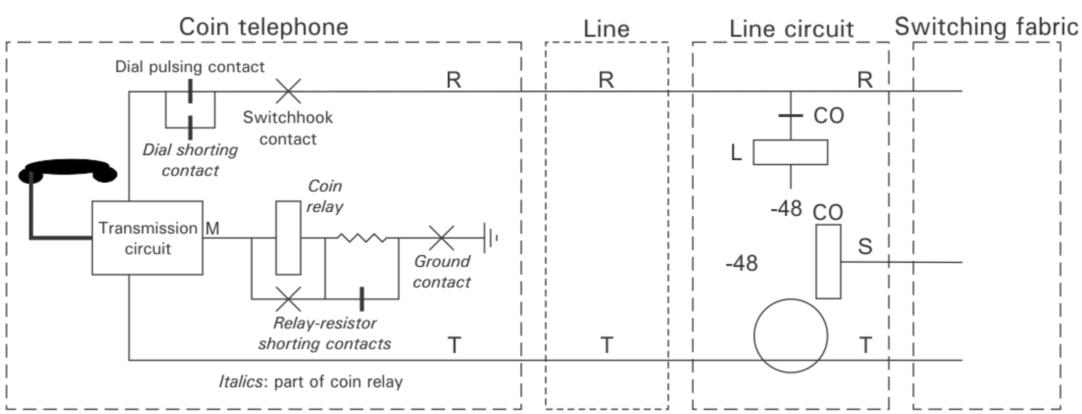

Figure 69. Single coil coin relay in typical multislot coin collector

We see in figure 70 the contact setup with the relay in its idle state:

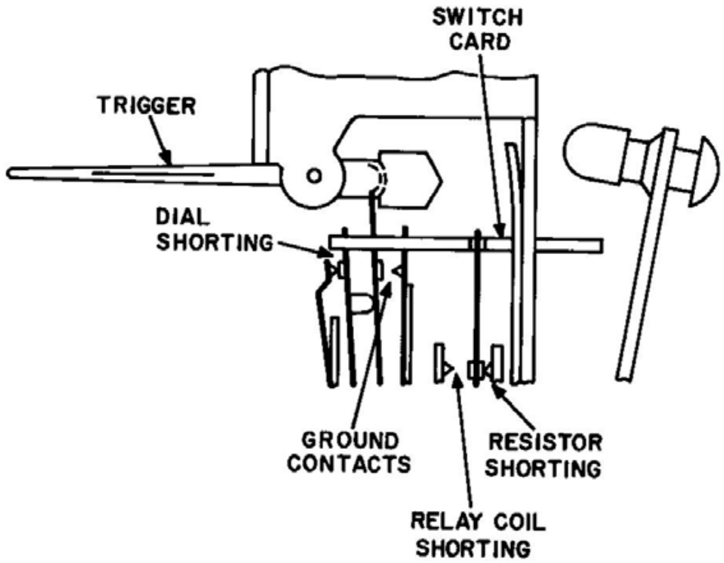

Figure 70. Contact setup—relay idle

In the larger view, we think of the ground contacts as a *make* (normally open), since they are open with the relay in its idle state. More microscopically, they are actually a *break* contact (normally closed), but held operated (open) in the idle state of the relay by the coin trigger.

When the coin trigger has been "tripped" by the passage of a coin, we have the state seen in Figure 71.

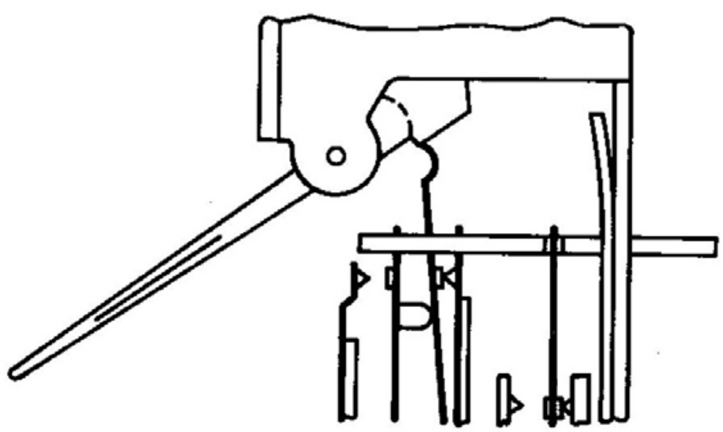

Figure 71. Contact setup—coin trigger tripped

We see that the ground contacts have closed and the dial shorting contacts have opened.

When the coin disposal pulse is received, the relay armature presses the contact operating card to the left, so we have Figure 72:

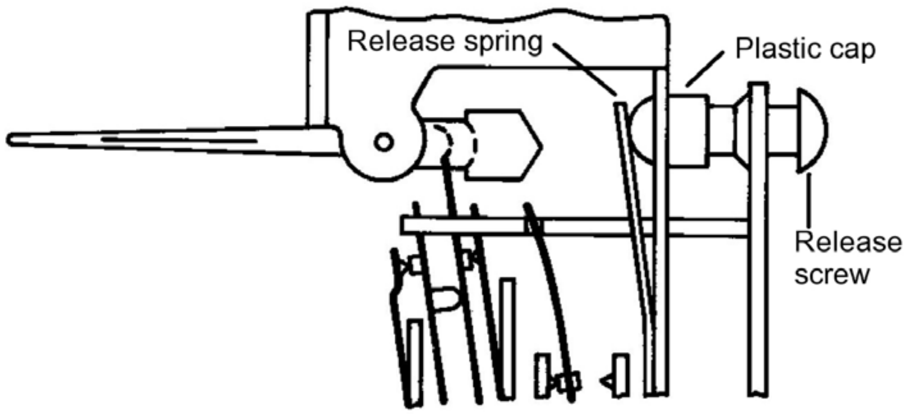

Figure 72. Contact setup—relay operated

The switch card pushes to the left the fixed spring of the ground contacts (4th spring from the left). This pushes the moving spring (3rd from the left) to the left, so the trigger will now return to its normal position (it has a small spring to do make it do that) and be able to "catch" the moving spring of the ground contacts.

