88th birthday series

The detached contact system for telephone switching circuit schematic drawings

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ABSTRACT

Electromechanical telephone switching systems are extraordinarily complex, and the schematic drawings that define their circuits are nightmarish. In the early 1950s, the Bell Telephone System introduced a new scheme for these drawings, known as the "detached contact schematic system."

The new drawing system allowed much more clearly the visualization of the circuit paths by which the circuit operated than with the previous drawing system. The labor required to make and revise drawings under this system also was substantially less than with the prior system.

In this article, the important principles of the detached contact schematic system are described.

1 INTRODUCTION

1.1 Scope and context

The scope and context of this article is circuit schematic drawing systems used in the (former) Bell Telephone System for elctromechanical telephone switching systems.

1.2 Telephone switching systems

Telephone switching systems were always "complicated", and the degree of complication escalated with each successive genre. Often a useful measure of the degree of complication of such systems, during the era of fully elctromechanical implementation, is the number of relays within a "circuit".

In manual switchboard systems, a *cord circuit* might (in the more elaborate forms) contain 8 relays. In the step-by-step dial system, a *switch* might contain up to 20 relays. In the panel dial system, a *sender* might contain almost 100 relays. In the crossbar system, a *marker* might contain almost 1000 relays.

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1.3 The circuit schematic drawing

The circuitry of any of these units was defined by the official *circuit schematic drawing*, whose identifier has the document class prefix "SD", and which accordingly was often called "the SD drawing". These were made by Bell Telephone Laboratories, which designed these circuits for use in the Bell Telephone System.

2 THE "ATTACHED CONTACT" CIRCUIT SCHEMATIC DRAWING SYSTEM

2.1 Introduction

Prior to the emergence of the drawing system described in this article, circuit schematic drawings used an approach to relays (which were the preponderant players in most switching circuits) that later (after there was another system, the one described in this article) came to be called the "attached contact" system, because of the way relays and their contacts were symbolically represented.

