Principles of traditional coin telephones

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Issue 1
January 22, 2023

ABSTRACT

Telephone-company provided coin-operated telephones ("payphones") were at one time ubiquitous around the world, and certainly in the US were an important part of our culture.

Various schemes were in use over the years, and the technical aspects were complicated and intricate.

In this article, I select a "mainstream" *modus operandi* for coin telephones (fully applicable up through perhaps 1950, and many of its principles beyond that)) and explain their operation.

Emphasis is on circuit and operational principles rather than on the physical construction and appearance of the telephone sets.

1 INTRODUCTION

For many years, coin-operated telephones[1], provided exclusively by the local telephone company, were a ubiquitous fixture on the streets and in the shops of every city around the world. 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.

Several different operating schemes were used, with several variations of each. I will speak of only the US/Canadian practice, and I will limit the initial discussion to what we might consider the "mainstream" mode, in a common form, as it existed in a certain period.

2 CAVEAT

The evolution of the different protocols described herein, and the motivations for them, have been lost (at least to me) in the fog of

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[1] In the Bell Telephone System, coin telephones (made by Western Electric Company) of the style used for many years were formally called "coin collectors", and those of a later style "coin telephone sets". Coin telephones made by Automatic Electric Company, and used mostly by non-Bell telephone companies, were formally called "paystations". Here, in the interest of generality, I will speak of them all as "coin telephones".

history. This story has 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 the author with their information.

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 cover the waterfront but rather to introduce and illuminate some of the principles involved, which in various ways differ from the principles of ordinary telephone operation.

3.2 Zeroing in

In this section I will identify, by way of various properties, the particular subset of coin telephone practice I will discuss. In some cases, where there are two or more possibilities described at length, I will put the one(s) I will not (initially) be considering in italics to make clear that this description **does not apply**.

3.3 Geographic range

I will be discussing practice that is common in the US and Canada. Practice in other countries may vary substantially from this.

3.4 Switching mode

Coin telephones operating under the general concept discussed herein were introduced when telephone switching was universally conducted with manual switchboards, and certain important principles solidified in that context. The concept migrated, at first rather directly, into the machine switching ("dial") systems that eventually superseded manual switching altogether.

The discussions herein are all in the context of machine switching.

3.5 Ownership of the coin telephone

3.5.1 *Ownership 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 (some might say "incestuous") collaboration of the telephone-company-owned coin telephones with the telephone company central office equipment.

3.5.2 *Ownership by the customer*

As part of the policy changes that were codified by 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 central offices ***would not*** *support "traditional" coin telephones provided by the customer (the signals that caused the coins retained in the phone since the beginning of the call to be either collected or returned).*

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 proprietor's rate table built in.

Such coin telephones were often called "customer owned coin operated telephones" (COCOT). 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 generally the "customer" of the local telephone company for the line on which the coin telephone operated.)

3.5.3 *Herein*

My descriptions herein will be predicated on the coin telephone being owned and administered by the local telephone company.

3.6 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.

Herein, unless I specifically mention otherwise, the detailed description will be predicated on the Bell Telephone System practice.

3.7 Prepay vs. postpay modes

3.7.1 *Prepay*

In the prepay mode, in its original form, the caller must deposit the basic charge for a local call (the "initial deposit") before being able to make any call (even if it would turn out to be "free"). This mode involves the coins being held in the telephone (sometimes described as being "escrowed") until 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, 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.

3.7.2 *Postpay*

In this mode, 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, those coins being directly sent 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 were encountered.)

The motivation for this mode is that the coin telephone set and the supporting equipment in the central office is less complicated and requires less maintenance (especially as to the coin telephone itself) than for the prepay mode.

3.7.3 *Herein*

In general, my descriptions herein will be predicated on the prepay mode.

3.8 Coin first vs. dial tone first in prepay systems

3.8.1 *Coin first*

For, many years, the *modus operandi* for the prepay mode was that the caller had to deposit coins for the basic local call charge (the "initial deposit") before any call could be made. The disadvantage was that "free" calls, notably to emergency services, 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 not have to pay for the call "on the spot". This form of the prepay mode, once an alternative came into play, came to be called "coin first" operation.

3.8.2 *Dial tone first*

In the mid-1960s, most prepay coin phone service in the US and Canada was converted to a new method of operation. Now, a caller at *a coin telephone could, without depositing any cons, receive dial tone, and place any "free" calls (Including to emergency services or to a long distance operator). But before a local call could be completed by the central office, the minimum deposit had to be made. This form is described as "dial tone first" operation. Note that in the normal usage that term implies this form of prepay operation. The term itself would seem to be by definition applicable to postpay operation, but that is not what it is taken to mean.*

3.8.3 *Herein*

In general, my descriptions herein will be predicated on coin first prepay operation.

3.9 10¢ vs. 5¢ minimum deposit

3.9.1 *5¢ minimum deposit*

For much of the overall era of interest (until perhaps the mid 1950s), the initial deposit for a coin telephone (which was by definition the basic 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.)

3.9.2 *10¢ minimum deposit*

In the mid 1960's, the telephone companies in most of the US and Canada increased the initial charge for coin telephone calls to 10¢. Then "any (single) coin" would no longer satisfy that requirement; if nickels were used, two had to be deposited before the phone would allow a call to be commenced. This required the retrofit of all prepay coin telephones, and many changes in the supporting central office equipment.

3.9.3 *Herein*

Until section 7, my descriptions herein will be predicated on a 5¢ initial deposit.

3.10 Multi-slot vs. single-slot designs

3.10.1 *Multi-slot*

In most of the coin telephones made prior to the mid-1960s in the Bell Telephone System, and after that for the sets most used by non-Bell telephone companies, there was 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 would fall down a narrow passage.

Each of those passages leads to a separate “channel” in the coin chute.

Especially once an alternate configuration came onto the scene, these telephone were known as *multislot coin telephones* (formally, in the Bell System, “M*ultislot Coin Collectors*”).

3.10.2 *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.

A prominent feature, from which these sets get their descriptive name, 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 kinds of coins into separate channels for further consideration.

They were known as *single-slot telephone sets*.

3.10.3 *Herein*

Except where mentioned otherwise, my descriptions herein will be predicated on the multi-slot form.

3.11 Type of dial

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

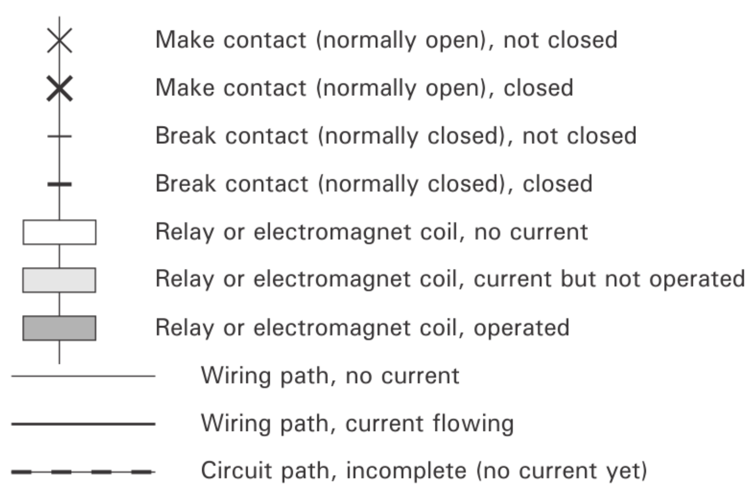

Figure 1. Circuit sketch symbols

4 FOR REFERENCE

4.1 Graphic symbols

In the many figures to follow, I will use some special conventions (shown on figure 1) for the schematic circuit sketches..

These conventions are based on the symbols used in the Bell Telephone Laboratories' "detached contact" schematic drawings, but augmented to give insight into the actual current state of the contacts.

4.2 The switching system

The discussions to follow are based on a "fictitious" switching system not necessarily exactly like any in actual use. But the principles illustrated are followed, in different ways, in all switching systems.

