



Developed by Bell Laboratories with Henry Dreyfuss as industrial design consultant, the TRIMLINE telephone is the evolutionary result of painstaking human factors studies and component design.

The Evolution Of A Telephone

C. L. Krumreich and L. W. Mosing

IN APPEARANCE, the TRIMLINE® dial-in-handset telephone is unlike any other telephone manufactured for the Bell System. Functionally, though, its purpose is the same—to extend human conversational range by permitting direct oral communication between two people over some geographic distance. Fulfilling this function successfully requires that the telephone be compatible both with the human user and with the Bell System communications network.

Human factors studies, a large part of the development of the TRIMLINE telephone, specified its characteristics in relation to the user; extensive component redesign made possible the realization of these characteristics. Human factors studies showed the advantage of placing the dial and recall button in the handset, for example, but components designers made the convenience a reality by developing smaller and lighter versions of the standard receiver, dial, and speech circuit. Although the TRIMLINE handset contains many additional components, it is no

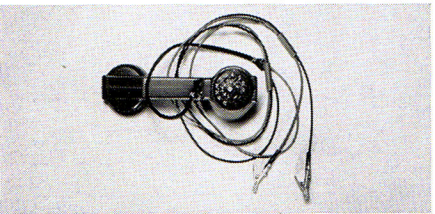
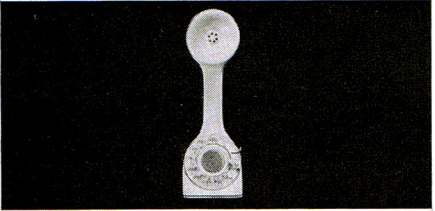
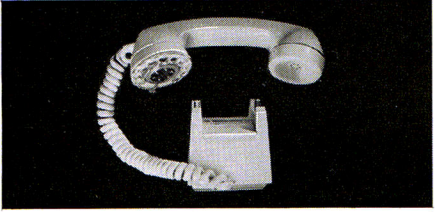
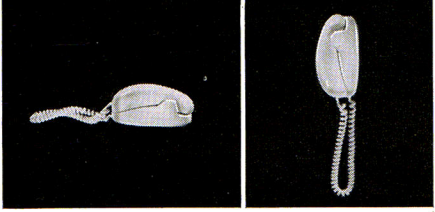
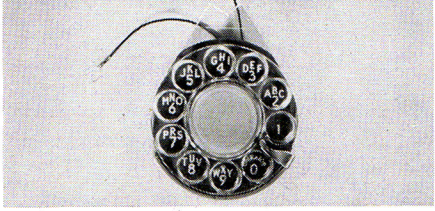
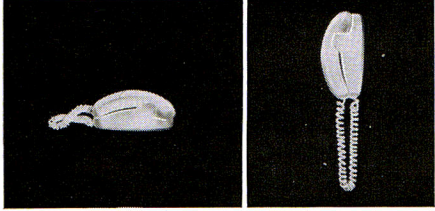
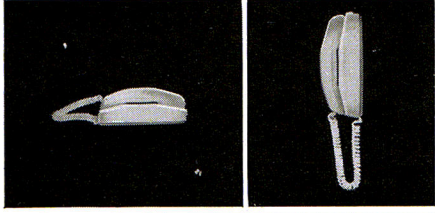
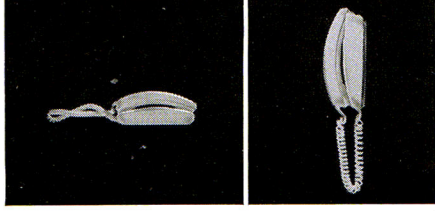
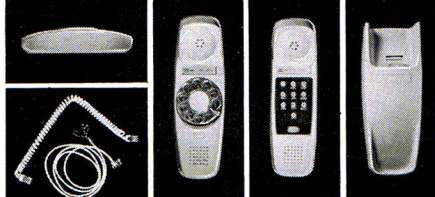
Production will start at Indianapolis this year on the newest member of the TRIMLINE set family, with TOUCH-TONE® calling, depicted here.

heavier than the original G-type handset of the 500-type telephone, familiar to most customers.

