Why was the Western Electric 500D telephone set not called the 500B?

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Issue 1
December 4, 2014

ABSTRACT AND INTRODUCTION

In 1950, the Bell Telephone System introduced a new family of general-purpose telephone sets, made by their internal manufacturer, Western Electric Company, called the "500 type".

In the past, the basic model of a telephone set family was given an apparatus code ("model number" to civilians) ending with "A" if the set did not have a dial and "B" if it did have a dial. But in the 500 family, the model (with dial) with which we were the most familiar over the years was designated 500D, not 500B.

This unexpected designation came about through a fascinating story of the evolution of this telephone set family in its early years—a true "war story". This article tells that story.

THE 500-TYPE TELEPHONE SET

The new family of telephone sets included numerous innovations with regard to performance, durability, ease of use, ease of manufacture, and ease of installation. Many (including this author) consider it to be the finest family of non-electronic telephone sets ever designed. And it was essentially the last such family.

Initially, the basic versions of the basic type were, following long tradition, given the apparatus codes 500A (if the set did not have a dial, as for example for use in "manual" central offices) and 500B if it did have a dial. The pair together were spoken of as the 500A/B. In fact, one could easily be converted to the other in the field, and the base unit was labeled "500A/B". But this did not last long.

THE TRANSMISSION EQUALIZER

An important innovation in the 500-type set was circuitry to automatically vary the transmitting and receiving "gain" depending on the apparent length of the individual "loop" (subscriber line). This served to compensate for the varying loss of the loops with length, so as to provide a more uniform transmission experience for subscribers located at varying distances from the serving central office. The apparent length of the loop was deduced from the level of the DC current flowing in the loop when the phone was active, as this principally depended on the resistance of the loop, which depended in a predictable way on its length.

The implementation of this behavior was very ingenious. It revolved around a component called an *indirectly-heated thermistor*, which was housed in a small glass envelope reminiscent of a small vacuum tube.

All of the DC current passing through the telephone set from the loop passed through the telephone set transmitter (”microphone”), to energize it. (It was of the traditional “variable resistance” type.) The path to the transmitter passed through a very fine tungsten filament (much like that in an incandescent lamp) located in the glass envelope. The current heated the filament. A voltage limiter across the filament protected it from extreme conditions.

The filament had a *positive thermal coefficient of resistance*, meaning that as its temperature rose, its resistance increased. Thus, for a higher loop current (implying a shorter loop), the filament heated more and its resistance rose. Since this resistance was directly in the transmitter path, the increase in filament resistance introduced more loss to the voice-frequency (“audio”) signal generated by the transmitter, reducing the overall gain of the transmitting aspect of the set.

Inside the glass envelope was a small electrically-conductive bead with two leads, made of a complex composition of elements (this was the actual *thermistor*). It was in thermal contact with the filament. This bead had a *negative thermal coefficient of resistance*, meaning that as its temperature rose, its resistance decreased.

This bead was connected in parallel with the telephone set receiver (“earpiece”). As the loop current increased, the filament temperature increased (as we earlier discussed), the bead temperature increased, the bead resistance decreased, and its shunting action on the receiver circuit introduced more loss to the voice-frequency signal on its way to the receiver, reducing the overall gain of the receiving aspect of the set. A resistor in series with the bead limited the maximum attenuation afforded (even if the bead resistance became almost zero).

The component in the little glass envelope, in a small metal housing with a terminal strip on top, was called an *equalizer* (because of course its task was to equalize the net transmission performance of the telephone set plus its associated loop over a range of loop lengths).[1]

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[1] This is of course a different use of the term “equalizer” then we find elsewhere in the field of audio engineering, where the term refers to a device whose response

This was an incredibly elegant implementation, and a gigantic effort went into its perfection (as for every aspect of the 500-type telephone set).

A simplified version of the circuit schematic of the 500B telephone set is given in Appendix A.

HEY—THERE'S A WAR ON

But shortly after the introduction of the 500-type telephone set, the US became embroiled in the Korean War, and various materials, critical to war production, were restricted in their availability for "civilian" projects. One of those restricted materials was critical to the manufacture of the temperature-sensitive "bead" in the equalizer. As a result the manufacture of the 500A/B telephone sets had to cease.

Thus, Bell Telephone Laboratories set out (rather frantically) to develop another implementation of the "automatic gain control" of the 500-type telephone set.[2]

The apparatus codes 500C/D were assigned to the new telephone sets. But the development was tedious, and it was clear that the 500C/D would not be available for a while.