5 THE OBJECT OF OUR AFFECTION

Although I said that this article would not concern itself with the construction nor physical appearance of coin telephones, just so the reader can be sure just what I am speaking of, the coin telephones I will mostly speak of look generally like that shown in figure 2:

Figure 2. Illustrative coin collector (Bell System)

This is a unit used in the Bell Telephone System and made by Western Electric Company; the ones used by non-Bell companies are very similar. (They all descended from a design originally manufactured by the Gray Telephone Paystation Company.)

6 OPERATION

6.1 Regular telephone sets

6.1.1 *Introduction*

An important aspect of the operation of the "traditional" prepay coin phones operating in certain protocols 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 topic as it pertains to "regular" telephone sets and their lines into the central office.

6.1.2 *Line idle*

Figure 3 shows the aspects of a regular telephone[2] and its central office interface that are of interest to us.

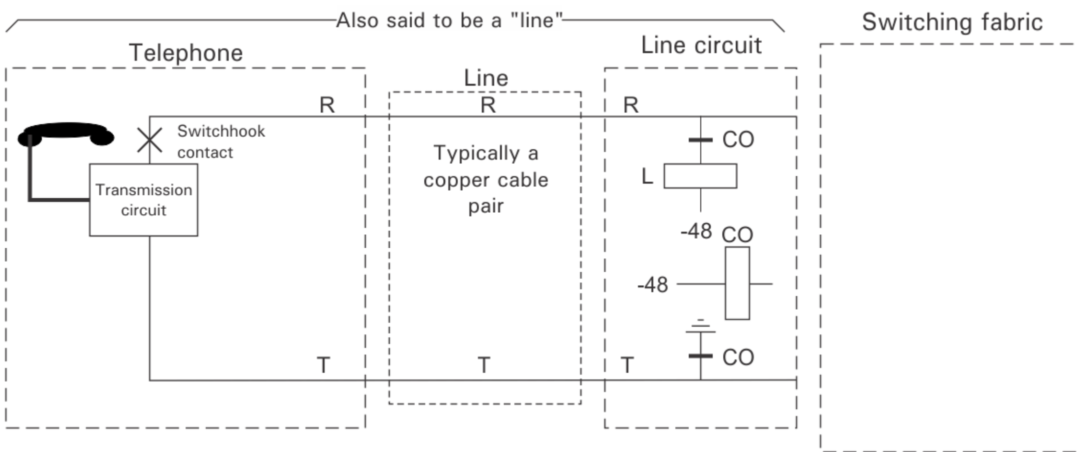

Figure 3. Regular telephone line–idle

At the set 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 switchhook"[3].

The box labeled "switching fabric" refers to the part of the central office switching system that will eventually provide a path from this telephone line (as a calling line) to the line that is being called (the called[4] line), or to a trunk to another central office.

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[2] The proper term is "telephone set", which I used earlier, but if use that here it will lead to a problem later, so from here on I just use the popular term "telephone".

[3] The graphics used for the handset "on" and "off" the switchhook are not apt for the physical construction of the coin telephone, but are used here for continuity.

[4] Traditionally spoken in two syllables, as a physicist or Texan would do anyway.

The box labeled "switching fabric" refers to the part of the central office switching system that will eventually provide a path from this telephone line (as a calling line) to the line that is being called (the called[5] line), or to a trunk to another central office.

The station line terminates at the central office in its *line circuit* (one for each line). There, the ring conductor[6] of the line (R) is connected through a *break* (normally-closed) contact on the cutoff relay (CO), through a winding of the line relay (L) to a nominally -48 V supply (referred to as "battery"[7]).

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 (or thus through the L relay).

6.1.3 *Caller lifts the handset*

Now, the user lists the handset. We will follow the result on figure 4.

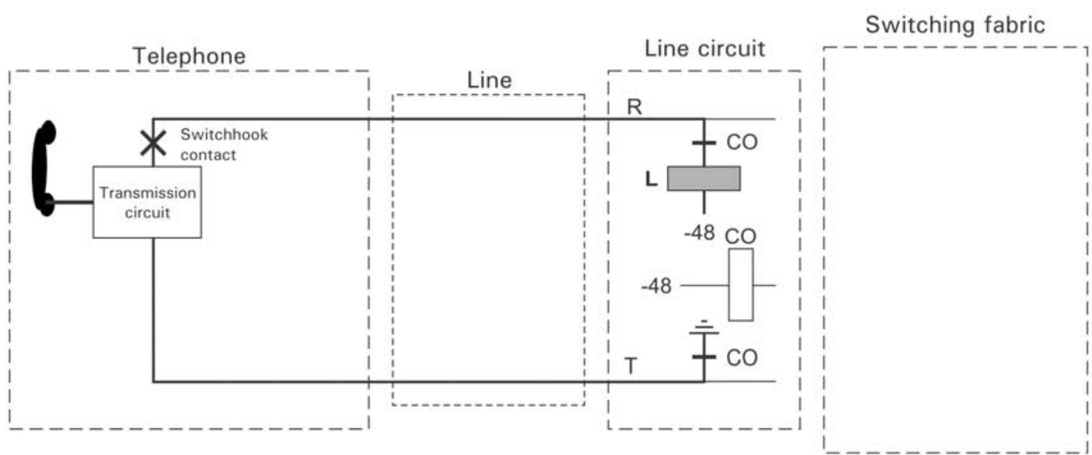

Figure 4. Telephone taken off-hook

The lifting of the handset causes the switchhook contact to close, completing a path from the -48 V battery through the coil of the L relay in the line circuit, the line, and the telephone , to ground. The current in that path energizes the coil of the L relay, which operates.

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[5] Traditionally spoken in two syllables, as a physicist or Texan would do anyway.

[6] 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.

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

6.1.4 *Caller gets dial tone*

In some way (differing greatly between different switching systems), this causes the switching fabric to attach to this line 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*.[8]

We see this on figure 5.

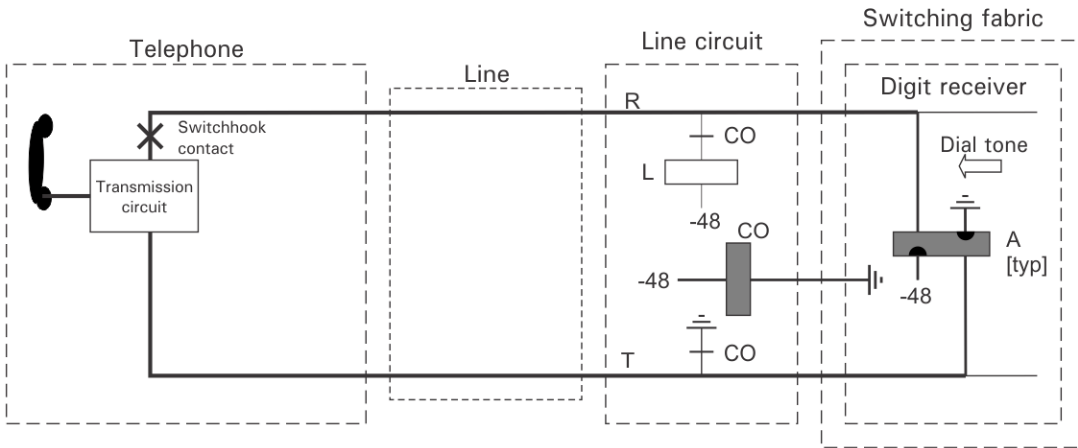

Figure 5. Calling line receives dial tone

Note that "talking battery" is now fed to the station through what I have called here, arbitrarily, the A relay of the digit receiver. 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" has not hung up the telephone .

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 a 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

[8] 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).

path in the line circuit.[9] 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.

