

*Bell Laboratories*

# RECORD

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Key Telephone Systems



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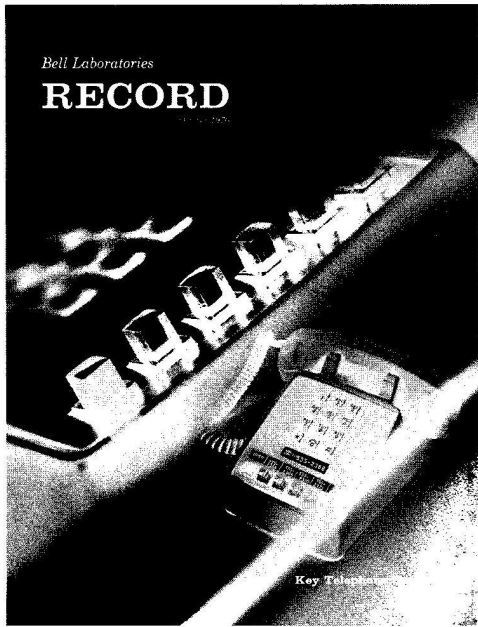
Today, there are over 32 million business telephones in use in the United States. And most modern businesses would soon grind to a halt without them. The 1A2 key telephone system, the theme of this month's cover, is one of many types of customer equipment that have played a major role in meeting the service demands of the business community.

From their introduction in the late 1930's, key telephone systems have enjoyed rapid growth. And this year alone, about 2¼ million lines of 1A2 key equipment will be shipped from Western Electric plants.

How key telephone systems have developed and the services they offer today is the subject of the article beginning on page 258. But the story also represents the very essence of our work.

At Bell Laboratories, the telephone is constantly under careful scrutiny. New telephone equipment and services are always on the drawing boards. But only those that can meet demanding requirements and tests reach the public. And even after they are introduced, telephone designs are continually improved in many ways.

In the case of the 1A2 equipment, for instance, many additional features have been added since its introduction in 1964. This plus the benefits of reduced size, higher reliability, easier and more economical growth, change, and maintenance, are typical examples of the Bell System's efforts to find the best and most economical way for serving the telephone customer.



*With the advent of the 1A2 key telephone system in the early 60's, less room was needed for relay equipment, plug-in cards reduced idle plant investment, and installation was easier. Today, along with new advances, 1A2 offers the customer more services than ever.*

## Advances in the 1A2 Key Telephone System

S. E. Bush

**I**N THE LATE 1920's AND EARLY 30's, the busy executive usually sat at a large mahogany desk with telephones lined before him like so many attendant waiters. He seemed besieged by phones that never stopped ringing—at least this was the familiar stereotype that was often projected by Hollywood and others.

This situation, however, was indicative of a larger problem: realistically, there was no way then for selectively answering phone calls. If the executive were in an important conference—it would have to be interrupted. If he received two or three calls at the same time (on different phones), the only way of holding a call was to take the phone's receiver off its cradle. Admittedly, this was a far cry from a secretary answering calls on her phone, as today, and holding them until her boss either answers or returns the call.

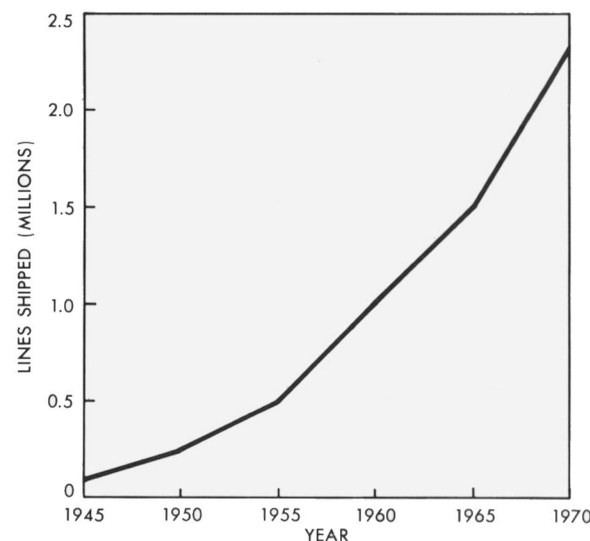
Key telephone service as we know it today evolved out of this need for having a single phone that could receive and “hold” various calls.