IN THE MEANTIME

As an interim ploy, a new form of the 500 set was developed that just did not have the equalizer. (It was replaced by a small terminal strip so the physical wiring arrangements could be unchanged.) That meant that on "short" loops its transmission would be "too hot" in both directions (which can be problematical in various regards), so it was limited in application to loops having a certain minimum length (actually, a certain minimum resistance, as that was how the loops were administered).

These telephone sets were given the apparatus codes 500J and 500K (collectively, "500J/K"), just to stay out of the way of other suffixes that might be assigned in the natural order of such things.

The final design of the 500C/D involved the use of nonlinear resistances ("varistors") to change the transmitting and receiving gains as the loop current varied. These were actually incorporated into a

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varies with frequency so as to compensate for variations of response with frequency elsewhere in the system.

[2] Actually, there had already been concern that the cost of the equalizer was fairly high, so an alternative approach would be desirable, war restriction or not.

new form of the block that held all the transmission circuitry (the "network"), not placed in a separate "equalizer".

Once the production of the 500C/D design had "ramped up", the manufacture of the 500J/K sets was discontinued, and that design was consigned to the ash heap of history.

And that, my dear readers, is why the most familiar type of the "500-type" telephone set was designated 500D and not 500B, as we might have expected. Even more familiar in fairly recent times is the equivalent type equipped with a 12-key pushbutton-tone dial, the 2500D.

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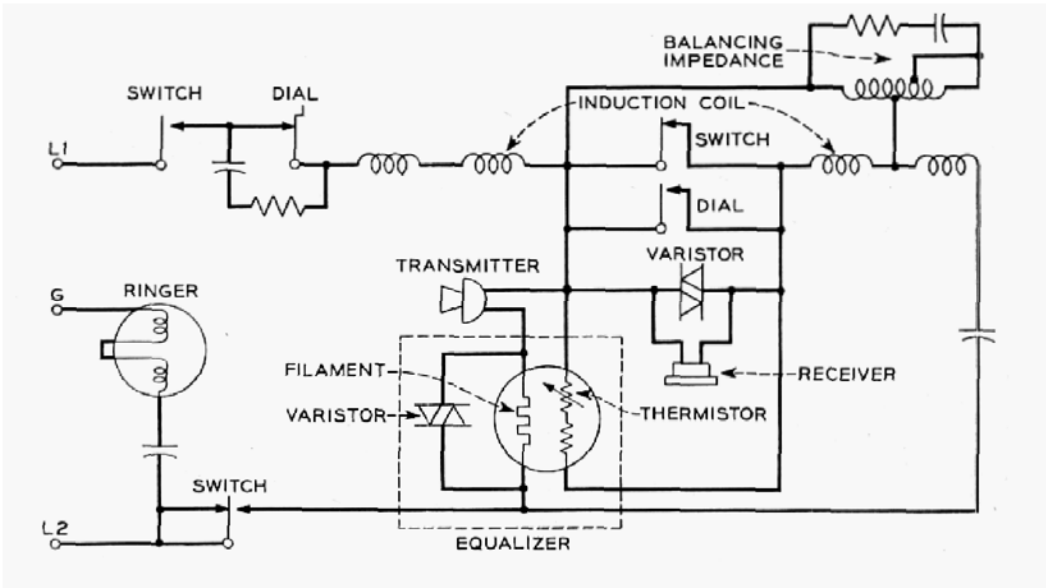
Appendix A

Simplified circuit schematic of the 500B telephone set

This is a simplified circuit schematic diagram of the 500B telephone set. It well illustrates how the equalizer fits into the transmitting and receiving circuits.



The astute reader may wonder about the apparent short-circuit across part of one winding of the induction coil (transmission transformer) near the label "balancing impedance" (which would better be pointed up to the nearby resistor and capacitor).

In fact, that last portion of the transformer winding is wound with resistance wire and thus has a non-trivial resistance. This, together with the "short circuit", is equivalent to having a small resistance resistor across that small winding portion. This in turn is equivalent to having a higher resistance resistor across the whole winding, which would provide a needed part of the balancing impedance. But using the resistance wire "trick" is less costly than using a discrete resistor.

The balancing impedance is part of the "anti-sidetone" circuit of the telephone set. This reduces the degree to which the voice-frequency signal generated by the transmitter when the user speaks is fed to the receiver (as a consequence of both being connected to the same line), a phenomenon called "sidetone".

An excess of sidetone is annoying to the user, and even a moderately-high amount causes the user to speak more softly than he otherwise would, thus reducing the outgoing speech signal level, to the detriment of the listener at the other end of the connection.

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