Many other innovations in the design of the internal components helped make the TRIMLINE telephone esthetically pleasing as well as easy to hold and use. This article traces the evolution of the TRIMLINE telephone and discusses the advances in components technology and the human factors studies which brought the set through many preliminary models to its final design.

The first “dial-in-handset” was developed for telephone craftsmen in 1939. This lineman’s handset had a talk-monitor switch in the handle and a small dial mounted behind the receiver. It was fine for its purpose because the lineman could hold the whole set in one hand. But the bulky and unattractive lineman’s handset was quite obviously not designed for customer use.

Thus the evolution of the TRIMLINE set for the public really began in 1952, with an experimental dial-in-handset designed at Bell Laboratories. This first model was a one-piece telephone that stood vertically on its base, with a small dial located in front of the mouthpiece (see photograph on the next page). Setting the phone down after a call depressed a switchhook under the base. This

DATE		NAME	DESCRIPTION
1939		LINEMAN'S HANDSET (1011B)	A SOFT RUBBER HANDSET WITH A SMALL DIAL (103A) MOUNTED BEHIND THE RECEIVER PORTION AND A TALK-MONITOR SWITCH ON THE HANDLE.
1952		ONE-PIECE DIAL-IN-HANDSET	EXPERIMENTAL DESIGN OF A ONE-PIECE VERTICAL DIAL-IN-HANDSET WITH SMALL DIAL SUPERIMPOSED ON THE TRANSMITTER AND A SWITCH-HOOK BENEATH THE BASE. REQUIRED AN EXTERNAL RINGER.
1957		DEMITASSE	A G-TYPE HANDSET, MODIFIED BY SUPERIMPOSING A 4/5 SIZE DIAL ON THE TRANSMITTER CAP, CRADLES ON A SMALL CUBE-LIKE BASE. REQUIRED AN EXTERNAL RINGER.
1958		DIH (SHMOO)	AN 8-TYPE DIAL IS INTEGRATED BETWEEN TRANSMITTER AND RECEIVER WITH A DIAL-NIGHT LIGHT. CAN BE USED AS EITHER A DESK OR A WALL SET AND REQUIRES AN EXTERNAL RINGER.
1959		SPACE-SAVER DIAL	A MOVABLE FINGER STOP ELIMINATES THE NEED FOR THE SPACE BETWEEN 1 AND 0, RESULTING IN A SMALLER DIAL WITH STANDARD SIZE FINGER HOLES.
1960		CONTOUR	CAN BE EITHER A DESK OR WALL SET INCORPORATING A SPACE-SAVER DIAL IN HANDSET, DIAL-NIGHT LIGHT, AND A MINIATURIZED RINGER IN BASE.
1960		Trimline I	INCORPORATES SPACE-SAVER DIAL IN HANDSET WITH A DIAL-NIGHT LIGHT. HAS A MINIATURIZED RINGER IN BASE AND CAN BE USED AS EITHER A DESK OR WALL SET.
1963		Trimline II	SPACE-SAVER DIAL, DIAL LIGHT, RECALL BUTTON, TRANSMISSION NETWORK, TRANSMITTER AND LIGHTWEIGHT RECEIVER IN HANDSET, WHICH IS USED WITH SEPARATE DESK AND WALL BASES CONTAINING MINIATURIZED (M-1) RINGERS.
1965		TRIMLINE	PRODUCTION MODEL SIMILAR TO Trimline II WITH RECALL BUTTON RELOCATED. INTRODUCTION OF PLUG-IN HANDSET AND LINE CORDS PROVIDES FLEXIBILITY IN STOCKING AND ASSEMBLY OF DIAL AND TOUCH-TONE TRIMLINE SETS.

one-piece phone required an external ringer. Although the dial-in-handset idea attracted considerable interest, the large postwar demand for telephones delayed any further consideration of a new telephone set at that time.