At first, one handset and a group of switches—each switch associated with a given line—were used. Each operating telephone company customized such systems, generally referred to as “wiring plans.” Any resemblance between two plans was coincidental. Telephone people soon realized, however, that using one phone with several lines

required additional service features; and although different systems performed basic functions in the same way, they were implemented differently.

Since a receiver lying on the desk would no longer indicate a line on “hold,” and spatial separation would no longer provide an indication of which line was ringing, a new method of indicating the status of each call was required. Also, if a line could be used by more than one person, a busy indication seemed desirable. All three of these needs were satisfied by providing a lamp associated with each line button. Initially, a steady lamp was used to indicate a busy line, then as key systems grew larger and more complex, flashing was used to indicate a ringing line, and winking lamps for a held line. To provide hold, busy, and other functions, a series of relays was used. Each unit, called a Key Telephone Unit (KTU), performed a single function and consisted of one, or in a few cases, two relays. While coded as a group designated the 1A key telephone system, (see *The 1A Key Telephone System*, RECORD, June 1940), they were in reality a formalization or standardization of the old wiring plans. Also, there were still almost as many combinations of these relays as there were business customers. As a result, installation, maintenance, and record-keeping for all but very small installations quickly became unmanageable.





The above chart illustrates the dramatic increase in the number of lines required to meet an ever-growing demand for key telephone service. In 1970, Western Electric shipments of 1A2 key telephone equipment are expected to exceed ten times the amount of equipment that was shipped in 1950.

In 1953, with the introduction of the 1A1 key telephone system (see *The 1A1 Key Telephone System*, RECORD, April 1956), a new approach was taken in key telephone service. Commonly used functions were combined in a single KTU to allow easier installation of basic services. Equipment packages called Key Service Units (KSUs) were developed that contained several of the new multi-functional circuits. Thus, all of the relay equipment necessary to provide line and intercom service for installations requiring fewer than fourteen lines could be obtained by ordering a single key service unit. Key telephone service was then offered as a complete packaged system.

From the first, growth in key telephone systems has been rapid. The number of lines required to meet an ever-growing demand for this service has increased to approximately ten times the number required twenty years ago. About 2¼ million lines of 1A2 key telephone equipment will be shipped from Western Electric plants in 1970, compared to less than a quarter of a million 1A lines shipped in 1950. The total expenditures for new key telephone equipment in 1969 were \$250 million. In addition, an estimated \$300 million was spent to install key telephone equipment required by our customers. Obviously, as one can see, key telephone systems now comprise a large and growing part of Bell System service.

The 1A2 key telephone equipment being installed

today provides many more services than the simple means to receive and hold various calls. While many services are available, they can be roughly classified as four groups: central office or PBX (Private Branch Exchange) line service; intercom service; direct line (sometimes called a tie line or private line) service; and miscellaneous services.

Central office or PBX line service is an outgrowth of the original need to receive and hold more than one call on a single phone. Also, more than one phone can have access to the line. This is important, for example, in group offices or when a secretary needs to answer or place a call for her boss.

Two kinds of intercom service are available: manual and dial. Manual intercoms are usually used for quick and easy communication between two people. Calls are initiated by simply depressing a button which causes a buzzer to sound at the other station. Dial intercom service, on the other hand, enables the individual to call frequently dialed numbers with one or two digits, or to push a button labeled with a person's name when the direct station-selection feature is provided. This can be done without tying up any of the other lines on the phone.

Direct line service provides a direct connection between two locations. When a line such as this is picked up, the telephone at the other end will ring or can be caused to ring by depressing another button. Since no switching is involved, there is no possibility of encountering a busy condition, and the called party always knows the source of the call.

There are several miscellaneous services. A typical example is add-on conference, which allows a three-way conference to be established and controlled by the set provided with this service. It is usually used when assistance is required in answering some question or obtaining additional information for someone on an existing call. The customer may add on a third party who has the required information. As a result of this and other added features, key telephone systems now offer convenience and flexibility for the business customer not contemplated forty years ago when this system was first evolving.

