The Type 82 "DIAL-LIGHTED"

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Most home subscribers, when ordering a "second telephone," want it installed in the bedroom. They appreciate the convenience and the feeling of security that comes from having a telephone right at hand all night long. We have learned, too, that they appreciate in this location a telephone having a dial with a light, so they can answer or dial familiar numbers without turning on the room lights and disturbing others. It was these facts that led us to start work on a development program which eventually resulted in the Type 82 "Dial-Lighted" Telephone.

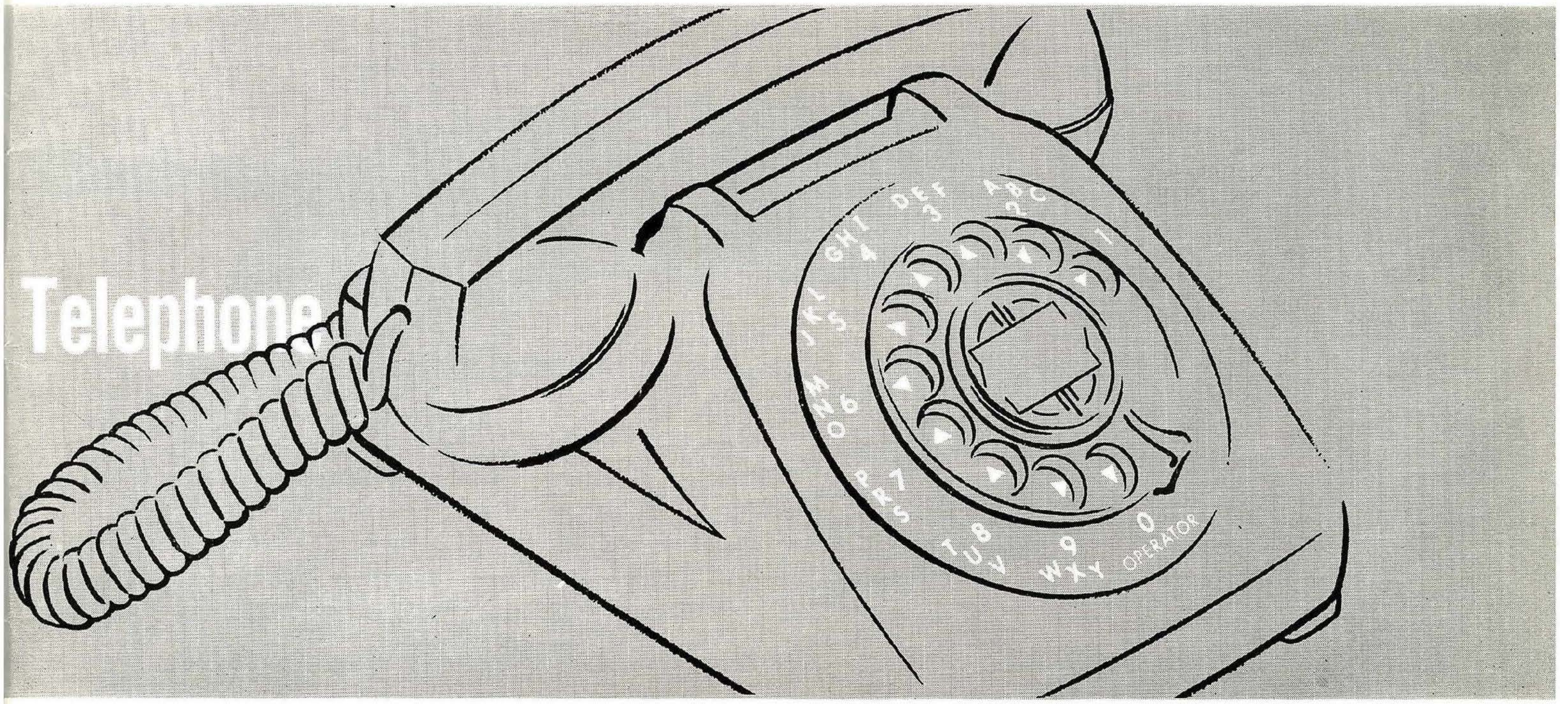
"Electroluminescence"

It was in June, 1956, that we learned of a promising light source for this purpose. This was a radically different kind of illumination, known as "electroluminescence." No white-hot filaments, nor arcing, nor activating rays were needed. We learned that this new light source compared visually with phosphorescence and fluorescence, but that instead of cathode rays or ultra-violet light, it requires simply an alternating current to excite electrons into energy-level changes that produce light over a desired area.