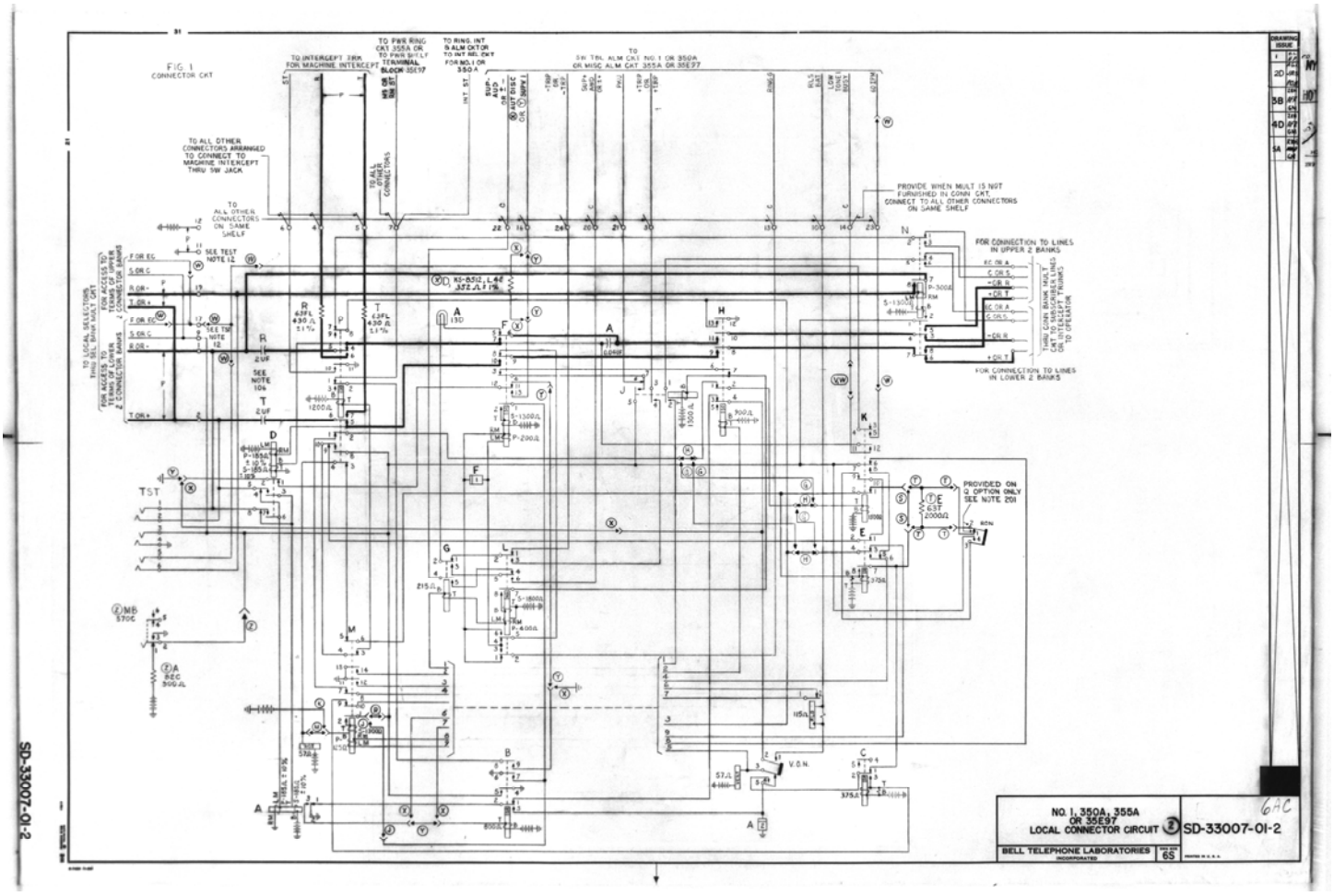

Figure 1. Step-by-step connector—attached contact circuit schematic

2.2 An example

To help put this story in perspective, Figure 1 is the main circuit schematic sheet of the actual SD drawing for a certain type of switch used in the step-by-step switching system. It is a "connector"—the last switch in a connection "train".

Within the entire realm of telephone switching systems, this is a relatively-simple unit. It consists of only 13 relays and 3 electromagnets, plus few resistors, capacitors, and such.

Don't worry about the component symbols—I'll come to that soon. But you can probably already see that to follow the circuit paths that, for example, operate each of those relays will take a full box of colored pencils, many hours of pondering, and perhaps a few fresh copies of the drawing.

Imagine how this would work out for an equipment unit with about 100 relays—or more.

2.3 A typical relay

I will digress for a bit to, by way of background, show in Figure 2 a relay of the family used almost exclusively in the "step-by-step" telephone switching system.

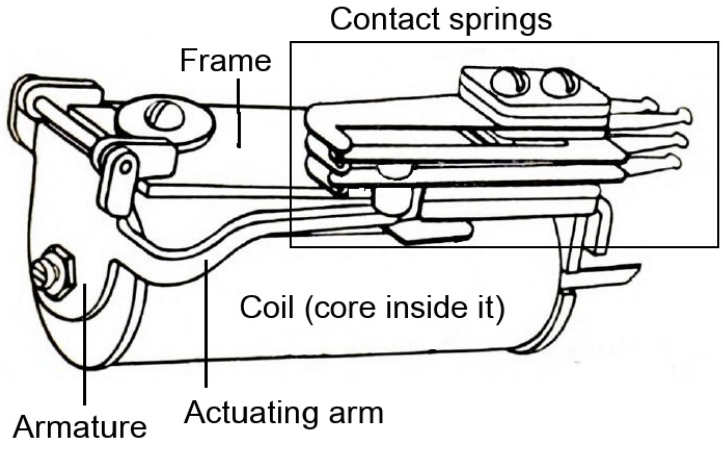

Figure 2. Typical step by step system relay

It is a very old design, actually "inherited" by the Bell Telephone System from an "outside the family" manufacturer.

The cylindrical object is the coil, wound on a steel core. The steel frame completes the magnetic circuit through the armature. On the upper right, we see the contact springs (5 of them in this particular type).

When the coil is energized, the magnetic force created pulls the armature toward the left tip of the core. As the armature rotates, its

actuating arm, through an insulating stud at its tip, pushes up one of the contact springs, making its contact button separate from the contact button on the (fixed) spring below it, thus opening that "contact" (which was closed with the relay idle). Then its contact button contacts that on the (fixed) spring above, closing a second contact.

That moving spring in turn, though another insulating stud, moves up another spring, closing a third contact.

2.4 The attached contact relay symbol

As I mentioned, it is the relay that is the major player in these switching system circuits, and its symbol is a major ingredient in this drawing system. We see an example in Figure 3.

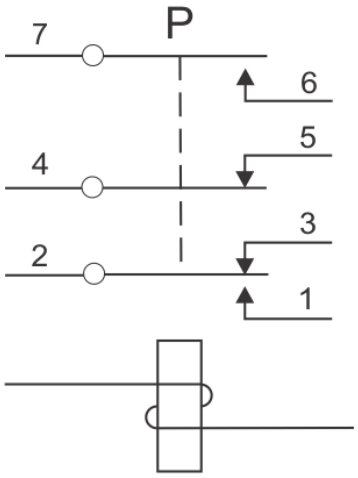

Figure 3. Basic relay symbol (attached contact form)

This hypothetical example relay is designated "P". This is not the "type" of the relay, just its identifier as a particular component in a specific circuit. Note that it is not unusually complex among the relays used in switching systems.