But this maneuver holds the ground contacts together, so the coin relay coil path to ground is still intact.

Additionally, the coil-resistor contact (3 rightmost springs) have operated, shorting out the relay coil and putting the 1 K resistor in the path to ground in its place.

The current in the short-circuited coil does not decrease immediately to zero, but decays following a negative exponential function of time.

Note also that the plastic cap on the release screw has deflected the release spring. The reaction force of this spring adds to the other forces trying to move the armature “back”, and thus, by adjusting the screw, we can control the current at which the armature will release.

When the current in the coil decays to that release value (after perhaps 400 ms), the relay armature releases. The relay then goes back to the state in which we first found it, as seen in Figure 70. The ground contact is open, the dial shorting contact is closed, and the coil-resistor contacts have the relay coil in the path that will go to ground when the coin trigger is next tripped.

D.6.3 The single slot coin telephone set version

In the version of the relay used in the single slot coin telephone sets (described in Appendix E), there is no dial shorting contact. The disablement of the dial is done in another way (by a contact on the totalizer, the mechanical "coin value counter" in that kind of telephone).

But recall that, in version of the relay I described earlier, it is the spring force of the moving spring of the dial shorting contacts that moves the ground contact moving spring when the coin trigger releases it.

How that task is done instead in this version of the relay is seen in Figure 73, which shows the relay idle.

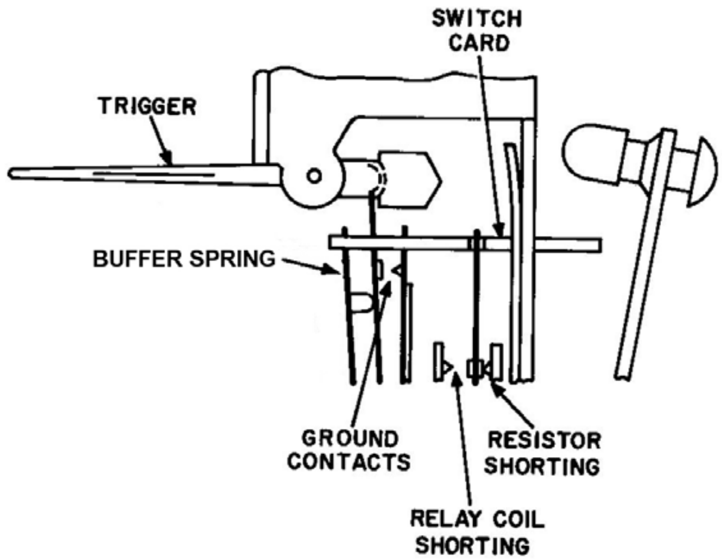

Figure 73. Single slot telephone type relay—contact setup—relay idle

We see a spring I have labeled "buffer spring" (with no contact) taking the place of the dial shorting contact spring to do that duty.

D.7 OUTSIDE THE BELL SYSTEM

Eventually essentially the identical mechanism came into use in the coin telephones made by Automatic Electric, this presumably done under license for patents owned by AT&T.

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Appendix E
Single slot coin telephone sets

E.1 INTRODUCTION

As mentioned in Section 3.7.2 of the body of this article, in the early 1960s the Bell Telephone System introduced a new line of coin telephones, called “single slot” (for a reason that will become obvious) and officially nomenclatured as “coin telephone sets” (as distinguished from the “coin collector” nomenclature used, in the Bell System, for all earlier coin telephone sets). Because of its greatly increased physical security over that of the coin collector family, it was sometimes described as the “Fortress” phone.

The whole matter is extremely complex. In this appendix, I will give an overview of these new creatures, with a discussion of how the operated they operated.

E.2 OVERVIEW

E.2.1 Overall physical form

The new line of coin telephones (to continue to use my “universal” term) were made in two physical styles.

The first (often called the “box” style) had about the same overall envelope as the earlier “multislot” coin collectors, although its overall shape was wholly rectangular. We see an illustrative one in Figure 74.

Figure 74. Single slot coin telephone set (box style)

It was intended for mounting in essentially the same position in many existing types of telephone booth as for the earlier coin collector, with little rework of the mounting facilities, thus facilitating retrofit of these new sets into existing installations (and their use in new installations of existing telephone booth types).

The second style (often called the “panel” style) was made on a flat stainless steel panel, and was intended for mounting in the corner of several new styles of telephone booth, designed specifically to be used with it. Figure 75 shows a typical type of that style.