While these services have been and are being provided by the 1A2 system, they are much the same as those previously offered by 1A1. However, since the development of the 1A2 in 1964, a few new services are now available, including some direct lines as well as miscellaneous features. The principal difference, though, between these two systems lies in their physical installation. The 1A2 key telephone system is more compact in size, is easier both to install and maintain, allows reduction in idle plant investment, and has greater flexi-

bility and reliability. In addition, the installed cost of the 1A2 system is competitive with the 1A1 key telephone system.

Let's have a closer look at some of the differences between these two systems, and then discuss the recent additions and changes in the 1A2 key telephone system.

The 1A1 circuits were implemented with large wire-spring relays mounted together (involving three or four relays) on a metal bracket; screw terminals were used for making connections to the outside world, power supplies, other associated circuits, and the key telephone sets. A single line circuit was approximately 3 inches wide by 8 inches deep by 7 inches high. These were placed on mounting bars in a relay rack or in large boxes on the wall.

Because of the complexity required in wiring circuits together, groups of three to eleven circuits were manufactured, while single circuits were usually used only for growth purposes. This resulted in idle plant investment since all of the circuits in a given package were rarely used due to the distribution of lines required by the customer. Without technological innovations this was unavoidable because wiring individual units together

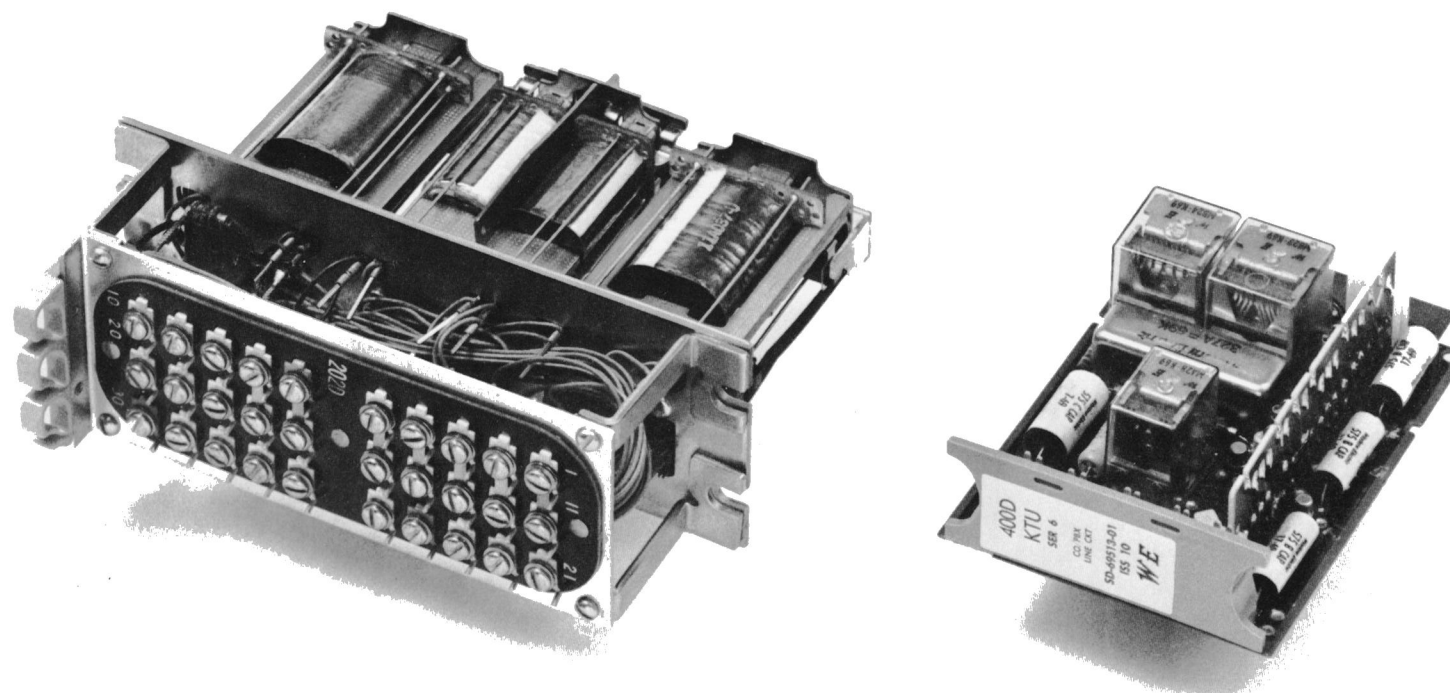
would have cost more than merely having a few idle circuits incorporated in each installation.