6.1.5 *"Loop start"*

This type of line circuit (the ordinary kind) is often spoken of, especially when there is need to distinguish it from the kind we will hear about next, as a "loop start" line circuit. This of course alludes to the fact that the L relay is operated, to **start** the call, over the **loop** comprising the ring and tip conductors (and through the telephone).

6.2 Coin telephone line–protocol "alpha"

6.2.1 *Introduction*

Now, in figure 6, we will actually look at a coin telephone line, operating in the protocol I call "alpha" [10].

It was actually little used, but it is the direct descendant of the protocol used in manual switching systems, and is the prototype of the more elaborate protocols than came into wide use under machine switching. It is relatively straightforward, and will be a convenient vehicle for introducing the basic concepts of coin telephone operation.

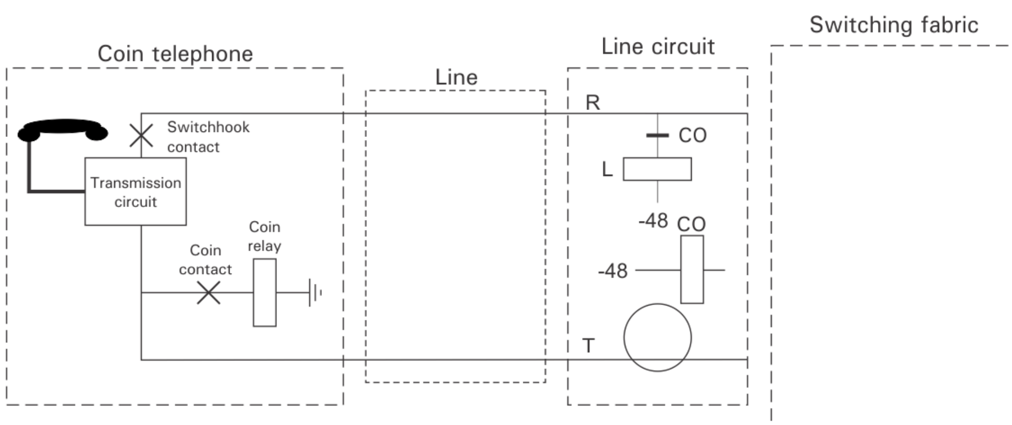

Figure 6. Coin telephone line–idle

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

[10] Not a notation used in any official documents, just mine for reference in this article.

6.2.2 *Line idle*

In figure 6 we see a circuit schematic sketch of a coin telephone (well, what we need to see so far) that will be operating in the "protocol alpha" mode, along with its line, line circuit, and the fanciful "digit receiver" at the central office. The figure shows the coin telephone (actually, the entire "coin telephone line", using "line" in the broader sense idle.

We note that the telephone has two new components, the *coin contact* and the *coin relay*, which will shortly be of great interest. But the punch line here is at the line circuit. We note that here, with the line idle, the tip conductor is not connected to ground there (the circle calls our attention to this omission).

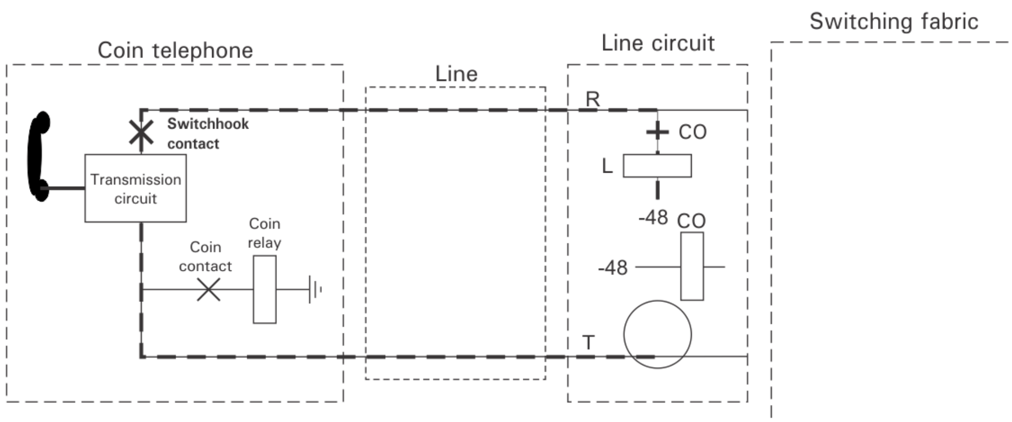

Figure 7. Coin telephone off-hook

6.2.3 *Caller lifts the handset*

In figure 7., we see that the user 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 alls our attention to this) mean that the path to do so is incomplete. In the figure, the dashed line overlay shows this "not quite completed" path. So the L relay does not operate, a linefinder is not started to serve this line.

6.2.4 *Caller deposits coin*

In figure 8, the user has deposited a coin—any coin will do.

The coin will, on its way to repose in an area called the *coin trap*, will pass by a small finger, the *coin trigger*, depressing it. This releases a spring loaded lever that closes the *coin contact*.

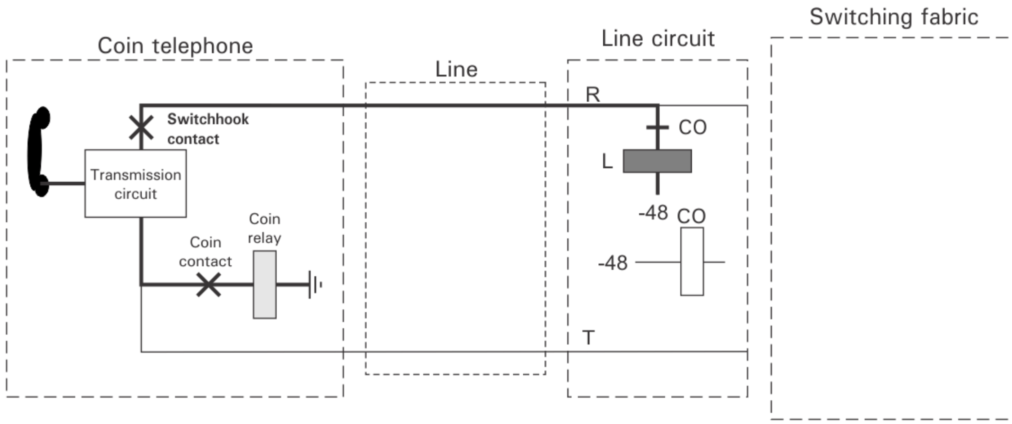

Figure 8. Coin telephone off hook and coin deposited

This closes a path from the tip conductor at the telephone 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, through the switchhook contact and the transmission circuit, and through the coin contact and the coil of the coin relay, 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.

6.2.5 *About the coin relay*

The traditional coin relay is a polarity-sensitive three-state electromagnet, constructed rather like a traditional "two coil" telephone ringer, permanent magnet and all.[11] Current (in either direction) below a well-defined minimum does not move the armature from its neutral position. Current above that threshold level does move the armature one way or the other, which depending on the direction of the current.

What that does for a living we will hear shortly.

6.2.6 *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 in figure 9.

[11] A later version has much different construction and operates on a different principle. But it participates in the scenarios described here in just the same way (almost), and I will not describe it in any detail here.