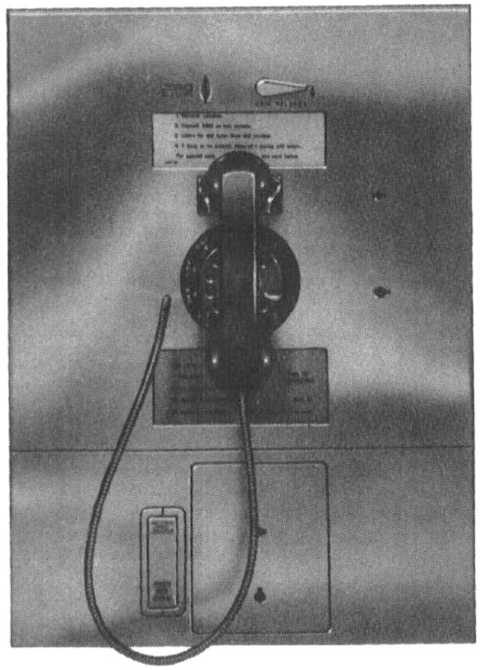

Figure 75. Single slot coin telephone set (panel style)

We see an important feature (from which the series gets its descriptive name): there is only a single slot for ingress of coins of all denominations, which are inserted edgewise (as was almost universal in other coin-operated devices, such as vending machines, with which the users were familiar.).

E.2.2 Advantages over the earlier type

The principle advantages of this new type of coin telephone over the earlier (coin collector) type were:

- Greater physical security (notably protection against “break ins” and various sorts of vandalism).
- Better protection against several types of fraudulent operation.
- Improved discrimination against bogus coins (“slugs”).
- Flexibility in changing the amount of the required minimum deposit (as it was visualized that this rate would continue to change in many locations over the foreseeable future, perhaps to substantially larger values. (The earlier change in this from 5¢ to 10¢ had been agonizingly complicated and costly.)

- For Dial Tone First operation, improved performance.
- In some situations, improved transmission performance.
- In some situations, ability to operate over longer station lines.
- No external subscriber set was required; the transmission circuit and ringer were both internal to the set itself.

E.2.3 Applicability

Within both style series, in general there were variants to cater to these differences in application:

- Manual or dial operation.
- For "dial" sets, rotary or Touch-Tone (DTMF) dials.
- Prepay or postpay mode. (Manual postpay only with a "box-style" type.)
- For prepay mode, coin first or Dial Tone First. (There was one type that only operated in coin first mode, another that only operated in Dial Tone First mode, and a third that could be field converted between the two modes of operation.)

E.2.4 Protocols

Broadly speaking, this new line of coin telephones utilized the same protocols as the earlier family, although with some new wrinkles (which will be described subsequently).

E.3 PHYSICAL AND MECHANISM DETAILS

E.3.1 Physical security

As to the earlier (coin collector) type of coin telephone, I did not much discuss the physical security arrangements (mostly that would refer to the locking systems controlling opening the set by removing the upper housing and for securing the door to the coin vault). That is an enormously rich and complex topic, not within the intended scope of this article.

As to the new coin telephone sets, suffice it to say that wholly new systems of securing the upper housing (for the "box" style sets) and controlling access to the innards of the "panel" style sets were used. I will not discuss these further here.

E.3.2 The mechanism

E.3.2.1 *The coin chute*

The coin chute here is dramatically different from that used in even the latest of the coin collectors. Of course for one thing, it has to deal with all three possible denominations of coins introduced through the single ingress slot, sorting them out at the beginning so they could each follow their own path though the chute.

Perhaps more importantly, the new coin chute followed essentially the then-current state of coin acceptance mechanisms used in vending machines and such (and I believe that these coin chutes were in fact made for Western Electric, to their deign and specifications, by a prominent maker of such mechanisms for the vending machine industry).

E.3.2.2 *The hopper and coin relay*

This discussion is in the context of telephones for the prepay mode (either of its submodes).

The coin hopper in these telephones is quite reminiscent of the hoppers used in the coin collectors It has a coin trigger that operates a coin contact, in essentially the familiar way. It has a coin trap to hold the deposited coins "in escrow' until disposal, and a vane to direct the coins to either of their destinations upon disposal (both much as we saw earlier).

The coin relay (always of the single coil style) is almost identical to the single coil style used in the coin collectors (shown in Figure 58 in Appendix D), and operates in essentially the same way. A small difference is discussed in section D.6.3 of Appendix D.

E.3.2.3 *The coin totalizer*

The elephant in the room here is a wholly-new creature, the coin totalizer (usually called just "totalizer"). This is a complex elctromechanical unit sitting adjacent to the coin chute near its bottom.

Two fingers from the totalizer protrude into the coin channels near their lower ends. One, deflected by a passing quarter, mechanically advances the rotary shaft of the totalizer (I will in the future just say "totalizer') five steps.

The other is deflected by a passing nickel or dime, the amount of the deflection depending on which kind of coin (by virtue of the different paths those two coins make in their chute channels as they pass the lever). A nickel deflects the lever enough that it steps the totalizer ahead by one step; a dime deflects it enough that it advances the totalizer by two steps.

Thus, this tots up the amount that has been deposited, each step being "worth" 5¢.

When the totalizer reaches a position that has been mechanically programmed to correspond to the required initial deposit, a contact is closed that will be part of the path through the coin relay to ground.

At an appropriate stage of the operating scenarios, the totalizer is stepped back to its home position by an electromagnet operating from loop current. As it takes each step (and the rate of that stepping was well-controlled), a tone “beep” is emitted. Thus an operator, by counting the ”beeps”, could determine what coins had been deposited (and a fully mechanized system could readily learn of that as well).

Initially that beep was a single frequency tone, but (to facilitate the reliable identification of the beeps by an automatic long distance call handling system, and to provide a little more protection against fraud), that was soon replaced by a two-frequency tone.

E.4 OPERATION–COIN FIRST MODE

E.4.1 The circuit

The circuits of each of the many types of set within this family are all quite complicated. I will simplify them greatly for our purposes here.

