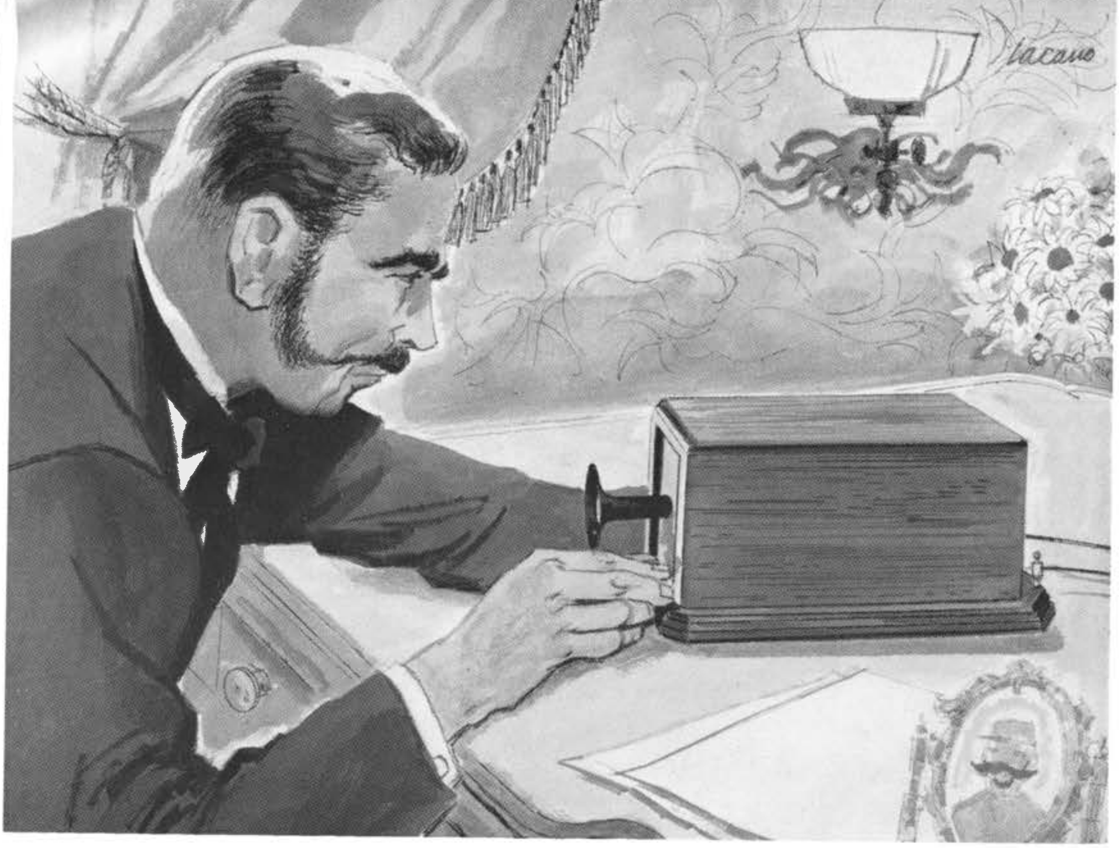

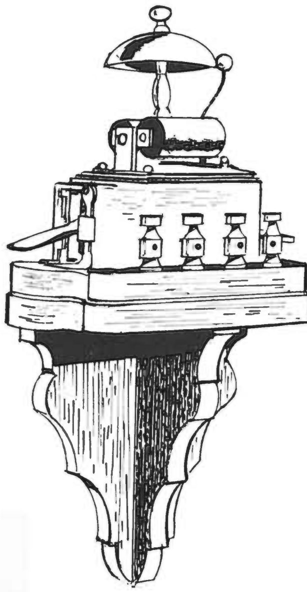

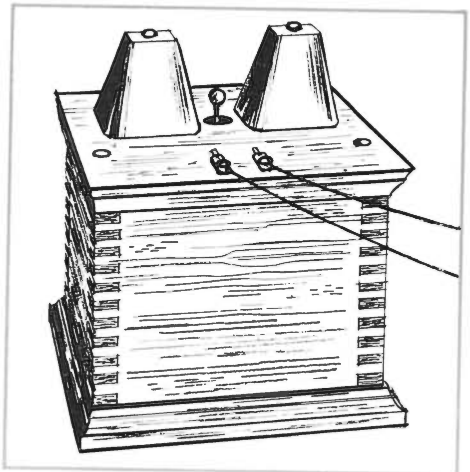

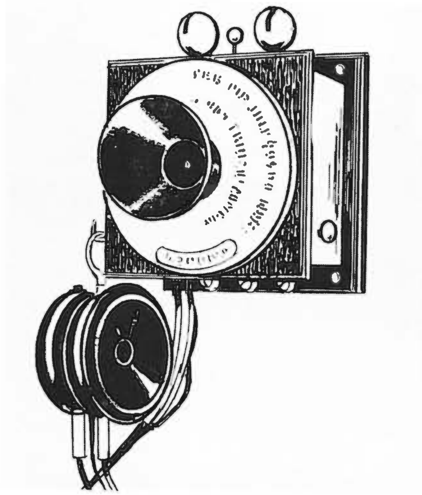

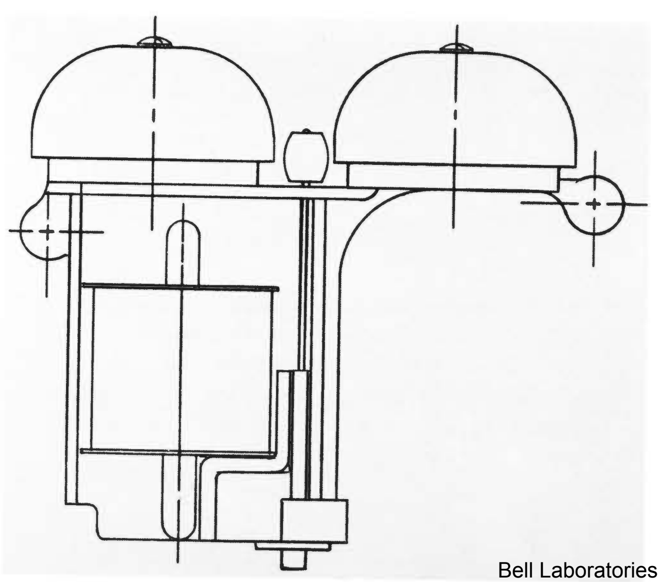

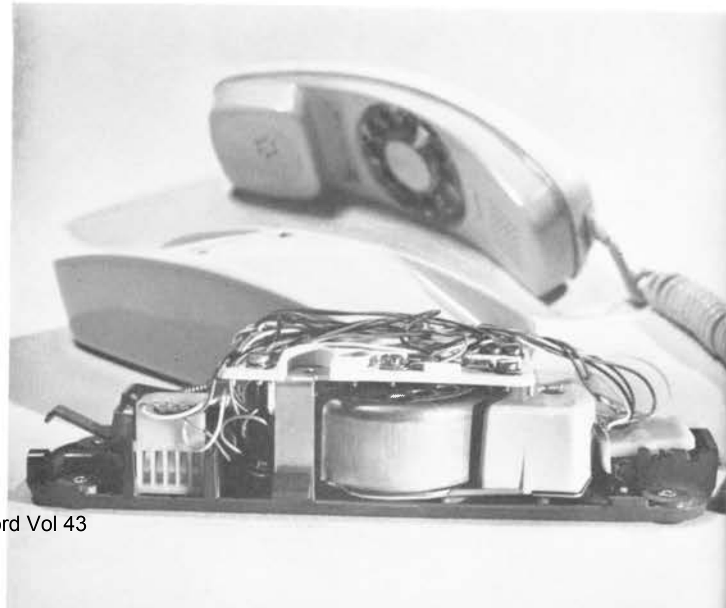

The purpose of a telephone ringer is to attract attention. The challenge of designing effective ringers that are compact enough to fit in the new smaller telephone sets is being met successfully at Bell Laboratories.

Designing Telephone Ringers

R. A. Spencer and C. W. McGee

OVER THE YEARS the telephone ringer has evolved into a far more sophisticated device than the simple bell it once was. The first telephones, in fact, had no signaling device at all. Before 1878 there were no central offices, and the line between two phones was always open. The caller simply shouted into the mouthpiece to attract the other party. Words ending with long sounding vowels, like "Ahoy!", seemed to carry best. Another word often used was "Hallo!", which later, transformed to "Hello", became one of the first words the telephone industry contributed to our language.

Another way to signal the called party before 1878 was to thump the center of the diaphragm inside the mouthpiece with a pencil. If the other party did not answer, the caller simply struck the diaphragm a little harder. Thomas Watson, Alexander Graham Bell's telephone designer and engineer, soon realized that he would have to modify the phone because the diaphragms were inevitably broken by this abuse. Inside his next telephone set, called the "Thumper", Watson mounted a small hammer to strike the edge of the diaphragm where it was attached to the outer box. Here it was safer from the limited force of the hammer, which was activated by a knob outside the box.

The 1877 telephone (upper left) had the first telephone signaling device, the "Thumper," from which it derived its name. Among the most interesting ringers to evolve later were the single-gong type on the Doolittle Secrecy Switch Subset (1897), the "sleighbells" of the Touraine set (1890's), and the bell-shaped gongs of the "No. 48" subset (1910). Today the workhorse of the Bell System is the C4A ringer (lower left), used in the 500 set. The Trimline® telephone contains the newest ringer design, the P1A type.