Thus, we learned, electroluminescence is an "area source" of light, that is basically simple and versatile. To make other sources of light into "area" sources, diffusing equipment is needed; this complicates the design, and reduces the overall efficiency of the system. This promising new light source, however, would glow uniformly throughout its area—require no diffusion.

Since no one had previously used electroluminescence as we hoped to use it, we began studies and experiments to learn whether or not it really was a feasible light source for dial illumination. We learned that, although the physics of light production of this lamp is a bit more complicated than that of its forebears, the fundamental requirements are quite simple: a phosphor which is sensitive to direct excitation is merely placed in a fluctuating electric field.

Commercially to produce an area source using this principle, the phosphor is suspended in a dielectric medium. This suggests the evolution of a light-producing "capacitor"—essentially an alternating-current device. In order to allow light to be emitted from this capacitor, at least one of the plates must be transparent; this requires an electrically conductive coating which is also transparent.



Construction of the Lamp

The lamp used in the Type 82 "Dial-Lighted" Telephone combines ruggedness, resistance to humidity, long life, compactness, light weight, and acceptable efficiency in converting electricity to light. As shown in Figure 1, the "backbone" of the lamp is a flat steel sheet (A), with all holes for mounting or use punched into it before further processing. One electrical connection (A-1) is made to this steel sheet, which serves as one "plate" of the "capacitor" and provides mechanical strength and rigidity to the completed lamp. Two "ground-coat" layers of solid ceramic material (B), similar to white porcelain, are fired onto this base sheet. Next is applied another layer of ceramic material (C), in which is suspended the electroluminescent phosphor. It is this layer that serves as the fundamental dielectric of the "capacitor," and emits light.

A transparent, electrically conducting layer (D) is then applied to the dielectric phosphor coating (C); an electrical connection (D-1) is made to this layer, and it serves as the other plate of the "capacitor." Finally, a layer of transparent glass (E) is applied over the electrically conducting layer, to protect the lamp from the effects of humidity and mechanical damage, and to provide an insulating outer surface. The total thickness of all the coatings applied to the metal backing is less than 0.020″; the total thickness of the lamp approximates $\frac{1}{32}$″.

Electroluminescent lamps can be made for various voltages and frequencies, but those designed for use at higher voltages and frequencies also give brighter light. (Naturally, the voltage rating of the lamp is dependent on the dielectric strength of the dielectric which contains the phosphor.) We therefore chose to use lamps operating at 110 volts—standard commercial power. The efficiency with which the power is converted into light, and the color emitted by the lamp, are dependent almost exclusively on the phosphor used; we adopted the most efficient lamp, which happens to be green.

One final question concerned us—what would be the probable working life of this new lamp? We found that, as an electroluminescent lamp is fundamentally a capacitor, it will fail when subjected to conditions which would cause a capacitor to fail—excessive voltage, or operation beyond design conditions. There are no filaments to fail, no gases to contaminate, and no emissive material to be consumed. In fact, the life of the lamp is meas-