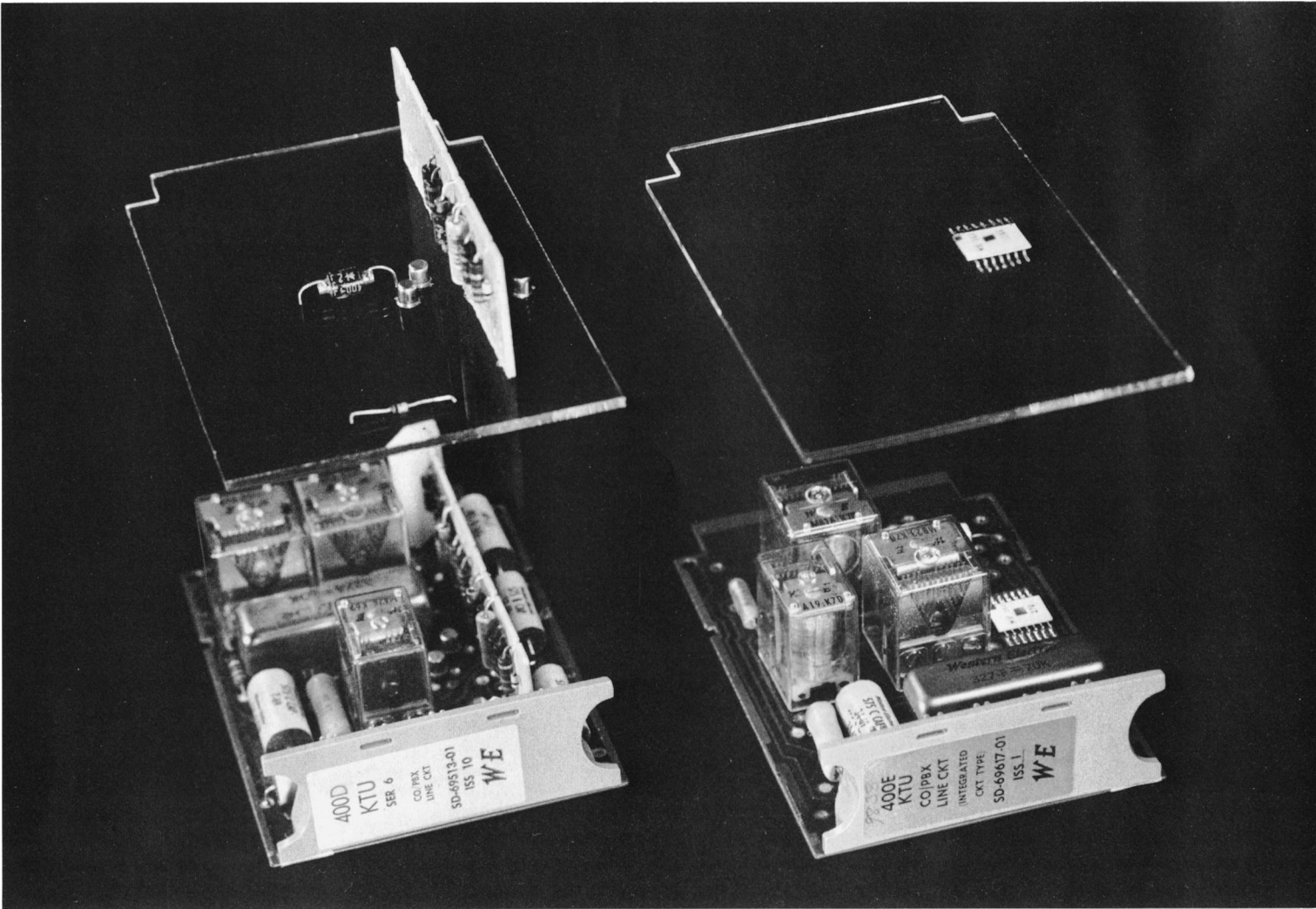
The line circuit of the 1A2 key telephone system, on the other hand, is a printed circuit card 1½ inches wide by 5½ inches deep by 3½ inches high. These cards plug into prewired carriers that can be directly connected to key telephone cables for wall-mounted units, or attached by connector cables in centralized installations. Thus, only the required number of circuits is actually plugged in, thereby reducing the installation time, and also the idle investment.