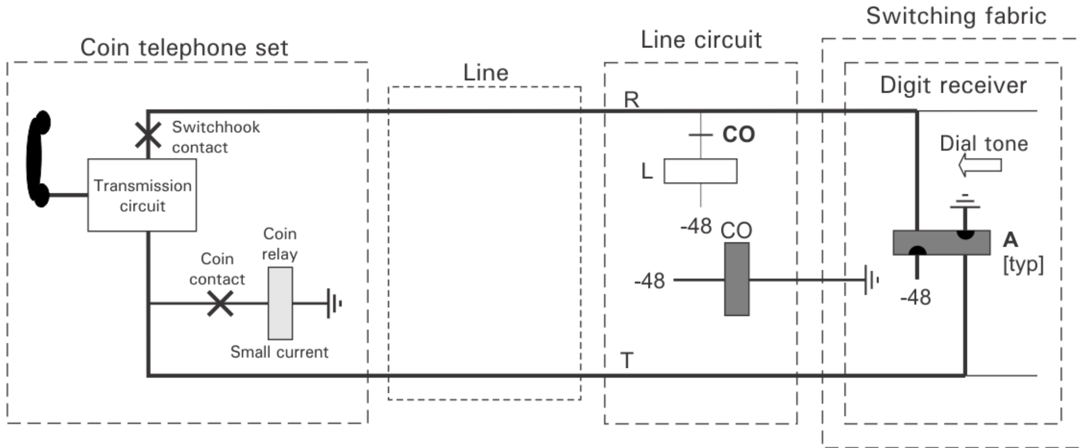

Figure 9. Coin telephone receives dial tone

A small difference here, though, is that part of the current through the winding of the L relay, going out over the ring conductor, goes to ground through the winding of the coin relay. But that is not really any sort of disadvantage.

6.2.7 *"Ground start"*

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**.

6.2.8 *Call is chargeable*

So we assume that the caller in fact 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 the role of 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 and so the charge will be the minimum deposit. Of course the funds for that are already in the coin telephone, in the coin trap ("escrowed").

6.2.9 *Call is finished*

When the caller hangs up the coin phone, the switchhook contact opens and releases whatever relay is giving the calling line talking battery at the time. If this call were from a regular telephone, the switching fabric would disengage, CO would release, and the line circuit would go 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. We see this in figure 10.

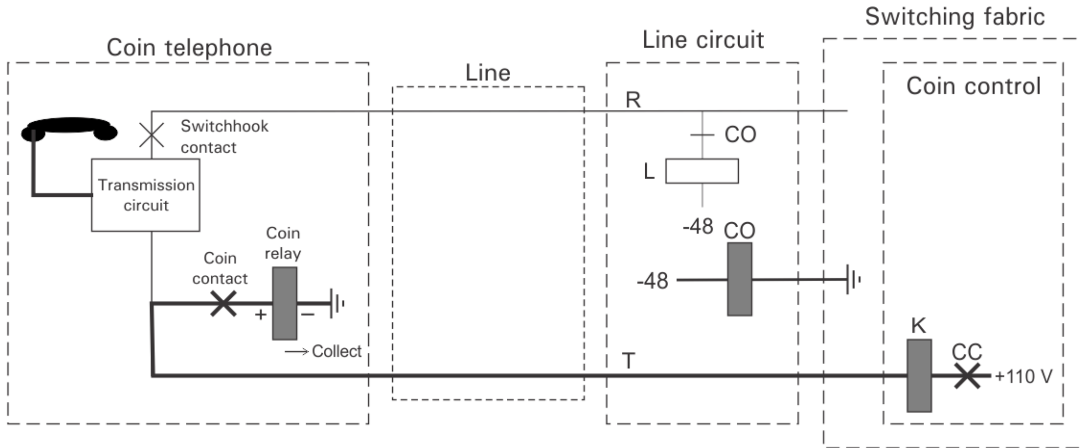

Figure 10. Collecting the coin

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.

This opens the floor of the coin trap, releasing the escrowed coin, and moves the *coin vane* to the position that will steer the released coin into a secure collection container in a locked coin vault.

The current also operates the K relay in the coin control circuit. 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 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 return to neutral after having been operated to one side or the other resets the coin trigger and opens the coin contact.

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

6.2.10 *Call was 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 11.

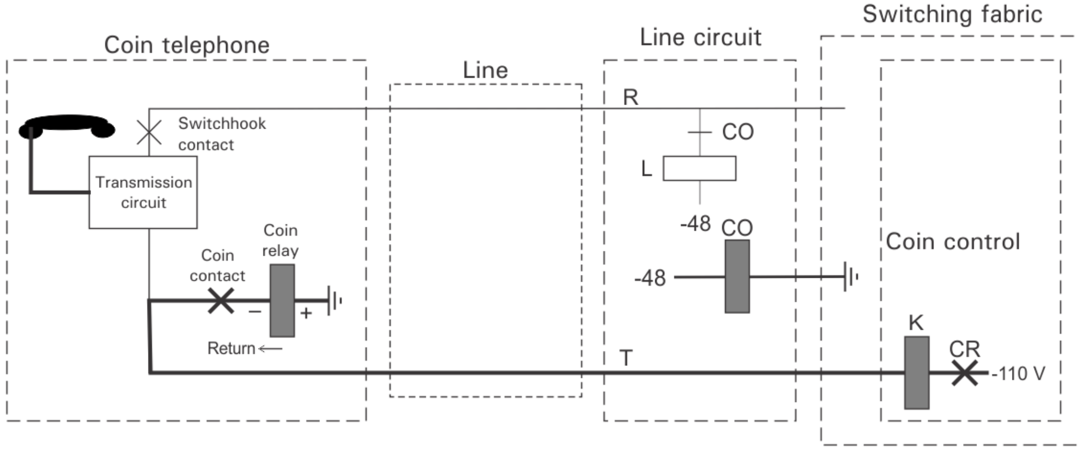

Figure 11. Returning the coin

Again, the coin relay armature moves, this time, by virtue of the polarity of the current, from neutral to the "return" position. Again, this drops the floor of the coin trap, releasing the escrowed coin, but the coin vane is moved in the opposite direction, steering the freed coin into the return chute, from which the caller can retrieve it.

6.3 Long distance call from a coin telephone

Suppose the caller wishes to make an long distance call, and we will assume this must be done through a long distance operator.

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 immediately returns the coin, just as seen in figure 11. 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.

Recall that for the genre of coin telephone we are considering (the "multi-slot type, as described in section 3.10.1) there is at the top a stainless steel turret (the *coin gauge*) with separate openings for nickels, quarters and dimes. Each leads to a separate "channel" in the coin chute.

As the coin it goes along its channel it strikes one of two gongs. One is a conventional gong, much as we might find on a telephone ringer, but a bit larger.

A nickel traveling along its channel strikes this once, at one edge, sounding a “ding”. A dime traveling along its channel strikes it twice, first at one edge and later at the other, sounding “ding-ding”.

A quarter traveling along its channel strikes (once) a gong made of a spiral of spring steel (called a “cathedral gong”), which makes a distinctive sound I will represent as “bong”.

These two gongs 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. This is connected into the telephone circuit so that its “audio” signal is transmitted into the line.

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, which is probably recognized 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 notes if the call was chargeable. 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.

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.

6.4 “Spoofing” the coin telephone

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.

Then 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 are had a direct impact on an upcoming topic, so I will give a brief peek into the matter here.

Suppose a miscreant could somehow (never mind just how; that quickly gets into the complications of the matter) temporarily apply a ground 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 8. 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.

Various measures for thwarting this scheme have been applied over the years. An early (and persistent) one is shown in figure 12.

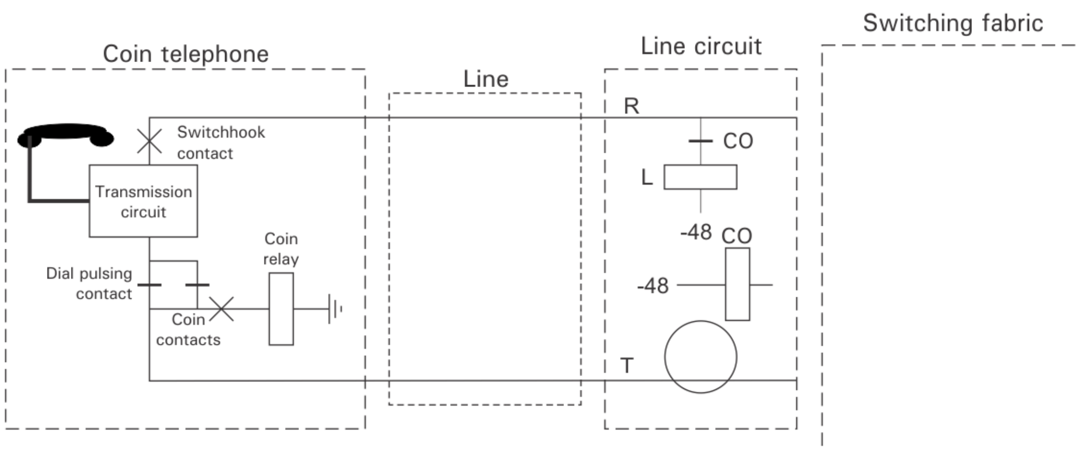

Figure 12. Dial shunt contact

We see here the dial pulsing contact (always present, but I didn’t show it before as it did not play a role in the earlier story). What is new is a second contact in the coin contact set, a break (normally closed) contact, connected across the dial pulsing contact.