This symbol is essentially a caricature of the physical relay itself.

We recognize the part of the symbol for the relay core and its coil winding, the "curlicue" graphic evoking an actual "winding". Here I will refer to that overall as the "coil".

The relay has three *contacts*, each of which is composed of two or three *contact springs*, which I have identified with the numbers 1-7.

We note that all the contacts of the relay are drawn adjacent to the coil (the premise, in fact, of the moniker "attached contact"), making the relay symbol an integrated graphic unit.

The dashed line (a “ganging” symbol”) reminds us that the three contacts it “joins” are all operated by the relay coil (the movable springs—the ones without the arrow tips—being “drawn toward the coil” when it is energized) .

2.5 Contact names

In the telephone world, the contact comprising springs 6-7 is described as a *make* contact. The contact comprising springs 4-5 is described as a *break* contact. The contact comprising springs 1-3 is described as a *transfer* contact. Of course functionally is it a combination of a make contact and a break contact, with one spring common between them.

3 THE DETACHED CONTACT SYSTEM

3.1 Introduction

Aware that the existing schematic circuit drawing system (now called “attached contact”) made it very difficult to follow and understand the circuit paths, in the early 1950s Bell Telephone Laboratories developed an entirely new schematic circuit drawing system It became known (for reasons that will soon be obvious) as the “detached contact” system.

3.2 The concept

The new circuit schematic drawing system had these two major tenets:

- The contact symbols were freed from being drawn nearby the relay coil symbol. Rather, each contact could be placed wherever on the drawing allowed the various circuit paths to be most easily delineated. (This is of course the premise of the moniker “detached contact”.) Which relay each such contact was part of was indicated with the relay identifier.

- The symbols for the various contact types were simplified, much easier to draw.

3.3 The symbology

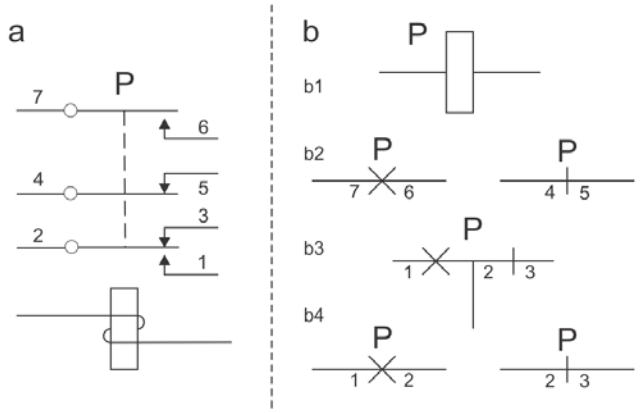

Figure 4. Relay symbols—attached and detached contact forms

In panel a we see our old friend, relay P, shown again in the "attached contact" form for reference. In panel b, we see all its ingredients drawn in "detached" contact form. Note how simple the symbols are.

At b1 we see the symbol for the coil. Note that we no longer have to draw the "curlicue" for the winding. The symbol is more symbolic, less representational.

The symbols used for the relay contacts are much different, not at all representational. At b2 we see the symbols for the make contact (springs 7-6) and the break contact (springs 4-5). These will not usually be drawn adjacent to the symbol for the coil, but placed wherever will allow the circuit paths in which they participate to be best portrayed.

At b3 I have shown the transfer contact (springs 1-3) with its two parts (the make contact and the break contact) drawn all together, which we might do if that fit in with a good layout of the circuit paths. But if needed for a desirable layout, we can readily draw its two parts separately, in different places, as suggested at b4.

3.4 When the contacts are numbered rather than the springs

In a more modern genre of the general-purpose relays used in Bell System switching circuits (called the *wire spring relay*, from a prominent feature of its construction), the contacts (rather than individual contact springs) are numbered. Thus for such relays, the contact symbols carry the contact number rather than two or three spring numbers. That does not change the principles involved.

3.5 Drawing sizes

Under the attached contact system, circuit schematic drawings were made in various sizes (often as large as 26" × 40", sometimes larger), as needed to accommodate the complexity of the circuits they described. These were physically cumbersome.

Under the detached contact schematic system, circuit schematic drawings were issued at a consistent size of 17″ wide by 11″ high. These could readily be put in a binder of that size.

Alternatively, the sheets could be given a simple "Z-fold" and be put in 8-1/2″ × 11″ binders. The fold was made such that the title block of each sheet was fully visible as one would leaf through the volume.

The consistent use of this relatively-small size for the drawings means that in many cases the drawing for a complex circuit will take more sheets than under the attached contact system. But now more often the circuit paths of interest will each be confined to one sheet, and the notations for paths that involve more than one sheet are improved, so overall these drawings are much easier to handle in their detached contact form, even if they have more sheets.