Among other things, although these sets invariably use the “single coil” coin relay, I do not show the circuit arrangements, described earlier (in Section D.4), for causing the relay to operate for a closely-controlled time.

Figure 76 shows, in this greatly simplified way, the circuit of a coin telephone set with a rotary (pulse) dial, set up for coin-first prepay operation. (In particular, this is the circuitry of the “field convertible type, configured for coin first operation). For clarity, this shows only the paths of interest to the description of operation, and omits the internal circuit details of the totalizer, treating it rather as a “black box”.

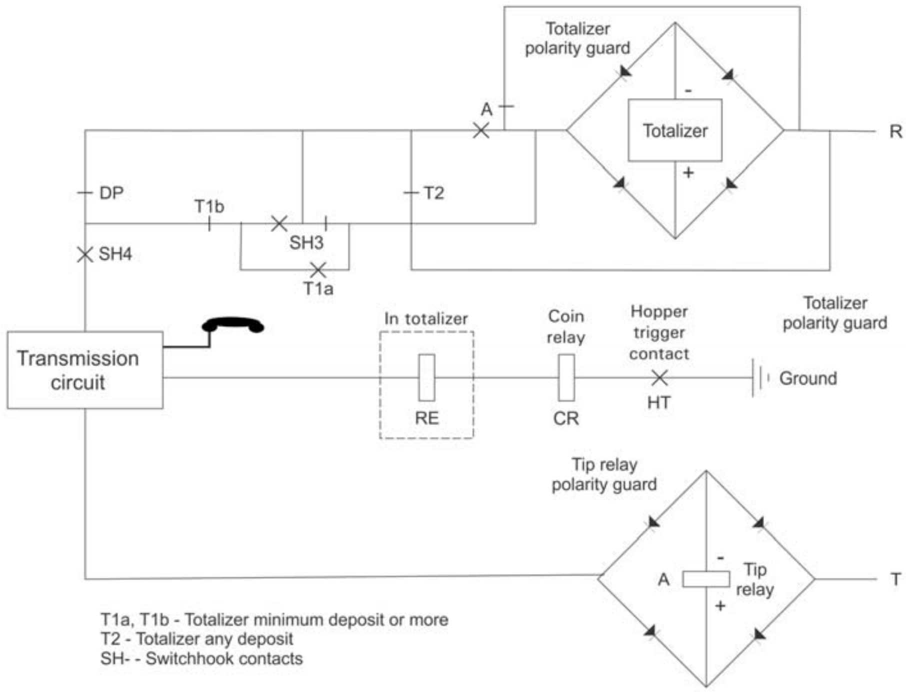

Figure 76. Single slot coin telephone set—prepay, coin first

Let me first discuss the two "polarity guard" circuits, both actually just bridge rectifiers. Both the totalizer and the tip relay circuit operate from loop current. Both contain electronic circuitry that of course require voltage of a certain polarity to operate.[25] So each of these polarity guard circuits routes the current so that the positive and negative sides of the resulting voltage are what the circuit requires, regardless of the direction of the loop current (which changes during different phases of various scenarios).

The transmission circuit is for all practical purposes the same as used in the 500-type telephone set (rather the "norm" for "modern" non-electronic telephone sets). (The same was true of later coin collectors.)

The coin relay circuit, which works to local ground (as for the coin collectors) runs not from the tip conductor but rather from what is approximately, from an AC basis, the "center" of the transmission circuit. This minimizes (but does not eliminate) the possible introduction of noise into the telephone circuit by AC components of the current through the coin relay from "AC ground potential differences". Background is given on this matter in Section 21 of the body of this article.

[25] It is hard to see why that is so for the tip relay. It may be that the type of relay used is in fact a polar-neutral type (because of its sensitivity), which we must energize with a consistent polarity.

E.4.2 Operation

E.4.2.1 *Basic outgoing call*

First note that we assume that this station operates with a ground start line circuit (as had come universally into effect for prepay coin collectors with the change in the initial rate from 5¢ to 10¢).

We suppose the caller has not yet deposited a coin and lifts the handset. Switchhook contact SH4 closes, and there now is a path from the ring conductor (R) through the break contact of T2 (in the totalizer), dial pulse contact DP (closed with the dial idle), switchhook contact SH4, the transmission circuit, and the tip relay's polarity guard (in the future I will just say "the tip relay") to the tip conductor (T).

But since the line circuit here is of the ground start type, the tip conductor of the loop is now open at the central office, and so no current yet flows anyplace.

We will assume that the initial deposit here is 10¢, and that the caller will deposit that as two nickels.

Note that, with no current flowing in the ring conductor, the totalizer has no electric "power" to operate its electronic circuitry. But its purely mechanical aspect (and the contacts that operates) can still function.

Suppose the caller indeed deposits his first nickel. Although the totalizer is not energized, the mechanical aspect works. The passage of the nickel through the nickel channel of the coin chute presses the nickel lever of the totalizer, which steps the totalizer by one step.

As soon as the totalizer comes away from "home" (I will later just say "totalizer"), contact T2 operates and opens. With A not yet operated, SH3 operated (so its break contact is open), and T1 not operated (T1a is open), the path from the ring conductor to the transmission circuit is now open.

The coin then reaches the hopper, where it trips the trigger, closing the hopper trigger contact, HT. There is now a path from the "middle" of the transmission circuit to ground. But, because of the opening of the path from the ring conductor to the transmission circuit (described just above) there is yet no path from the ring conductor to ground.

