

computers are bad

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Let's talk about overhead paging. The concept goes by various names: paging, public address, even intercom, although the accuracy of the latter term can be questionable. It's probably one of the aspects of business telephone systems that gets the most public attention, on account of the many stories (both true and mythical) of the exploits of people who have figured out the paging extension at a given WalMart.

Some form of public address is about as old as telephony, but voice paging is a relatively new innovation. Early telephone systems relied on the microphone, more properly called the transmitter, in a telephone to create the talking current. The amount of power produced by the transmitter was very small... small enough that the volume level of telephone calls would degrade over long loops, even with the very high efficiency of the telephone receiver (speaker).

Perhaps counter-intuitively, telephone technology predates useful sound reinforcement or amplification technology. This is perhaps not so surprising, though, when you consider that telephones basically predate electronics as we think of them today, although it's more accurate to say that telephones represent one of the earliest forms of electronic technology. Early telephone engineers struggled greatly to develop amplifiers that could be used to extend the range of telephone calls. The construction of the first transcontinental telephone line during the first half of the 1910s was enabled by the invention of Lee de Forest's "Audion," the first practical sound frequency amplifier.

There was of course a problem, in that de Forest worked not for the Bell System but for his own competing company. After validating the technology, AT&T employed subterfuge to obtain ownership of the Audion technology, after construction of the First Transcontinental had begun and not that long before it was finished. Despite AT&T's guile we can thank de Forest for enabling everything from truly long-distance telephony to much of modern music [1].

Although vacuum tubes like the Audion were suitable for signal amplification, it would be some time further before audio amplifiers were developed that could produce enough power to drive a large speaker. Until that time, the electrical methods developed for the telegraph and telephone were also quite useful in the improvement of bell signal systems.

The electrically-sounded bell is surprisingly old, a direct consequence of the invention of the electromagnet in 1823. Over the following years a number of arrangements were devised for electromagnets to sound bells, and just as quickly electrical bells connected to switches were employed as a method of signaling across distances. The doorbell is a simple and common example that, in many homes, still uses essentially 19th century technology. It's hard to say when exactly, but it was probably well before the turn of the 20th century that electrical bells were used as a way to signal events in large buildings. In some cases bells displaced steam whistles for industrial timekeeping, but their smaller size and quieter operation made them suitable for environments like stores and schools, where bells became a common way to not only signal shift times but summon a manager or principal to the front office.

Electromagnetic bells were prominently used as a signaling device in telephones, and the fact that telephone wires could drive bells was a convenient one. It was common for bells to be integrated into telephone and especially interphone (internal-only telephone) systems. A store, for example, might have an interphone system that allowed the sales manager of each department to call to the telephone operator---but also bells, running from the same wiring, that sounded throughout the store to signal a manager that they were wanted on the phone. In apartment buildings, interphones were installed to connect the front door to various apartments---this is a surprisingly old technology, one that emerged naturally considering that the same wiring installed for door bells or buzzers could also support a telephone connection. Western Electric catalogs for interphone systems almost always discussed both the ways that existing bell wiring could be reused for interphones and how interphone systems could be extended with bells.

To understand these systems in the retail environment, it's useful to talk a bit about department stores. The department stores of the mid-century had more to them than what we're used to today. It's not necessarily that they were larger---the floor space of a WalMart Super Center is formidable. But in the 1930s and 1940s, undistinguished tilt-up warehouses leased from investment banks had not yet been perfected. Department stores were more substantial edifices, usually with multiple stories and a great, if not grand, staircase. Ceilings were relatively low, and interior walls far more common. These large stores were challenging environments for communication and logistics. They bred many building-scale logistical technologies like cash railways, cash balls, mail chutes, and pneumatic tubes. Most of these have not survived to the modern era, and the fate of the pneumatic tube is looking increasingly grim as robotics companies elbow into the space with solutions that are more expensive and less reliable, but require less architectural planning.

Bell systems became very popular in department stores, especially in the coded form. In a coded bell system, sequences of chimes indicate different messages. By convention, these are often written as two numbers separated by a hyphen. 2-3, for example, would indicate two chimes, a pause, and three more chimes. Other coding schemes existed as well but the n-n seems to have been ubiquitous in department stores. Unfortunately, despite being quite sure I remember finding a catalog from one of the manufacturers of these systems, I cannot figure out what company it was now. I was able to find various discussions of these systems online that confirm my recollection of how they worked; maybe I had read these originally and imagined the photos.