Customers soon wanted a better signal, however, and Watson obliged with the "Watson Buzzer". The Buzzer was louder, but its harsh rasping sound, somewhat like the grating shriek of the mechanical automobile horns used then, did not win the public's favor. In 1878 Watson patented his two-gong bell, or ringer, and designed the hand-cranked magneto to power it. Excluding several short-lived changes—such as the use of wooden gongs—this type of signal has survived in basically the same form through many telephone set designs. In recent years, however, many types of ringers have been designed, each to serve a different need in the expanding family of telephone sets. Although all ringers used in the Bell System must meet certain electrical requirements, other variables such as size or loudness vary so that each model can best meet its particular application.

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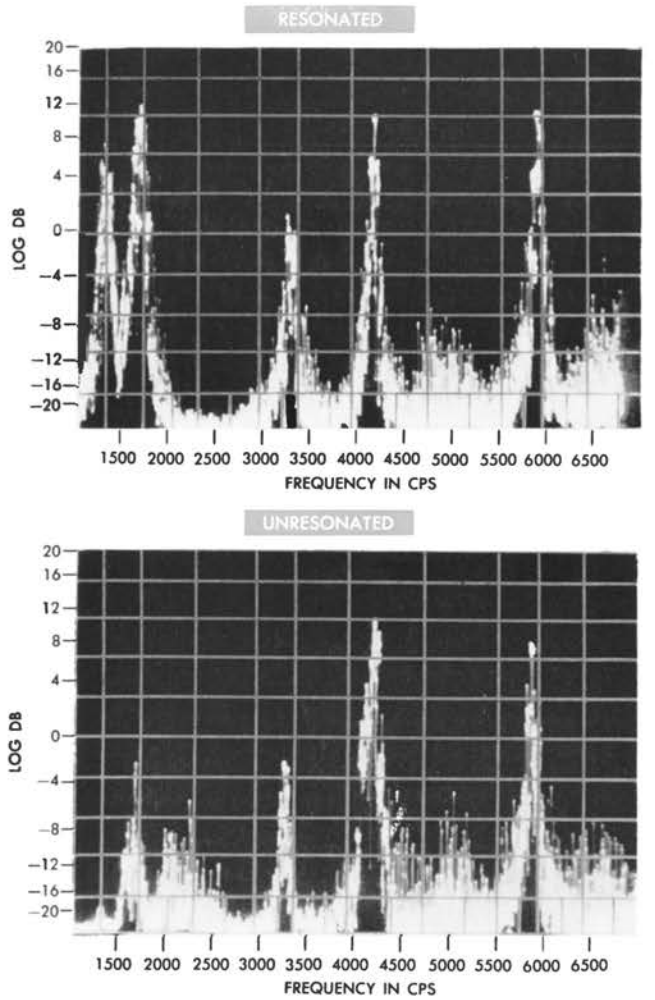

These oscilloscope traces show how a resonator amplifies the fundamental frequencies (1280 and 1610 cps) of the two gongs in the C4A ringer. The harmonics are not significantly affected.

The tonal quality and the loudness of each ringer's signal usually depend upon the size, shape, and number of gongs struck, as well as the force with which the clapper strikes the gongs. The effectiveness of a ringer as a signal, however, depends not only on its loudness, but also on the parts of the frequency spectrum at which the sound is concentrated. Usually the fundamental frequency of a ringer gong is amplified by an integral resonant air chamber, which increases the energy at that frequency. The gong of a ringer for general use, for example, is designed so that its fundamental frequency is between 1000 and 1500 cycles per second, where hearing is most acute. This frequency is then resonated to a level that can be heard above the usual room noise (see figure above).

A smaller ringer, the G type, is being used in several telephone sets—Data-Phone sets, certain coin phones, and Card-Dialer® sets—because of space considerations. The reduction in ringer size yields valuable space for other components. The gong of a G-type ringer is shaped like a square cup, providing the largest gong area in the smallest volume. Slots in the top of the G1B gong increase the resonance, or persistence, of the gong's tone.

The trend to smaller telephone sets for the customer has led to a constant effort to reduce the size of customer telephone components, including the ringer. Both the M1A ringer of the Princess® set and the P1A ringer of the Trimline set produce a signal suitable for general purpose use in spite of their small size. The gong of the P1A ringer, a cylindrical cup, doubles as a protective housing for the ringer motor, which is mounted inside the gong.