Each new dial-in-handset telephone model since this first one has incorporated new ideas and devices, and each has benefited from the designers' experience with its predecessors. For the design of a new telephone is an evolutionary process. A closer look at this procedure should illuminate the details of the evolution of the TRIMLINE telephone.

A cyclical process characterizes the evolution of the shape and operating features of a new telephone set. The three recurring phases of the cycle could be labeled design, development, and evaluation. The designer first incorporates his new ideas in wood or plaster models; then operating sets are developed from the most promising preliminary designs for user evaluation in both laboratory and field studies. The process is repeated until the refinements suggested at each stage are incorporated into a final design.

In the first step the designer's thoughts are like an artist's first rough penciled sketches. He invents what will become the new set's distinguishing functional and esthetic features. He may, for example, decide to put the dial in the middle of the handset, or to give the telephone a rectilinear shape. These ideas change and grow in the second step. The designer creates many wood or plaster models, each reflecting some variation from his initial concept. A skill in sculpting is useful here, of course, but the designer's task is not simply creating a pleasing shape; however stylish a new design may be, the telephone is still primarily a functional instrument. And as such it must be compatible with the rest of the telephone system and the customers who use it.

To insure that a new design meets these primary considerations, the designer must from the outset work closely with telephone components experts and circuit designers to learn if his ideas are practical. It is of no use, for example, to specify a dime-sized receiver if such a component does not exist or cannot be incorporated in the handset so that it will satisfactorily couple sound to the ear.

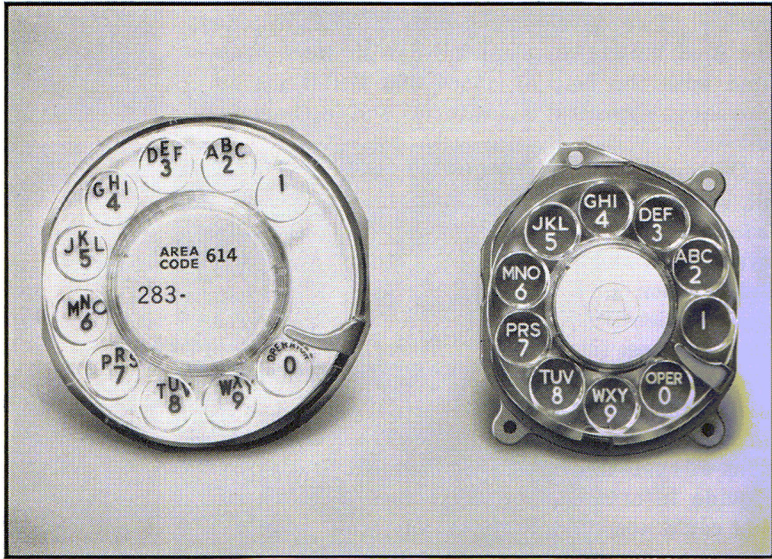
The final step, evaluation, supplies feedback for the designer as well as for the components specialist. In human factors laboratories Bell Laboratories' professional psychologists can observe the reactions of other Bell Labs employees using different types of experimental telephone

models. Two development models that preceded the final TRIMLINE telephone design were evaluated with the help of about 300 Bell Labs employees in appraisal laboratories and in their own offices.