4 AN ACTUAL EXAMPLE

In Figure 5 we see the circuit of a hypothetical step-by-step connector switch (a slightly different kind than the one in Figure 1), drawn in detached contact form. This is not from an SD drawing, but from a drawing by this author to illustrate the operation of this switch in another article. The red highlight is added for its use here.

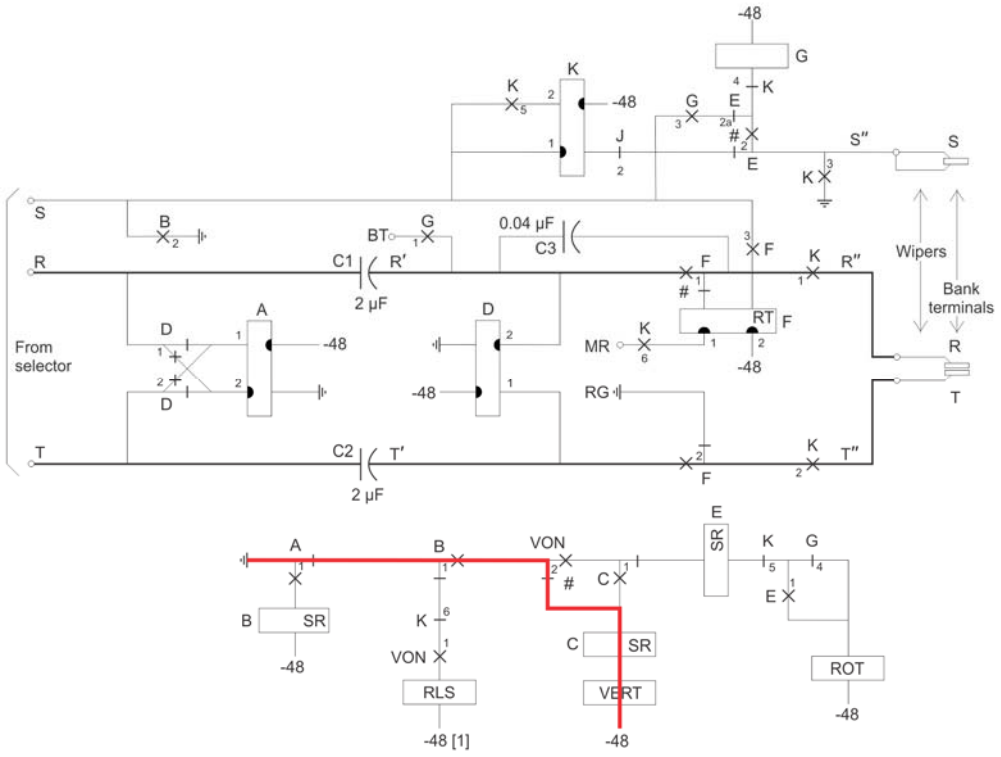

Figure 5. Typical step-by-step connector—detached contact form

We can see how much easier it would be on this style of drawing, compared to what we see in Figure 1, to see just what, for example,

controls the operation of the C relay (I have actually highlighted that path in red on Figure 5).

Note that, since this is a hypothetical switch, I have numbered the contacts (arbitrarily) rather than their individual springs, just for simplicity.

In all fairness to the comparison with Figure 1:

- This is actually for a connector switch that is not quite as complicated as the one in Figure 1 (and has a few less relays).

- Not included on this "tutorial" drawing are many "fussy" notations, included on the drawing we saw as Figure 1, covering such things as optional alternative circuitry (and which an actual SD- drawing in detached-contact form would still have).

Still, I think we can see how much easier it would be to understand the operation of the circuit from the detached contact form *vs*. the attached contact form. In more complex circuits (from which I will spare the reader), the difference would be even more pronounced.

5 DRAFTING AND SKETCHING

I referred several times to the greater ease of making schematic drawings using the detached contact system than in the prior system (the attached contact system).

This does not only apply to the "original issue" of a drawing. Suppose that the circuit design is later modified to add a certain relay contact in the path to another relay. Under the attached contact system, no doubt on the original perpetual "vellum" drawing much of the circuit path would need to be erased and lines drawn to where the new contact is. Under the detached contact system, in many cases all that is necessary is to draw the new symbol astride the existing path and properly label it.

This same fluency is equally valuable when an engineer is trying to develop a circuit by sketching (perhaps doing this on a blackboard in a collaborative group). Want to add another contact in a certain path to provide some sort of interlock function? Just draw it. No need to erase anything, or draw long and complicated lines.

6 CONCLUSION

The development and adoption of the detached contact schematic system was a gigantic step forward in making circuit schematic drawings easier to understand in the field, and brought with it substantial economies in the original preparation of the drawings.

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