Of course with this “dial shunt” contact closed, dialing would be ineffectual. In normal operation, by the time the caller might dial, the initial deposit had been made, the coin trigger had been tripped, and the coin contacts operated. The dial shunt 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 shunt contact would still be closed. Thus dialing by our fraudster would be ineffective.

6.5 Coin telephone line–protocol "beta"

6.5.1 *Introduction*

I suspect that the introduction of this modus operandi was motivated by the desire to provide greater protection against fraudulent operation with a ground applied at the station than given by the dial pulsing contact shunt just described (but I actually have no authentic information on that).

6.5.2 *Operation*

Here again the line is served by a ground start line circuit, and so, as with protocol "alpha", if a caller lists the handset off the switchhook, this does not operate the L relay in the line circuit, and there is no action at the central office.

As before, if a coin is then deposited, the coin contact closes and the coil of the coin relay is connected from the tip to ground. This operates the L relay, just as before, and a line finder is summoned, and the line is ultimately connected to a "digit receiver".

But this now has a new component, which we see in figure 13, and some new duties.

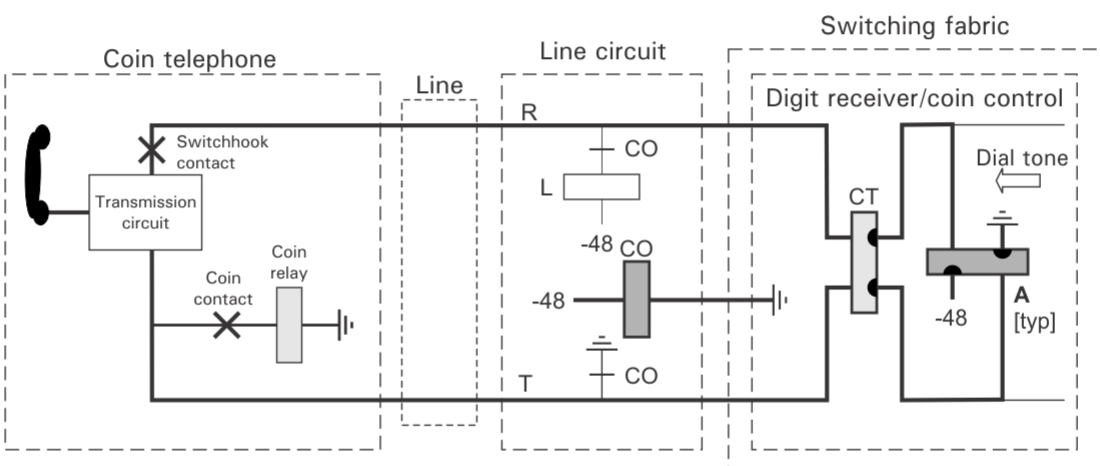

Figure 13. New ingredient in the digit receiver

Because the digit receiver knows this is a coin telephone line, no dial tone is at first provided, and initially any dialing is ineffective.

The loop current goes through both windings of relay CT (coin test) in the coin control circuit, but (as shown by the little half dots) they are poled so that the effects of the two currents oppose.

If there were no ground through the coin relay at the coin telephone, the two currents would be unavoidably equal, their effect in relay CT would cancel, and CT would not operate. This would tell the coin control circuit that there was something funny going on (the ground that allowed the L relay to operate may have been bogus, and was now gone), and the coin control circuit does not allow the scenario to proceed.

But if in fact the ground is legitimate (or bogus but clever enough to be kept in place for a while), the ground at the telephone increases the current in the ring and decreases the current in the tip. Now, the effects of the two currents do not completely cancel out in relay CT (a relatively sensitive type of relay), and CT operates.[12] This is in fact what figure 13 shows. This makes the digit receiver send dial tone to the calling line and allows digits dialed on it to be received and acted on.

The rest of the story proceeds as previously described.

6.5.3 *A further refinement*

In the basic form of this protocol, the fact that there is what looks like a path to ground through the coin relay coil is confirmed (for example, by hypothetical relay CT) by the coin control circuit. But suppose that our miscreant spoofer is careful to apply the bogus ground at the coin station for long enough that its presence can be confirmed. Oh, dear!

To guard against this, a feature was added to the coin control circuit so that the test for the ground will not respond favorably to just any ground, but only to a ground whose resistance is in the range expected when the ground is provided through the coil of a coin relay. This is typically done with a second “ground detection” relay whose operating current is carefully calibrated (a “marginal” relay).

But of course the resistance to ground, seen from the perspective of the coin control circuit at the central office, will vary with the resistance of the line conductors, which varies greatly with the length of the line.

To accommodate this, the “threshold” of the second ground detection relay is based on the resistance of the line, which is inferred from the current “around the loop” (from ring to tip). This is done by having the current through the ring conductor fed through a further winding on the detection relay, where it will in effect create a bias for that relay.

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[12] The actual circuit may be different from that seen on this figure, whose purpose is to allow the principle to be clearly seen.

6.6 Protocol "gamma"

6.6.1 *Operation*

Now that the digit receivers have been equipped with a new functionality, checking to see if there indeed seems to be a legitimate ground at the station, presumably caused by the deposit of a coin, it was noted that now there seemed to be no reason to delay the summoning of a digit receiver until a coin had been deposited (by the use of a ground start line circuit.

So in some cities, the coin lines were now connected to loop start line circuits. So now, when a caller lifted the handset, a linefinder would be started and the line would be connected to a digit receiver.

But, because this is a coin line, just as with protocol "beta", the digit receiver would not give dial tone, and would not be receptive to dialed digits, but would make the coin relay test (with our hypothetical relay CT), just as described before.

As before, if the results of that test were that there was a path to ground on the line (assumed to be through a coin relay coil), the digit receiver would give dial tone and would become receptive to dialed digits. And in general the "more discriminating" type of coin relay test described above in section 6.5.3 was actually employed.

6.6.2 *Free calls*

Often, when operating with this protocol, the central office was arranged so that calls placed to "free numbers", notably, calls to the "local operator" (formally called the dial service assistance operator, or DSA), a long distance operator, "repair service". and perhaps even to telephone company offices, which calls were free) could be made without having deposited a coin.

To arrange for this, the switching system, handling a call from a coin line, would not make the test for a ground until the entire number had been dialed and it could be ascertained whether this would be a "free" call.

Of course, for this to be sensible to the caller, in general when this was the *modus operandi*, the coin control circuit would allow the digit receiver to return dial tone as soon as the line was connected to it (just as on a call from a regular telephone line).

This was a bush-league precursor to the "dial tone first" form of prepay coin service introduced, at gigantic expense, in the 1960s.

6.6.3 *Dial shorting contact*

When this protocol was used and the central office provided for free calls to certain numbers (as discussed in section 6.6.2, the dial shorting contact of the coin relay was disconnected, as the caller had to be able to dial without having made a coin deposit.

6.6.4 *Incidence*

It seems likely that this protocol was the one most often used in machine switching systems until the problem discussed in section 7.3.5 arose.