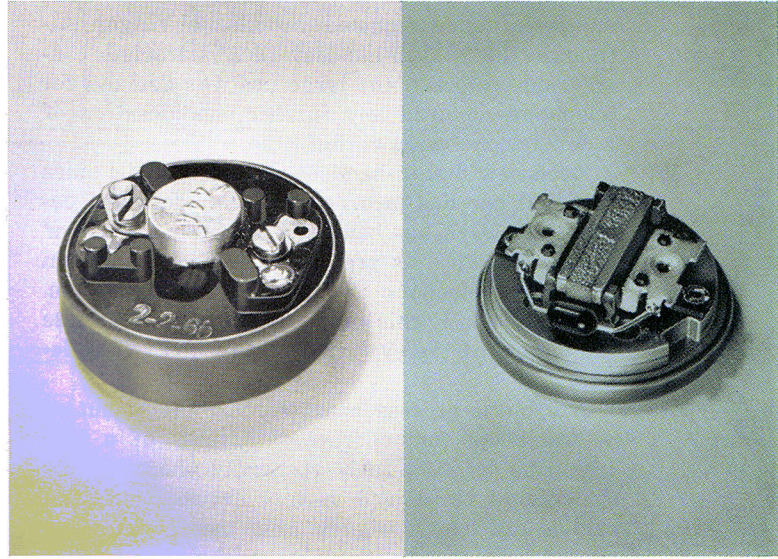
Customer field trials were more elaborate. In all, seven customer trials in eight states yielded information on five different dial-in-handsets between 1958 and 1963. In these studies over 2000 Bell System customers helped the telephone designers identify the popular and unpopular features of each trial model. Although each type of component is tested individually before it is adopted as part of a new design, life and environmental tests can never duplicate all the conditions of customer use. Therefore field trials often provide information on component performance that could not be gathered in any other way.



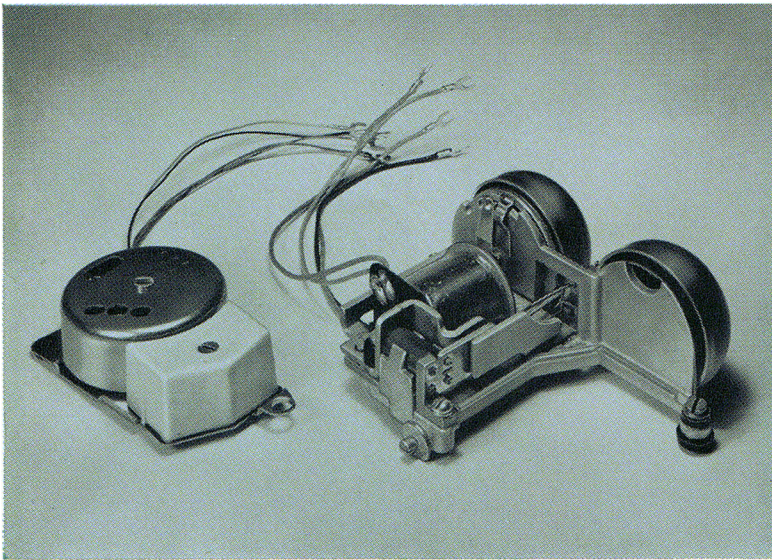
The sculptured beauty of the TRIMLINE telephone has won it a place in the Design Collection of the Museum of Modern Art.



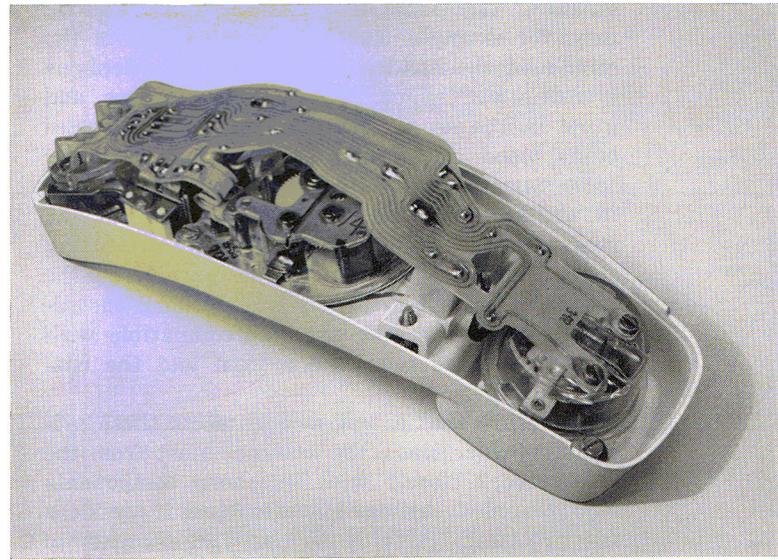
The diameter of the new 10A space-saver dial is about $\frac{5}{8}$ inches smaller than the 8-type dial used in the PRINCESS® telephone. The weight was reduced from 7 ounces to 3 ounces and the dial is also slightly thinner than previous dials. The movable finger stop eliminates the need for the space between the 0 and 1.