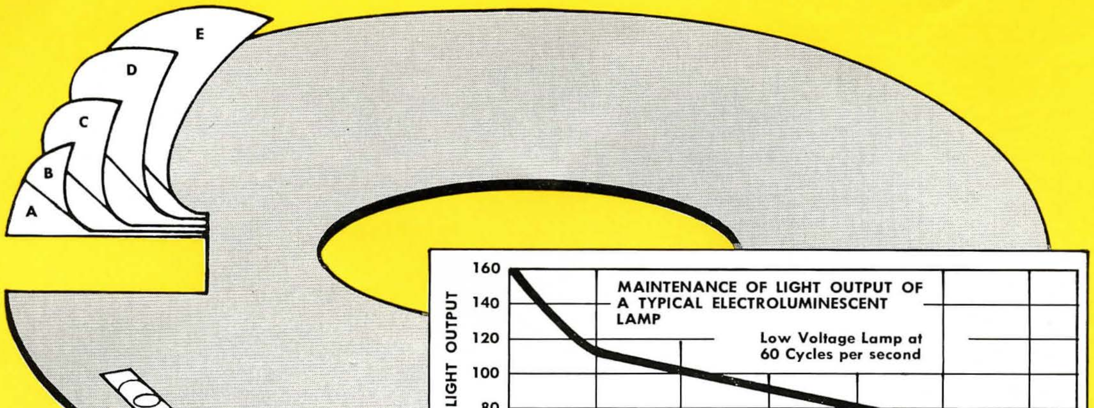


Figure 1. Electroluminescent Lamp

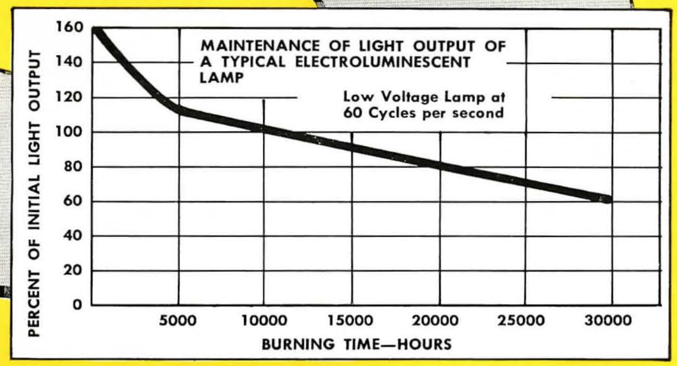


Figure 2. Lamp Output Chart

ured in years of continuous operation; however, its light output *does* gradually decrease, as shown in Figure 2, and the practical end of its life will be at the time that its brilliance becomes inadequate for the use to which it has been put.

Having decided that the electroluminescent lamp was the most straightforward approach to the design of a "dial-lighted" telephone, we still had three major problems to work out:

1. Designing a suitable number-plate for use with an electroluminescent lamp as a source of back-lighting.
2. Mounting the power components within the housing of the Type 80 Telephone.
3. Meeting the requirements of Underwriters' Laboratories as regards isolation of the commercial power within the telephone. UL listing of the complete telephone was mandatory.

Designing the Number-Plate

Since our standard number-plates are molded with characters of opaque Tenite II, we thought of substituting a transparent Tenite II, through which the back-light would be seen. But we realized that this would not provide contrast required with the background for easy visibility in daylight—and especially not with telephones of all the standard colors in which the Type 82 Telephone was to be offered.

The number-plate we adopted starts with a transparent acrylic blank; this is sprayed with white paint—a layer thin enough to be translucent when back-lighted, but opaque otherwise. Then, using a mask to produce the desired characters, it is sprayed with one of the telephone colors. The paint is oven-hardened to an extremely durable, abrasion-resistant finish; when assembled into the telephone, the final plate is identical in appearance to a standard number-plate. In semi- or complete darkness, the characters are back-lighted by the electroluminescent lamp, and glow with its green color.

Mounting the Power Components

We thought of two ways of powering our lamp: (1) converting the 50 v., d.c., telephone power to 110 v., a.c., using a small transistorized oscillator for this purpose; (2) using the 110 v., a.c., power source in the home, through a power cord on the telephone. The transistorized oscillator would have had the attraction of comparative novelty, and permit location of the telephone without reference