In any case, a typical system of the early 20th century looked something like this: at the telephone operator's position, there was a panel with a grid of holes. When a call was received with a question for a specific department, the operator would insert a peg or plug into the hole matching the code number for the sales manager in that department. The correct bell sequence would be automatically rung, repeating every so often, until the plug was removed.

Originally, these systems used physical bells placed throughout the store. As telephone technology advanced, though, it offered new ways of distributing sound. Likely the first public address system was announced in 1910 by Automatic Electric. The "Automatic Annunciator," as it was called, had to function on the most basic amplification technology and so must not have been very loud, but this didn't prevent a few large-scale installations in outdoor venues. In the two decades after, though, amplifiers improved rapidly.

Before long multiple voice address systems made it to market. The large-scale public address system perhaps reached its apex when Altec Lansing, a Western Electric spinoff best known for its theater speakers, responded to Cold War civil defense demands with Giant Voice. In the early 1960s, Giant Voice installations provided voice address across entire towns. They were so common in military applications that the term "Giant Voice" is still used on some military bases, decades after Federal Signal and Whelen assumed that market.

Voice public address systems seem to have become common in department stores by the 1940s, as companies like Magnavox and Altec Lansing had made speakers and powerful amplifiers relatively inexpensive. Voice address had the upside of flexibility, but intelligibility still wasn't that great, and overhead announcements seemed gauche in the polished environment of the department store. Coded bell systems made a transition: instead of bells distributed throughout the building, many sounded a single chime equipped with a magnetic pickup. The sound of the chime, quite clear compared to a microphone, was then amplified by the public address system.

This same concept, of a "chime" signal source directed into an audio address system, is still common today. Many school bell systems, for example, are now really an electronic tone generator connected to a voice address system. Of course the use of a tubular bell or vibratory chime struck by solenoid as a signal generator would be hard to find today.

Coded bell systems would come closer to telephone systems with time. From the 1930s, for example, Automatic Electric offered a coded bell system as an optional feature on their popular PABXs. Telephone calls could be dialed not just to phones but also to coded bell numbers, which would be rung out on a distributed bell system. Into the 1960s this feature was included on increasingly capable telephone systems.

While there was an obvious relationship, telephone and public address systems stayed mostly separate. Automatic Electric's involvement in the industry, for example, didn't last long. By the 1950s, public address was associated with companies like Bogen and Crown, not Western Electric and Automatic Electric (nor Northern Electric or any of the other Electrics, for that matter). The high power levels required for PA in large buildings required a different kind of electronics expertise.

Large-area audio systems are usually "constant-voltage" systems, with 70v being most common. Unlike a typical audio amplifier that produces only the voltage required to drive a four or eight ohm speaker, constant-voltage systems output audio at a high voltage which is decreased to a more appropriate coil driving range by a transformer in each speaker. There are a few advantages to constant-voltage audio: first, the higher voltage results in a lower current, and thus smaller wire gauge, for equivalent power. Second, most constant-voltage speakers have multiple transformer taps that allow individual speakers to be adjusted to be louder or quieter. Finally, the transformers in a constant-voltage audio system provide impedance matching, so an arbitrary number of speakers can be connected to the amplifier in parallel without the need for accommodations like a Strauss transformer.

A more traditional approach is to have one or a few amplifiers in the range of a few hundred watts that drive all of the speakers in a business. In more modern installations you will find "distributed" amplifiers, which might involve signal-level audio lines to transformers in different closets but today more often distribute the audio over IP. They have the advantage of more flexibility and less power-level wiring required. Companies like QSC make sophisticated system where multiple channels of audio and control information are distributed by IP, allowing individual zones of speakers to be switched between different audio streams under network control.

There are a few ways of connecting the input to a PA system. Most PA amplifiers offer some variation on a two-input scheme. One input, sometimes called "program," is connected to a background music source like an audio player or the streaming appliance provided by a background music service like Mood Media. The other input, often called "page," has a special property: when an input is detected on the page input, the program input will either be muted or ducked (attenuated to be quieter). The page input thus overrides the program input, perfect for making occasional announcements over the overhead speakers.