Now the caller deposits a second nickel. The second nickel again presses the nickel lever of the totalizer, and the totalizer is stepped to position 2. The totalizer has been set (a mechanical adjustment) for an initial deposit of 10¢ (two steps).

Since that position has now been attained, totalizer contact T1 operates. The path from the ring conductor through the break contact of A (now still closed) T1a (now closed) and the make contact of SH3 (closed) continues through the DP contact (closed), switchhook contact SH4 (closed), half of the transmission circuit, and so forth through the coin relay and to ground.

Whew!

Note that the break contact of A provides a short circuit of the totalizer's polarity guard (in the future, I will just say "totalizer"), so now, even though current is flowing in the ring conductor, the totalizer innards still have no electrical "power".

The resulting current in the ring conductor operates the L relay of the line circuit at the central office. The central office connects a digit receiver to the line (and it feeds dial tone to the calling line). The ground its battery feed circuit places on the tip now allows the path from the ring to the transmission circuit (described above) to be continued from the transmission circuit through the tip relay to ground at the central office.

The result is that the tip relay, A, operates. The break contact of A opens to removes the short circuit from the totalizer. The make contact of A and provides a path directly to the DP contact. The rest of the path to the tip is as already described.

The totalizer innards now have power for its electronic circuitry to operate. The "step back" magnet, S, in the totalizer (not shown here) operates and releases, for each operation stepping the totalizer back one step ("eating" 5¢ worth of credit each time). Each time S is operated, a "beep" is also sent (which will play a role when we get to operator-handled calls).

When the totalizer has stepped back to "home", totalizer contact T2 releases (and thus closes), providing a path from the ring conductor directly to contact DP, bypassing the totalizer. The totalizer is then no longer energized, and its S magnet steps no more.

Note that when the totalizer steps "below" the initial deposit point, and in fact back to the home position, totalizer contact T1 does not release, it being for now mechanically latched in the operated position. Thus contact T1a remains closed and the path earlier described from the ring conductor to the transmission circuit is not disrupted.

At the end of the call, assume that the caller hangs up. Switchhook contact SH4 opens, and loop current is interrupted. Relay A releases. The central office, as described in the body of this article, applies coin collect (+130 V DC) or coin return -(130 V DC) to the tip.

Current passes through the tip relay and the “lower half” of the transmission circuit, through totalizer reset electromagnet RE, and through the coin relay to ground. This causes coin disposal in the familiar way.

The current through RE operates it. That unlatches totalizer contact T1, which releases. The totalizer, and in fact the entire telephone set, are now fully back to the idle state, ready for the next call.

E.4.2.2 *A call through a long distance operator*

The initial part of the call proceeds as described in Section E.4.2.1. The caller dials the code to reach a long distance operator. We assume that the call is routed to a cord-type toll switchboard.

As soon as the connection is taken up by the toll operator, the toll trunk initiates coin return in the familiar manner. As before, the RE magnet unlatches the totalizer T1 contact, so the totalizer is back to its idle state.

The path from the ring conductor to the transmission circuit passes through totalizer contact T2, bypassing the totalizer and leaving the totalizer unenergized.

The toll operator, as we heard in the body of the article, advises the calling party of the initial charge for the toll call. As the caller inserts each coin, the totalizer lever in the appropriate coin chute channel advances the totalizer 1, 2, or 5 steps (for a nickel. dime, or quarter).

As the totalizer moves from home, its T2 contact operates (opens). The path from the ring to the transmission circuit now passes through the totalizer’s polarity guard circuit. The totalizer is now energized, and begins to operate its S magnet to step back to the home position, making a beep for each step (for each 5¢ worth of value of the deposited coin).

As before, when the totalizer reaches its home position, its T2 contact releases, closing and bypassing the totalizer so that it stops any further activity.

In any case, if any coin deposited constituted the initial deposit or more, totalizer contact T1 would have operated (and latched operated,, but with A operated (as it is in this situation) that does not cause any change in the path from the ring conductor.

This seems like a good time to mention that in the totalizer, when one of the coin levers is depressed (mechanically stepping the totalizer ahead by some distance, the “step back” circuit is disabled, so it does not fight the advance being caused by the switch lever. In the current scenario, this means that the totalizer waits until the coin has passed and released the coin lever before it begins to step back.

This also seems a good time to note that if the coin is a quarter, its coin lever operates a contact that causes the subsequent step back to occur at a grater rate than otherwise, so the five beep sounds occur in rapid cadence (recognizable by the operator by *gestalt* as being worth 25¢).

E.4.2.3 *Incoming call*

On an incoming call, the central office applies ringing voltage to the ring, with the tip grounded. This operates a ringer in the coin telephone in the familiar way.

When someone answers, picking up the handset, all the SH- contacts operate. As to the totalizer, it being in its idle state, contacts T1 and T2 are released. As a result, there is a path from the ring through T2 to DP and thence to SH4, through the transmission circuit, and so forth to the tip. This closure trips the ringing at the central office, and the connection is put into the talking state.

E.4.2.4 *Dial shunting*

In Section 17.2, we learned that one way to frustrate fraudulent operation, attained by putting a bogus ground on some part of the telephone set circuit, was to have the dial pulsing contact short-circuited until the coin trigger was tripped.

The coin-first prepay version of the single slot coin telephone set does essentially the same thing. Refer to Figure 76.

We see that, if the minimum deposit has not yet been deposited (so totalizer contacts T1- are not operated, and of course contact SH3 is closed during the period of interest, dial pulse contact DP is short circuited.