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

7.1 Introduction

Over a few years in the mid-1950s, in most areas the telephone companies, raised the initial deposit for a coin call (which was, by definition, the base cost of a local call) from 5¢ to 10¢.

Implementing this required retrofitting of every prepay coin telephone as well as making extensive changes in the central office coin control circuits.

The changes needed in the coin telephones came from the fact that when the initial deposit was 5¢, the deposit of any coin would suffice. Accordingly, the telephones were originally arranged so that any coin coming down any channel of the coin chute, into the coin trap, would trip the coin trigger and close the coin contact, allowing the telephone to call for dial tone.

But with a 10¢ initial deposit required, the telephone must not "advise" that the initial deposit had been until two nickels had been deposited (or of course, as always. a dime or a quarter).

7.2 Two approaches

During the era of interest, the coin telephones used by the Bell Telephone System were made by Western Electric Company, and improvements in them designed by Bell Telephone Laboratories.

But the coin telephones use by non-Bell telephone companies were mostly made by Automatic Electric Company, a major manufacturer of telephone sets and telephone switching systems for the non-Bell portion of the US telephone system.

The prepay coin telephones made by the two companies were very similar overall, in part the result of both having descended from coin telephones made by the Gray Telephone Paystation Company.

But the two companies took dramatically different approaches to the matter of requiring two nickels to be deposited to be able to place a call where the initial deposit was 10¢.

I will describe both of these, separately.

7.3 The Western Electric implementation

7.3.1 *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 encounter an angled flap, the *holding latch*, which prevents that nickel from continuing down the coin chute.

A second nickel will encounter the held first nickel, off center, which caused the second nickel to roll of to the side and into a “bypass” portion of the nickel channel. Traveling through that part of the channel, the second nickel encounters a second angled flap, the *locking latch*, which had been holding the holding latch in place.

The second nickel presses the locking latch flap outward as it passes. The holding latch is released by the motion of the locking latch, and can now be pressed put of the way by the first nickel, which is 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, strike the gong, making a very rapid “ding-ding” sequence.

7.3.2 *On a long distance call*

But on a long distance 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.

To provide for this, the 10¢ coin chute is equipped with a small electromagnet whose coil is essentially in series with the line.

We can visualize its operation in the context of protocol “alpha”, 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, the line current 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 the holding latch, so that (just as if one nickel were there, held by the holding latch) any nickel deposited would be deflected into the “bypass” branch of the nickel channel, evading the holding latch and freely continuing through the chute, striking the gong once, and into the coin hopper.

7.3.3 *Return of an orphaned nickel*

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.

7.3.4 *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.

7.3.5 *A problem under protocol "gamma"*

Imagine that, prior to the conversion, the coin lines in this locale operated under protocol "gamma". There, a coin line was served with a loop start line circuit, and the scheme looked to the coin control circuit to ascertain for the fist time 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.

That current will 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 can deposit a single nickel, which will 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 the digit receiver willing to receive dialed digits.

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 that operating with protocol "gamma", which involved a loop start line circuit, were changed to have ground start line circuits. Thus, the *modus operandi* became, essentially, protocol "beta" (again).

But this change bollixed the "bush-league dial tone first" feature that typically came with protocol "gamma".

But not to worry. Perhaps 15 years later, those capabilities (and more) will come back into being as part of the elaborate and very expensive "dial tone first" prepay operation (given glancing mention here in section 3.8.2.

7.4 The Automatic Electric implementation

7.4.1 *The basic principle*

Here, for a telephone that could operate with a 10¢ initial deposit done with nickels (there were versions in which the 10¢ initial deposit could only be paid with a dime), an entirely new coin chute was also used. It fallows a dramatically different principle than that described above.

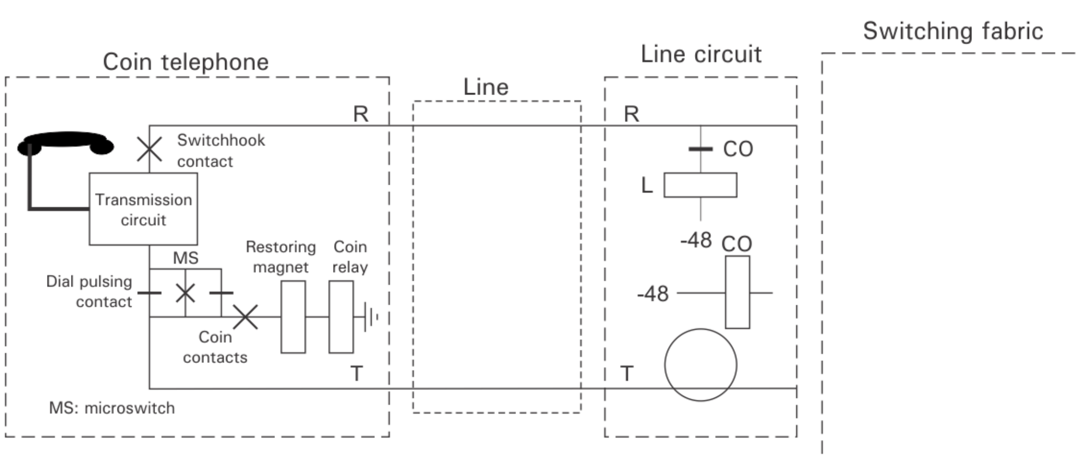

Figure 14. Automatic Electric two-nickel prepay coin telephone

We see an illustrative circuit in figure 14.

Here the first nickel deposited, as it passes through the coin chute, strikes the tip of a wire operating arm that operates a small switch (of the "Micro-Switch" type, and usually called here the "microswitch"), pressing the lever down. It is held down by a latch. The switch closes and shunts the dial pulsing contact.

This first nickel, continues along its channel into the coin hopper, tripping the coin trigger as it arrives, causing the coin contact(s) to operate. The coin relay coil is connected from the line tip to ground just as we saw in figure 8. This operates the L relay in the line circuit, and the caller receives dial tone. But he cannot dial, as the microswitch, having been operated by the first nickel, has shunted the dial pulsing contacts.

If the caller now deposits a second nickel, it too strikes the arm on the microswitch, in its latched position, as it travels through its channel, pressing the arm down from its latched position. But this "knocks out" the latch, and the arm, after the second nickel is done hitting it, returns to its normal position. The microswitch opens, and the shunt it had placed across the dial pulsing contacts is removed.

The fact that the coin contacts are now operated (since the descent of the first nickel into the coin hopper) means that the dial shunt contact there is now also open. Accordingly, the dial is now completely unshunted and thus operative, and the caller can proceed to make the call.

7.4.2 *The restoring magnet*

If the caller deposits a nickel and then (perhaps realizing that he does not have any more coins) hangs up, and the coin control system sends the coin return voltage over the tip of the line, freeing that nickel from escrow in the coin trap and sending it to the return chute, the microswitch operating arm is still latched down. If the caller then lifts the handset and deposits a nickel, this will be treated by the coin chute as a "second nickel", and will release the microswitch, removing its shunt across the dial pulsing contacts. The caller can proceed, making a local call for only one nickel.

To avert this scenario (and other more obscure ones), there is a small electromagnet (the *restoring magnet*) on the coin chute, with its coil connected in series with the coil of the coin relay. Any time coin control voltage (of either polarity) is sent (with the coin contacts operated) this electromagnet operates from the resulting current through the coin relay coil.

This electromagnet forces "out" the latch arm that might be holding the microswitch operating arm down, allowing the switch arm (if it was indeed latched down at the time) to return to its normal, upward, position, where it would be ready for the next outing.

7.4.3 *On a call through a long distance operator*

If the caller, having deposited two nickels, calls the long distance operator to make a long distance call, as discussed before the central office first automatically sends coin return voltage, sending the two nickels to the return chute, where the caller can retrieve them.