The LB1 receiver (right) for the TRIMLINE set weighs less than one-third as much as the U1 type receiver in the 500 set. The new design, which features extensive use of aluminum and an improved magnetic circuit configuration, can now serve as a possible replacement for all other receiver types now in service.



A new smaller ringer, the P1A type (left), contributes to the low profile of the TRIMLINE base. The motor of the new ringer is under the gong, unlike the previous C4A type (right) used in the 500 set. Resonant air chamber is outside the gong.



The TRIMLINE telephone is the first set to include printed wiring circuitry. This innovation necessitated a complete circuit redesign, and several components had to be miniaturized, but the final result is a smaller and lighter telephone handset.

Five telephone models were designed between 1955 and the final TRIMLINE telephone design of 1965. The successor to the 1952 one-piece dial-in-handset phone was a two-piece set developed at Bell Labs in 1955 and called the Demitasse model. This phone had a handset similar to that of the 500 set, but modified by superimposing a 4/5-size dial on the transmitter cap. The handset cradled on a small cube-like base and the phone required an external ringer. In 1958 this model was field tested in three states simply to determine if there was a demand for *any* kind of dial-in-handset. Many features needed improvement. Some customers found it awkward to hold, and the smaller finger holes in the smaller dial made it harder to use. But many customers applauded the idea of a portable dial and a new design was soon underway.

The next model had a new shape with the dial in the center of the handset. Another innovation was a dial-night light. This dial-in-handset design was soon nicknamed the "Shmoo" because of its appearance (see photograph on page 10).

In field trials in New Jersey in 1959 the Shmoo model was preferred by more than two to one over the 500 set. But the customers were more enthusiastic over the idea of a dial-in-handset than the specific design; many complained the handset was just too bulky to hold comfortably. Somehow the dial had to be made smaller. Human factors tests showed that the most obvious solution, making the finger holes smaller, would result in too many dialing errors. Experience with the Demitasse model also supported this view. Dial designers at Bell Labs came up with several solutions. Metal spokes separated the number holes in one smaller dial design. Another dial had U-shaped cut-outs in the plastic wheel instead of the usual enclosed finger holes.

Both these and other dial designs were potential solutions to the problem, but user tests showed that none of them had so low a dialing error record as the larger standard dial. The solution was a movable fingerstop, which rotates through the angle previously allocated to the blank space on the dial (see photograph at left). In this new dial, aptly named the "space-saver dial", the finger holes are arranged uniformly around the entire 360 degree finger wheel circle, instead of the 300 degree arc used before. Human factors studies showed that the movable stop did not annoy dialers. In fact many did not even notice that the fingerstop moved.

Other innovations in the dial design included the use of small acetal resin and nylon gears in the dial mechanism to reduce size and weight.

The new dial has a smoother, quieter operation than previous dials. Bearings, spacers, and fasteners of Nylatron are integrally molded to the metal frame plate of the dial. With these changes the 10A dial weighs only 3 ounces, compared to 7 ounces for the 8-type dial used in the PRINCESS® telephone set.

Two new telephone set models were designed to incorporate the space-saver dial. One was a curved design called the Contour model, which resembled the Shmoo but was slimmer and easier to hold. Another model, more rectilinear in shape, was named the TRIMLINE telephone set (now called the TRIMLINE I set). The LA1 type receiver, with a cast aluminum frame and an improved magnetic circuit configuration, was first available for the TRIMLINE I and Contour handsets. This receiver weighs less than one third as much as the receiver in the 500 set, and its use in the dial-in-handsets shaved their weight by two ounces (see photograph at left).