E.4.2.5 *Switchhook pulsing*

I did not mention this in connection with the coin collectors (since there we had in general no way to counter it). It was a way for miscreants to circumvent the protection against fraudulent calling given by dial pulse shorting.

The technique was, after having gotten dial tone by the application of a spurious ground, but with the dial pulse contacts still disabled, dial pulses could be sent by just rapidly manipulating the switchhook to open and close the loop. just as the dial pulse contact would normally do.

In the single slot coin telephone sets, thus ploy was frustrated by having, as part of the switchhook contact assembly, a mercury switch (SH2, but I don't show it on my drawings), connected in parallel with SH4. It cannot change from open to closed or vice-versa rapidly. It closes when the handset was off hook, this just in steady state adding to the closure from SH4.

But if the switchhook is depressed for a brief time (to create a bogus dial pulse), the mercury switch will not respond quickly enough, and so it maintains the closure for long enough to suppress the bogus dial pulse.

E.5 OPERATION–DIAL TONE FIRST MODE

E.5.1 The circuit

Figure 76 shows, in this greatly simplified way, the circuit of a coin telephone set with a rotary (pulse) dial, set up for Dial Tone First prepay operation. (In particular, this is the circuitry of the "field convertible" type, configured for Dial Tone First operation). As before, for clarity, this shows only the paths of interest to the description of operation, and omits the internal circuit details of the totalizer, treating it rather as a "black box".

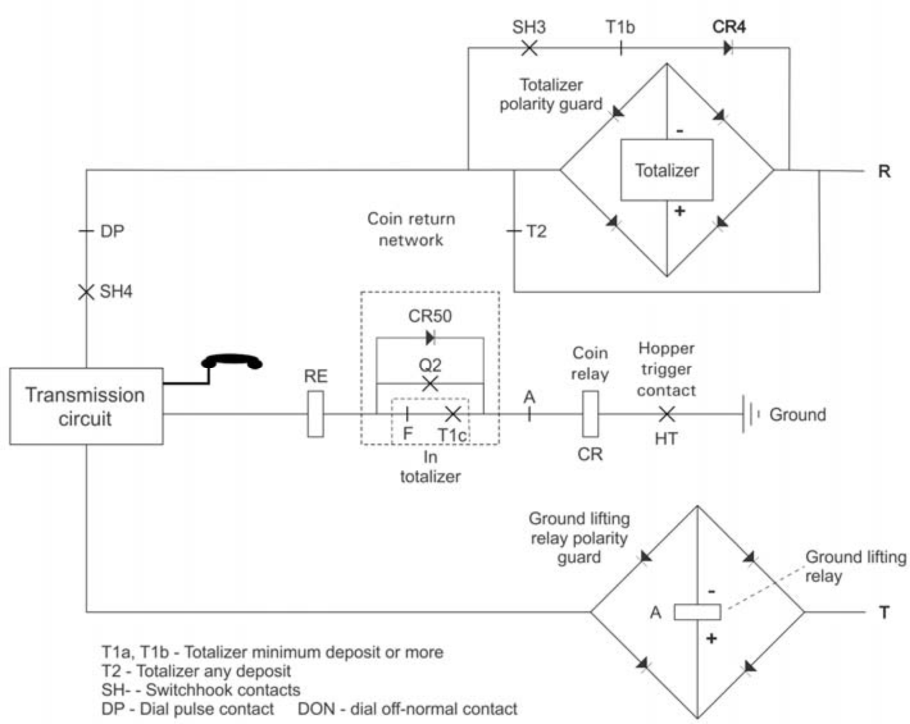

Figure 77. Single slot coin telephone set—prepay, Dial Tone First

The circuit is in some ways simpler than that for coin first operation. But there are some surprise wrinkles in parts of the protocol.

E.5.1.1 *Basic outgoing call*

First note that we assume that this station operates with a loop start line circuit.

We suppose the caller has not yet deposited a coin and lifts the handset. Switchhook contact SH4 closes, and there now is a path from the ring through the break contact of T2 (in the totalizer), dial pulse contact DP (closed with the dial idle), switchhook contact SH4, the transmission circuit, and the tip relay and its polarity guard to the tip.

Note that the path from the ring is led around the totalizer by contact T2, so the totalizer will not be energized when current flows though the loop.

Since the line circuit here is of the loop start type, the tip of the loop is grounded at the central office line circuit, so loop current flows. The A (ground lifting) relay operates, opening a path (not yet completed elsewhere) to ground through the coin relay.

The central office connects a digit receiver, which provides dial tone to the calling line.

The caller is able to dial, and the dialed digits are registered at the central office.

Suppose the digits dialed indicate that this is clearly a call for which there is no charge (to a long distance operator, for example, or, as these came into existence , a "911" emergency service bureau.

But, if the dialed digits do not indicate a call that would inevitably be "free". the central office makes a test to see if any cons had been deposited.

Suppose that the caller, knowing that the call to be made would not be "free", had (even before dialing) made the minimum deposit.

We will assume that the initial deposit here is 10¢, and that the caller will deposit that as two nickels.

As the first nickel presses the nickel arm of the totalizer, the totalizer is mechanically stepped to the "1 count" position. Totalizer contact T2 operates (opens), and removes one path bypassing the totalizer polarity guard. As that coin reaches the hopper, it operates the hopper trigger, and contact HT closes

However, current from the ring passes through diode CR4, which is forward-biased (recall that the battery polarity on the ring is negative), totalizer contact T1b (still closed since the totalizer has not yet reached the minimum deposit position), and SH3 (closed since the switchhook is “off hook”), thus in fact allowing the loop current to bypass the totalizer so it is not now energized.