Suppose now that, when the initial cost for the long distance call has been quoted by the operator, the caller decides to pay it (in whole or in part) with quite a few nickels. The first nickel deposited pushes down the switch arm, which is latched down. The microswitch, operated, shunts the dial pulsing contacts, but since there is no need now for the caller to dial, that is of no consequence.

The second nickel deposited strikes the switch arm, freeing it from the latch, and it returns to its normal upward position. The switch opens, and removes the shunt from the dial. But as before, this is of no consequence,

The third nickel deposited strikes the switch arm, pushing it down, and it latches in that position. The fourth nickel strikes the switch arm, freeing it from the latch, allowing it to rise to its normal position.

And so forth. The switch is alternately operated and released by successive nickels, shunting the dial when it is operated. But since there will be no further dialing in this part of the scenario, this curiosity is of no importance.

Of course, when the call is completed, or is aborted owing to a busy signal or no answer, the operator causes coin control voltage of one polarity or the other to appropriately dispose of the escrowed coins, upon which the restoring magnet also operates, making certain the switch operating arm is in its upward, normal position for the next use of the telephone.

7.4.4 *Some cute nomenclature*

The model numbers of Automatic Electric coin telephones ("Paystations") equipped to require a 10¢ initial deposit, which can be made either with a dime or two nickels (the latter case working as described just above), have a "55" suffix[13].

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[13] This calls to mind, sort of in reverse, "double nickel", the nickname for the nationwide highway speed limit of 55 MPH in effect at one time. Thus, perhaps, "55" for the "double nickel" mode of operation of AE coin phones.

Just to complete the picture, I note that those Automatic Electric models equipped to require a 10¢ initial deposit which must be submitted as a dime (a simpler mechanism than described above) have a “10” suffix.

7.4.5 *Detailed description of the latch mechanism*

Appendix A describes in detail the actual mechanical principles of the clever latch mechanism referred to above.

8 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 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, arranged much like the coil on a typical telephone 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 called a “two-coil” coin relay.

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

I will not discuss thr single-coil coin relay further in this article (maybe in a later issue).

9 “DIAL TONE FIRST” OPERATION

The term “dial tone first” customarily alludes to the new form of the prepay mode of coin telephone operation introduced starting in the mid-1960s.

In this mode, a caller can, without having any coins, make any “free call” (importantly including to emergency services, such as the “911” service widely in use at the time this mode was introduced. Another case was making a collect call or a call to be billed to a credit card (or equivalent), which the caller could also do without having any coins. The caller could also, with no coins, call a telephone company office (which calls were traditionally “free”)

This mode had extensive ramifications on both the coin telephones and on the central office.

I will not discuss this mode further in this article (maybe in a later issue).

10 SINGLE-SLOT COIN TELEPHONES

In the 1960s, the Bell system introduced a new family of coin telephones, often characterized as "single slot" phones (and formally, rather arbitrarily, designated "Coin Telephone Sets" rather than with the nomenclature for the original "multi-slot" sets, "Coin Collector") since they had a single slot for the deposit of coins of any acceptable denomination.

These were dramatically different physically from their predecessors, and their mechanism was rather different in many ways. But they were essentially interchangeable with the earlier coin phones. There coin relay was a specific form of the "single-coil" coin relay briefly described in section 8.

When the mode of operation was "Dial Tone First", the protocol was changed in many ways, tolerated by the "multi-slot" coin collectors (with a few modifications, but fully exploiting specila features in the new, single-slot, phones.

I will not discuss the operation of single-slot Coin Telephone Sets in this article (maybe in a later issue).

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Appendix A
Operation of the AE “two nickel” mechanism

A.1 INTRODUCTION

Certain Automatic Electric Company coin telephones (actually styled “Payphones” by AE) are equipped to require a 10¢ initial deposit, which can be paid either with a dime or with two nickels. The operation of the ”two nickel” mechanism was described in functional terms in section 7.4 of the body of this article, Here, I will discuss how that mechanism actually works from a mechanical standpoint.

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. It has been used here under the doctrine of fair use.

A.3 OBJECTIVE OF THE MECHANISM

As discussed in considerable detail in section 7.4, 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 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 15 represents the pivotal (!) components of the system in their initial state.

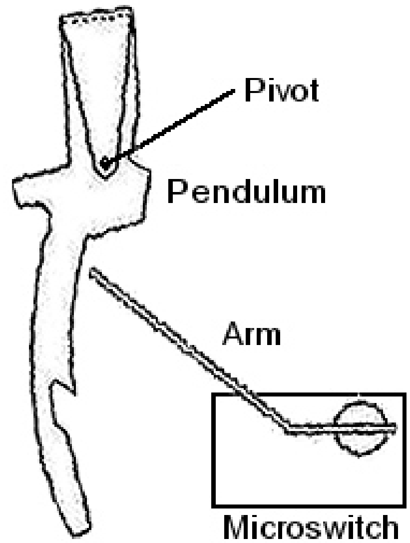

Figure 15. The principal players

“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 (at its upper left as seen in the figure) 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 most of that mass at a greater 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 16, 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.

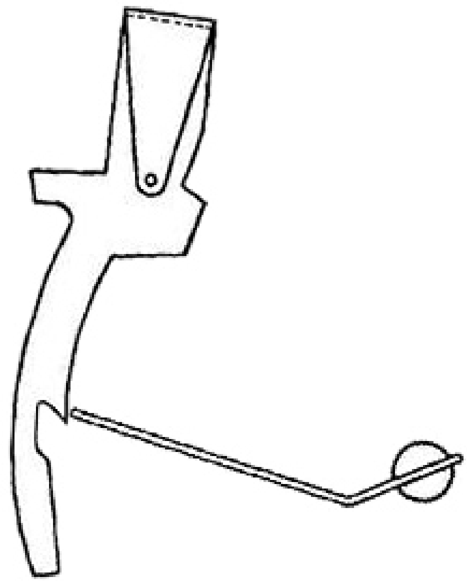

Figure 16. Arm struck by nickel

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.

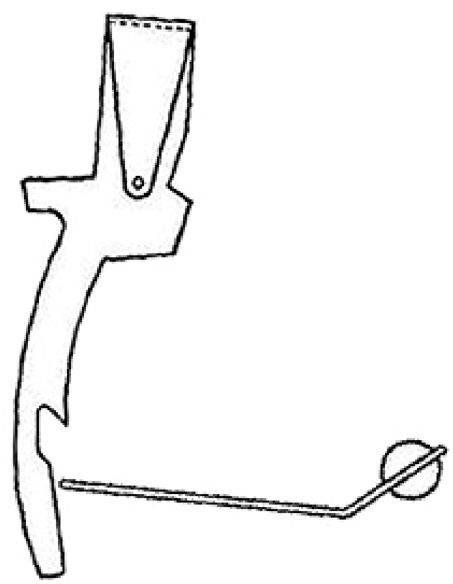

Figure 17. Arm pushed past the notch

In figure 17 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.

As to our intrepid switch arm, it, now freed from 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 passes the lip of the notch in the pendulum, the bottom of the pendulum is free to move to the right (toward its equilibrium position) under the influence of the gravitational-based force on it. Because that force is small, and its moment of inertia is substantial, it accelerates relatively slowly. But it only has to rotate a small amount to position it for its next feat.

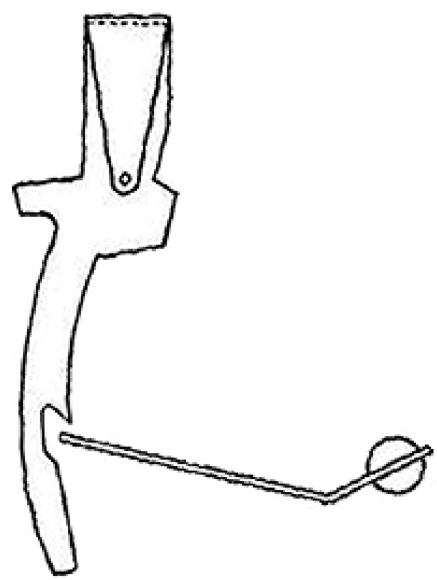

Figure 18. Arm rises and is caught ly the lip of the notch

In figure 18 we see that by the time the arm has risen to where we see it, the lower end of the pendulum has moved a little to the right, enough that the lip of the notch will catch the tip of the arm (just about to happen in the figure).