But where does the page input come from? It could be a microphone, and you do see this in some

smaller businesses. But in most larger environments, the phone system is an obvious way to provide paging. Many business PABXs have a line-level paging output as a standard or optional feature. When a dedicated paging feature isn't available, there are specialized devices that act as an extension phone that immediately answers and provides a line-level output. The line-level output from the phone system goes to the page input of the PA amplifier, and you now have an overhead paging feature.

Increasingly common today are all-IP paging systems. Some of these use more audio-centric approaches based around UDP streams or RTP, but the telephone industry prefers a SIP-based solution in which paging speakers are essentially just weird-shaped phones. These have the advantage that the paging speakers can be PoE devices installed by the networking contractor, without the need to bring in an audio systems integrator. Despite these ostensibly being IP phones and pretty much always having the ability to act as a SIP endpoint, they usually also accept multicast RTP streams. For that matter, most IP desk phones can also accept a multicast RTP stream for paging purposes. Finally, telephone and distributed audio systems are converging.

This whole thing has really been burying the lede, though. If the overhead paging is an output from the phone system, how do you "call" it? What most people want to know are the paging codes at the WalMart.

Well, it's hard to say exactly, because it depends on the specific phone system and the way it's configured. In some cases the paging output of the phone system is just a special extension number. Even when it's not, there can often be an extension assigned as a convenience.

Nearly all business phones will have some number of buttons, variously called line keys, BLFs, multifunction keys, etc. depending on the manufacturer and system. On modern phone systems the idea is pretty much the same: they can either be assigned to a line appearance (a "line" on the phone with which you can place a call) or to a feature, like a speed dial, voice mail, or paging. In a lot of offices where paging is used, one of the line keys will be assigned for paging, and all you need to do is pick up the phone and press that button.

In stores, though, that's usually a little too easy. Stores often have phones out on the floor where they're not very well secured, and people are tempted to experiment with them. This leads to a certain degree of obfuscation.

Sometimes paging will be a simple extension. Internet commentary and experience suggest that "4444" is common in some chain stores. Another approach is to assign paging to a feature code, a somewhat vaguely defined concept that generally means a number starting with * or #, like #968. These are just a matter of configuration, although some PABXs might limit your choices to one or the other. There are undoubtedly some chain stores that exercise complete central control of telephony (perhaps Target?), but this doesn't seem to be all that common. The way you page varies from store to store, depending on the phone system installed, corporate practice at the time, and the whims of the integrator that installed it.

Overhead paging is sort of dying out in retail, as a lot of stores have gone to radio systems. Fred Meyers, of my native Portland, seems to have been an early adopter of fully-addressable radio systems. By the late 2000s, they were issuing DECT handsets to nearly all employees and making full use of DECTs surprisingly good support for large systems. More recently, Walgreens is adopting an IP-based wireless communications platform called Teatro (basically a competitor to Vocero focusing on retail rather than healthcare). Oddly, some of the largest retailers just stick to handheld radios on MURS channels.

There's still a bit of an overlap to our main topic here, though. It's surprisingly common for

older retail overhead speaker systems to have a radio receiver of some sort on a page input to support "push for help" buttons. Many of the older products of this type are really just MURS radios that transmit a prerecorded message whenever the button is pressed. Of course, this means you don't even need to find a phone and figure out the extension to make your own announcement... you just need to figure out the MURS channel and squelch code.

[1] Incidentally, similar work on vacuum tubes was being performed by Irving Langmuir, who was ahead of de Forest on manufacturing techniques but a bit behind him on the electronic principles. Langmuir's research into electrical physics formed the basis of later work on lightning by E. J. Workman, the most prominent historical president of my alma mater New Mexico Tech. Workman founded a laboratory to research atmospheric phenomenon, operated by Tech and adjacent to the observatory that briefly employed me. It is the closest thing I have ever seen in real life to a mad scientist's mountaintop lair, being equipped to literally draw down lightning. It is named the Langmuir Laboratory in Langmuir's honor. This satisfies my target of relating everything I write to some piece of New Mexico trivia.