So nothing further happens in the totalizer at this point.

Now the caller deposits the second nickel. It presses the nickel arm of the totalizer, stepping the totalizer to “position 2” (worth 10¢). Since the totalizer is set to recognize this as the minimum deposit, totalizer contact T1 operates. Contact T1c closes, almost completing the path to ground though the coin relay..

But not quite. Since relay A is operated, contact A is open, spoiling for the moment the path to ground through the coin relay.

In fact, the main purpose of this is so that, in the conversation mode, there is no opportunity for spurious AC currents to pass through the coin relay into the transmission circuit, where (since the transmission circuit is not perfectly “balanced”) they could cause spurious AC voltages across the telephone line, to be heard as noise by this or the other party.

Contact T1b opens, removing the path bypassing the totalizer. Thus the totalizer is now energized.

As a result, the totalizer S magnet steps twice (beeping for each step), so the totalizer is returned to its home position.

When that happens, totalizer contact T2 is released, and closes, placing a short circuit around the totalizer. But totalizer contact T1, being mechanically latched, does not release.

Note that, with no current flowing in the ring, the totalizer cannot be energized.

Suppose the caller indeed deposits his first nickel. Although the totalizer is not energized, the mechanical aspect works. The passage of the nickel through the nickel channel of the coin chute presses the nickel lever of the totalizer, which steps the totalizer up by one step.

As soon as the totalizer comes away from “home”, contact T2 operates and opens. With A not yet operated, SH3 operated (so its break contact is open), and T1 not operated (T1a is open), the path from the ring to the transmission circuit is now open.

The coin then reaches the hopper, where it trips the trigger, closing the hopper trigger contact, HT. There is now a path from the “center” of the transmission circuit to ground. But, because of the opening of the path from the ring conductor to the transmission circuit (described just above) there is yet no path from the ring conductor to ground.

Now the caller deposits a second nickel. The second nickel again presses the nickel lever of the totalizer, and the totalizer is stepped to position 2. The totalizer has been set (a mechanical adjustment) for an initial deposit of 10¢ (two steps).

Since that position has now been attained, totalizer contact T1 operates. The path from the ring conductor through the break contact of A (now still closed), T1a (now closed), and SH3 (closed) continues on through the DP contact (closed), switchhook contact SH4 (closed), half of the transmission circuit, and so forth through the coin relay and to ground.

Suppose now that the central office, having determined that this is not a “certainly free” call, wants to see if the caller has made the minimum deposit that would permit a local call to proceed, so it makes a “coin test”. The central office removes the -48 V battery from the ring and instead applies it to the tip, the ring now being open.

There is no loop current, which releases the A relay,. Contact A closes, which completes the path to ground through the coin relay (if in fact the minimum deposit had been made so T1c is closed). If there is now path to ground through the coin relay, the current flowing under the applied voltage of -48 (considering the fairly high resistance of the coin relay) is not sufficient to reoperates the A relay.

If in fact the minimum deposit had been made, the current in the tip flowing through the coin relay to ground is detected by a relay in the central office. Since the initial deposit had been made, the central office restores the normal conditions on ring and tip and allows the call to proceed.

If at this time the minimum deposit has not been made, the central office sees this (by lack of current in the tip during the “coin test” described just above). The central office provides a recorded announcement reminding the caller that, for this call, a certain amount must be deposited.

The central office then repeatedly makes the “coin test” (as described above) until it is seen that the minimum deposit has been made, at which point the call is allowed to proceed. If indication of the minimum deposit is not seen after some predetermined time period, the call is routed to an operator.

E.5.1.2 *At the end of the call*

At the end of the call, the coins are disposed of in the familiar way.

E.5.1.3 *The coin disposal test*

Just as discussed for coin collector operation in Section 12.3 of the body of this article, here, after completion of the coin control voltage pulse, the coin disposal test (sometimes called the "stuck coin test"), is made to confirm that the coin relay and coin trigger have properly reset, and thus there is no longer a path to ground through the coin relay.

Under the Dial Tone First mode, as predicated on the use of a single slot coin telephone set, this test is made by applying +48 V to the tip of the loop with the ring open. The flow of any current reveals that in fact this part of the set has not properly reset. Appropriate steps are then taken so this will be looked into.

Why must this use +48 V (not perhaps -48 V, as we might expect? Suppose that the coin control operation that was being confirmed was the return of deposited coins less than the minimum deposit (the "orphan coins" scenario). Thus totalizer contact T1c would not have been operated (closed).

If the coin disposal test were done with -48 V, with contact T1c open there would be no path through the coin return network through the coin relay to ground that could reveal that the coin trigger had not reset. But by applying +48 V for this test, diode CR50 provides a path around T1c that would reveal if the hopper trigger had not reset.

E.5.1.4 *Abandonment with partial initial deposit made*

Suppose our intrepid caller deposits part of the required initial deposit and finds he does not have any more coins. He hangs up.

The central office attempts to return these orphaned coins (still in the trap of the coin hopper). But because totalizer contact T1c is not closed (the totalizer never having reached the "minimum deposit received" state), the path through the coin relay to ground is open. That would seem to doom the return of such orphaned coins.

What is shown as "contact" Q2 in the coin return network is actually an SCR switch, controlled so it will only "fire" (conduct) if the voltage across the coin return network is somewhat greater than 48 V Since the regular coin test uses -48 V battery, this SCR will not fire, thus allowing T1c to control whether or not there is a path through the coin relay to ground, as needed for regular call management.