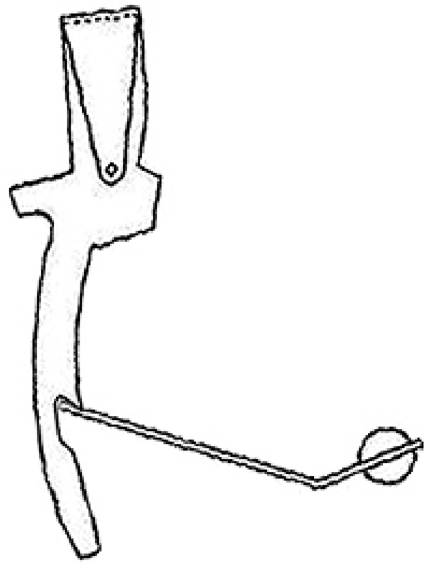

Figure 19. Arm in repose in the notch

In figure 19 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 teh 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.

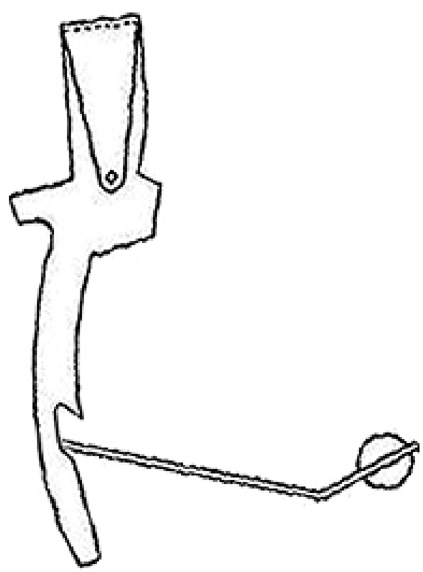

Figure 20. Arm struck by second nickel

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 20.

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, imparting a substantial amount of angular momentum (in the clockwise direction) to it (owing to the steep slope of the bottom of the notch.

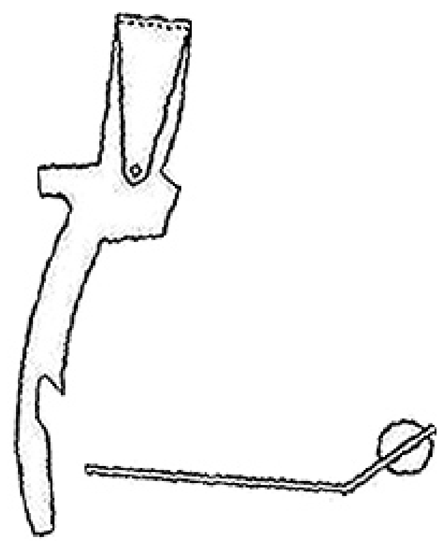

Figure 21. Arm kicked out

In figure 21 we see the arm as far down as this nickel will 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.

This time, when the arm tip rises to the altitude of the lip of the notch, the lip is still way left of the tip of the arm. We see that in figure 22.

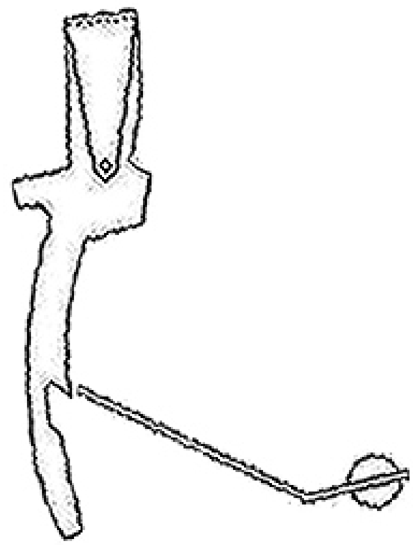

Figure 22. Arm misses the tip of the notch

and the arm misses it completely. The arm continues to rise, until it returns to its original position, as shown in figure 23.

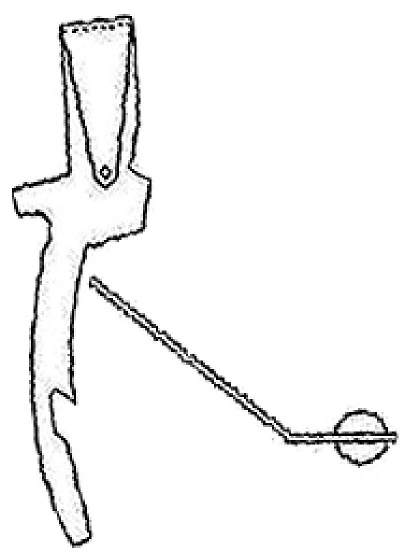

Figure 23. Arm returned to normal

And 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

As discussed in section 7.4.2, 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 24.

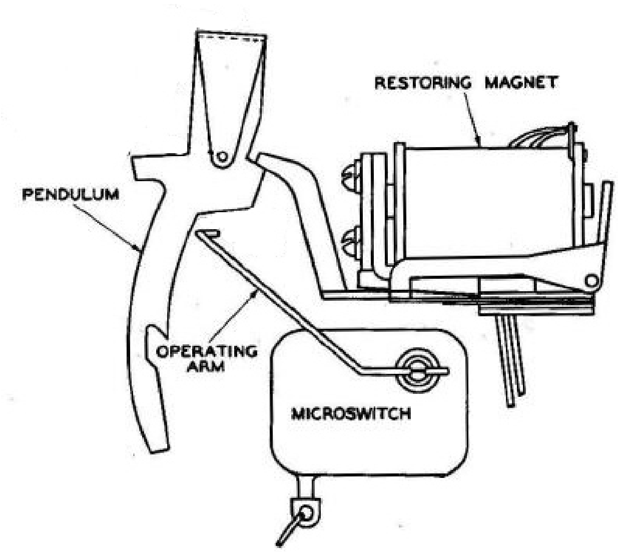

Figure 24. Restoring magnet

This also shows a somewhat more realistic portrayal of the microswitch.

We see that when the restoring magnet operates, its arm presses on the pendulum so as to rotate it counterclockwise, moving its lower end to the left. Thus, if the switch arm (labeled “operating arm” in this figure) had been latched by the notch in the pendulum, the arm would be released and would return to its “normal” position, readying the mechanism for its next outing.

10.1.1 *An anti-fraud feature*

Imagine that a coin telephone 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).[14] 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.

[14] I have trouble seeing how that would work out, but . . .

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 scenario is the job of the *shock lever*, seen in figure 25.

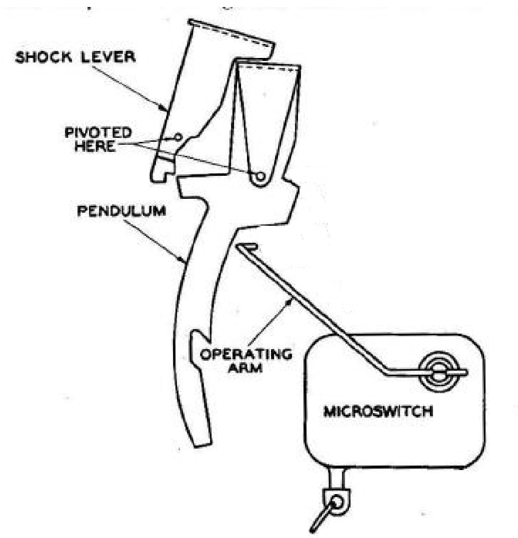

Figure 25. Shock lever

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

As mentioned just above, 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 the bottom of the shock lever to the right. 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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