In 1960 field trials in New Jersey and Pennsylvania of the three dial-in-handset telephones showed that about one-half the customers preferred the TRIMLINE I set, one-third the Contour, and one-eighth the Shmoo. In 1961, in two user studies of Bell Laboratories employees and one extended field study of customers in Virginia, the subjects were asked to choose either the TRIMLINE I telephone set or the Contour set. In all three studies the rectilinear design of the TRIMLINE telephone was preferred to the other dial-in-handset telephone.

Thus, in 1963 another fairly rectilinear model, the TRIMLINE II telephone set, was designed. It incorporated several more advances in component design. A recall button was added to the handset, allowing the caller to dial successive numbers without returning to the switchhook on the base after each call. The button was located at the lower right of the dial.

Earlier dial-in-handset models required eight conductors in the retractile cord between the handset and the base, resulting in a stiff handset cord. In the TRIMLINE II telephone set all the speech circuitry was moved into the handset, reducing the number of conductors needed and allowing a slimmer cord to the base of the phone. The circuit first had to be redesigned and the components miniaturized wherever possible. Although this change was not so obvious to the customer as, say, the addition of the space-saver dial, it was quite important to the success of the final TRIMLINE set. The final weight of the TRIMLINE handset had to be close to that of the 500 set, customers were accustomed to handling.



This injection molding machine is one of many at the Indianapolis Laboratory, which will produce about one and a half million TRIMLINE telephones this year.

In field trials in 1963 customers in Michigan and Wisconsin preferred the TRIMLINE II set over the 500 set design by about nine to one. This set was redesigned slightly, becoming the TRIMLINE telephone now being made available to customers. The redesign of the transmission circuit for the TRIMLINE II set was refined for the TRIMLINE telephone. The new circuit, called the 854A network, is the first use of flexible printed wiring circuitry in a telephone handset (see the photograph on page 12). Notwithstanding the circuit redesign and miniaturization, the transmit and receive characteristics of the final speech circuit in the TRIMLINE set are directly comparable to those of the 500 set.

During manufacture, all circuit components are set rigidly on a flexible Mylar printed circuit

by holding jigs, and are then soldered in place simultaneously with a fountain solder bath. Bell Laboratories and Western Electric Company engineers developed a unique machine for this operation that automatically applies flux and solder to the proper connections without shorting any of the other plastic-embedded conductors.

Plug-in handset cords and line cords were introduced in the TRIMLINE telephone. Since the same handset can be used with either a wall base or a desk base, the inventory of telephones on the installers' trucks can be reduced: handsets, desk bases, wall bases, and cords are stocked separately in five colors for desk sets and four colors for wall sets. The telephone specified on the customer's order is then assembled from these components. No complete telephones will be shipped from the factory—only the four main components. Replacing worn cords or substituting long cords for standard cords will be much easier now that they have plug-type terminals. The installer can replace a defective handset or cord simply by plugging in a new one.

Several other improvements were made for the final design of the TRIMLINE set. The recall button was moved to directly below the dial, where it is less likely to be pushed accidentally. For the TRIMLINE telephone another ringer, the P1A type, was developed with a larger volume range. Its gong is mounted over the ringer mechanism, instead of beside it as in other telephone ringers. The P1A ringer produces a sufficient signal despite its small size and weight.

Several steps have been taken to insure that the base of the desk phone will not slide. First, it is weighted. Also, the standard handset cords for the TRIMLINE set are extra long, reducing the force on the base when the phone is being used. Special Neoprene feet on the base also retard any tendency to slide. And of course since the dial is no longer in the base, it will not slide during dialing.

Western Electric manufactured over 400,000 TRIMLINE telephones during 1965. During 1966 about one and a half million more will be produced. A TOUCH-TONE® version of the handset is now being tested in a product trial in the Chicago area. Production on this model will start this year. The evolution of the TRIMLINE telephone from its primitive predecessors of years ago was a long, careful process, typical of the diligence that must be exercised to meet the Bell System goal of the best possible service for its customers.