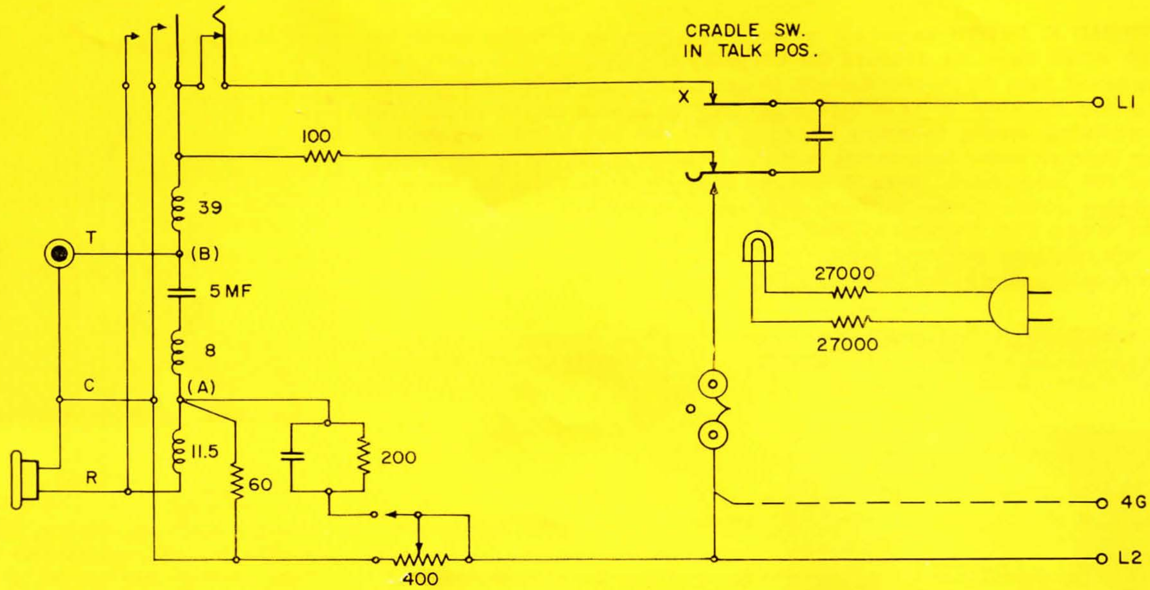


Figure 3. Power Circuit

to external power. However, we realized that it would be a continuous drain on the line, which would contribute to the total leakage and thus impair dialing, cause ringing difficulties, and nullify the advantage of using high-impedance ringers. This idea was therefore discarded, and we adopted the power-cord arrangement.

Isolation of the power circuit from the telephone circuit was begun by providing separate entrances for the two cords, and a special bushing which provided both insulation and strain-relief of the power cord at the point of entrance. Inside the telephone, care was taken to insure physical separation of the two circuits, with at least 1/8″ through air, and 1/4″ over the surface of insulation, between them. All spade terminals are designed to prevent them from turning or being pulled off if the terminal screws should become loosened slightly.

Finally, isolating resistors are provided in the power circuit (see Figure 3), so that no more than 5 milliamperes can be delivered, even under short-circuit conditions. (This is not only a safety feature; it also protects the electroluminescent lamp by damping out any transients which may occur, and thus extends its life.) All live parts are especially guarded, at the resistor assembly.

The Type 82 "Dial-Lighted" Telephone is listed by Underwriters' Laboratories; wiring bears the UL label, and the distinctive type number, together with the voltage and current rating, is printed on the bottom of the set. This listing was not obtained until after the Underwriters' Laboratories had conducted input, temperature, current measurement, and dielectric strength tests, and had completely examined constructional details of the set.

Light Output

The Type 82 "Dial-Lighted" Telephone will operate continuously for a full year at a cost to the subscriber of less than a nickel. Its light output is only about one foot-lambert (for comparison, the brightness of a TV screen is 15 to 20 foot-lamberts)—and this is admittedly too little to be visible in a brightly lighted room. In total darkness, however, the normal human eye becomes 50,000 to 150,000 times more sensitive to light, within ten to twenty minutes. Thus, the user of the Type 82 "Dial-Lighted" Telephone who will allow a reasonable time for his eyes to become accustomed to the darkness will find that the dial provides very adequate light—and without lighting any other part of the room.