But in this particular scenario, when -130 V is applied to the tip to refund the orphaned nickel, the transistor switch does "fire" (and is maintained conductive by the current through it), so current can flow through the coin relay, causing the orphaned coins to be returned, whether of not contact T1c is closed.

The discrimination of this SCR circuit is not needed when a +130 V coin control signal is used (when the coins are to be collected for a completed "chargeable" call), in part because in that situation, totalizer contact T1c would inevitably be closed. But in any case, for that polarity, diode CR50 (mostly there for another purpose we will hear about later) bypasses the entire coin return network.

E.5.1.5 *A call through a long distance operator*

The initial part of the call proceeds as described in Section E.4.2.1. The caller dials the code to reach a long distance operator. We assume that the call is routed to a cord-type toll switchboard.

As soon as the connection is taken up by the toll operator, the toll trunk initiates coin return in the familiar manner. As before, the RE magnet unlatches the totalizer T1 contact, so the totalizer is back to its ideal condition.

But for the rest of the call, talking battery on the ring) is made +48 V rather than the usual -48 V.

> The adoption of this protocol of course required that the central office be able to supply +48 V. But we note that in modern central offices there are numerous cases of DC-DC converters being used on a frame-by-frame basis to provide various needed voltages from the general -48 V distribution, so this is just another one of those.

The point of this is that now diode CR4 is back-biased (and thus nonconducting), so the path around the totalizer though T1B and SH3 is now ineffectual. Now, if the totalizer were to be stepped away from its home position (even by one step), totalizer contact T2 will open. Now the totalizer is energized

The implication of this is that if, as the first stage of depositing the charge for the call requested by the operator, the caller deposits a nickel, the totalizer will promptly step back to home, giving a "beep" (worth 5¢) as it does.

We might ask why this circumventing of the short-circuiting of the totalizer though diode CR4, on a call through a long-distance operator, could not have be relieved by just reversing the tip and ring at the central office (thus also leading to CR4 being back-biased and nonconducting). This would have avoided the need to introduce a voltage of +48 V into the picture.

The official explanation is that doing so would have screwed up something else (I have not yet tried to figure out just what).

E.5.1.6 *The F contact of the totalizer*

When the RE magnet operates (when coin disposal current goes through the coin relay to ground), it operates (opens) the F contact in the totalizer. If the totalizer is away from the home position, a latch is in place that holds the F contact operated (open).

Only when the totalizer is completely reset to the home position will the F contact be released and thus reclosed. This means that after the end of a call (with the coins disposed of), no ground, indicating an initial deposit made, could be presented for a subsequent call prior to the totalizer having been fully reset.

This is said to avert some fraud ploy I have not yet come to fully understand for making a call with less than the defined initial deposit.

Yes, “F” is said to be mnemonic for “fraud”, and the latch that holds it operated is called the “fraud latch”.

E.5.2 Ground noise mitigation

In Section 21 of the body of this article, I discuss an exposure to noise caused by an AC component of the difference in potential between the local ground at the coin station and the reference ground at the central office. That Section also discusses how this phenomenon is mitigated in coin collectors. But those steps incompletely solve the problem.

In the single slot coin telephone sets of the Dial The First flavor, a rather Draconian solution to the residual ground noise problem is used.

When the telephone is in the conversation phase, loop current of course flows and so the A relay operates. Contact A opens, which opens the path through the coin relay to ground (that not being needed for anything during the conversation phase of the call). Thus, there is no oath for currents (DC or AC) into the picture from ground potential differences. Problem solved!

E.6 NOMENCLATURE

In the body of this article, where coin telephones of the “coin collector” type were discussed, I made no attempt to speak of the formal nomenclature (for Western Electric system units called the “apparatus code”), since there were a myriad of major variations.

But for the single slot Coin Telephone Sets, the landscape is a little more compact, so I will give the basics of their apparatus codes here.

The first part of the apparatus code for a single slot coin telephone set always looks like this (including the noun phrase which a Western

Electric item must have since the alphanumeric apparatus codes may recur for wholly different items):

1C2 coin telephone set

The first digit (1 in this example) is 1 for the "box" style sets and 2 for the "panel" type sets.

Jumping to the second digit (here, 2) it tells the type of dial the set has: 1 for a rotary (pulse) dial, 2 for a Touch-Tone (DTMF) dial, and 3 (only applicable to the E series) no dial at all (that is, for use in a manual central office).

The alphabetic character (C in the example) tells the operating mode(s) for which the set is intended, thus:

A—Prepay, coin first only

B—I think reserved for prepay, Dial Tone First (but I think none were actually made under that code).

C—Prepay, convertible in the field for coin first or Dial Tone First operation.

D—Prepay, Dial Tone First, but with a dramatically new innards, using integrated circuits, piezoelectric coin travel detectors, and so forth. They are not discussed at all in this article.

E—Postpay (either manual, with no dial, or dial, with a rotary dial). (Only made in the "1"–box–style.)

The detailed discussions above are for the "1C1/2C1" series.

Of course, the complete apparatus code will typically have further characters, notably a color code, since both box and panel versions were made with several different finishes (different repertoires for the two types).

E.7 OUTSIDE THE BELL SYSTEM

In the early 1970s, Automatic Electric Company (by then part of GTE) introduced a line of "single slot" coin telephone sets overall similar to the Western Electric sets described above, but with many differences in detail. (Among the most visible differences is that the coin return chute is now on the right side.)

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