The volume and mounting area required for the latest designs of miniature ringers probably approach a practical minimum for general purpose mechanical ringers. If mounting space for ringers becomes more restricted, the electronic tone ringer may be the answer. All the various models of electronic ringers designed in recent years have been more expensive than their mechanical counterparts. As size becomes more important, however, the use of a tone ringer may be justifiable. More design flexibility is possible with the electronic tone ringer, which is about the same overall size as the miniature ringers, because it consists of several subassemblies which can be optimally placed: the sounder is mounted where it radiates the loudest signal, the volume control is located where it is most convenient and attractive, and the electronic components can be packaged to take advantage of the spaces between the components whose locations are relatively inflexible.

The output signal of the tone ringer has been set at the level and frequency spectrum that will alert the majority of people. This signal consists of several well separated frequency components between 700 and 3000 cycles per second.

Thus far this article has emphasized the progress made in reducing the size of ringers while maintaining an adequate signal. But however important these considerations may be, the designer cannot permit himself to concentrate on ringer size and sound level to the exclusion of all other design variables. Maximum sound output, for example, is achieved from the available operating power only when the mechanical and magnetic forces in the ringer are carefully balanced. Thus the designer must consider even the orientation

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Co-author C. W. McGee uses a "sound integrator" to analyze the frequency spectrum of an electronic tone ringer for persons with impaired hearing. The output from four microphones mounted on the rotating frame is continuously monitored by spectrum analyzers.

Co-author R. A. Spencer and J. D. Zimmerman are recording the sound output of an extra loud ringer for detailed analysis later. Some larger ringers, such as those used for signals outdoors, are mounted on the wall in the background.

Each ringer is carefully adjusted during manufacture at Indianapolis. These M1A ringers will be used in Princess telephones.

of the ringer in the telephone set. Most ringers are designed to be mounted on a telephone base with the armature and clapper moving in the horizontal plane. If a ringer is mounted vertically, as is required in some wall-mounted sets, it must be properly positioned so that it will meet its original operating requirements.

Several indispensable ringer features add to its sophistication. The ringer must be able to "recognize" and respond to the ringing voltage sent by the central office, and it must ignore all extraneous voltages. During dialing, for example, the effective voltage across the ringer alternates between 48 volts (central office battery voltage) and about 10 volts (when the dial pulsing contacts are closed). These fluctuations of nearly 40 volts occur ten times per second (the dial pulsing frequency) and could cause the calling telephone and any of its extension phones to "dial tap." This effect is prevented by a permanent magnet which polarizes the ringer motor, thus prohibiting the ringer armature from responding to these spurious voltage pulses.

The volume control is probably the ringer feature that is most familiar to the customer. Generally the volume control restricts the armature motion in varying degrees so as to reduce the energy imparted to the gong by the clapper ball. Mechanically damping the gong or allowing the clapper to strike only one gong of a two-gong ringer are two other methods sometimes used in addition to limiting armature motion. A mechanical stop on the volume control normally prevents the customer from completely silencing the ringer, but the installer can remove this stop if the customer wants to silence the ringer in an extension phone.

Selective ringing, another sophisticated ringer feature, is used to ring, or call, only one party on a multiparty line. A diode is wired in series with each of the phones in the ringing circuit. The central office superimposes a dc biasing voltage on the 20 cycle ac ringing voltage. Only one party's phone will ring if the diodes are oppositely polarized; i.e., one diode will conduct the ringing current to its ringer if the central office sends a positively biased signal, and the other diode (and ringer) will respond only to a negative bias. Four party selective ringing is possible if two phones with diodes are part of the "tip-to-ground" circuit of the central office, and two other phone-diode pairs are included in the "ring-to-ground" circuit. If, for example, the positively-biased phone in the tip circuit is called, relays at the central office automatically connect the 20-cycle ringing generator to the tip circuit and ground the ring circuit.

The normal ringer circuit includes a high impedance coil connected in series with a capacitor. The values of these elements are so chosen that the 20-cps ringing current is conducted with very little resistance, but all higher frequencies are blocked by a high impedance. In other words, the circuit is designed to be approximately "series resonant" at the ringing frequency. Therefore little of the voice frequency talking current from the phone is shunted through the ringer coil-capacitator combination, which if permitted to happen would cause the transmission to drop.

Each new ringer design must thus meet many different specifications. The ringer must respond only to the ringing current from the central office; it must even ignore ringing current meant for another phone in the same circuit. The ringer must attract the attention of the called party; its signal must be loud enough and concentrated in specified frequencies. Like other telephone components, the ringer design must be durable, reliable, and economical to manufacture. To demonstrate these features it must pass exacting life and environmental tests. And finally, the size, shape, and weight of the ringer must be compatible with the overall set design. Meeting this specification without sacrificing any of the other requirements is often the designer's most challenging task.