The use of printed wiring boards also provides other advantages. Circuits can be designed to take maximum advantage of solid-state and integrated circuitry. The 1A2 system makes extensive use of solid-state devices, and where relays are required, due to high voltages or current, miniature flat-spring relays are used. Another advantage of plug-in circuit cards is easier maintenance. A circuit suspected of being faulty can be checked by replacing it with a unit known to be good. The defective units are then returned to a central location for repair.

Since progress was last reported on the 1A2 key telephone system (see *Key Telephone Systems*:

The older 1A1 line circuit (left), and the 1A2 line circuit (which is shown at right), help to illustrate graphically the reduced size of the 1A2 unit as a result of its solid-state components.





The 400D Line Circuit, which consists of 41 components, is being modernized by using an integrated circuit chip (shown at right) that will reduce the components in the 400E line circuit to only 17; as a result, this should lead to substantial annual savings.

The Latest Chapter, RECORD, March 1966), many service features have been added along with the several significant changes that have been made.

The dial intercom, which was intended to replace the selector version of the 6A intercom (see A Versatile New Intercom System, RECORD, March 1958), has been redesigned. The basic unit serves 10 station codes and is replaced with another printed circuit card when service for 19 station codes is required. Flashing lamps, dial tone, and ringback are provided with additional plug-in units. Two new features have also been added. A long-line circuit is used for stations that exceed the 50-ohm loop limit. When the station busy circuit is used, a busy tone will be returned to the intercom caller if the called telephone is busy on another line. Also, the 247B TOUCH-TONE® unit has been replaced by two printed circuit boards, which together are approximately one half the price of the older unit.

Because this flexible intercom service is now available in the 1A2 system, the 501 and 502 KSUs have been replaced by new key service units designed for the 1A2 intercom. One unit, the 513 KSU, provides space for an intercom and six lines. Another, the 515 KSU, provides for additional intercom features and up to 10 lines. More lines can be used if some intercom features are not needed.

The 584 panel, which was designed to hold up to 13 line circuits for large centralized installations, has been simplified, and the similar 583 panel has been discontinued.

Many additional circuits have been made available since 1966 to complete the 1A2 family. Five tie-line circuits (used to supply direct line service described previously) are available. There are five different circuits since two kinds of signaling (manual and automatic) and two kinds of supervision (ac and dc) are provided. The fifth circuit (the short-range tie line) is used when the two telephone sets are in the same building.

Three miscellaneous circuits have also been added. The add-on-conference circuit has been described. The auxiliary ring-up circuit (413 KTU) is used where only a ringing indication is required. The 421 KTU is a power-failure transfer circuit that connects bells to the line during power failures so that the customer will have an audible indication of incoming calls.

The current central office or PBX line circuit in the 1A2 system is the 400D Key Telephone Unit, which contains 41 discrete components. A new unit under development, the 400E Key Telephone Unit, contains only 17 components. This reduction is possible because an integrated circuit replaces all

LINE SERVICE
<ul style="list-style-type: none"><li>● Central office or PBX line circuit</li></ul>
INTERCOM SERVICE
<ul style="list-style-type: none"><li>● Manual intercom</li><li>● Dial intercom-10 stations</li><li>● Dial intercom-19 stations*</li><li>● Long line circuit*</li><li>● Station-busy circuit*</li><li>● Dial tone and ringback circuit*</li><li>● Flashing lamp circuit</li><li>● TOUCH-TONE® adapter circuit*</li></ul>
DIRECT LINE SERVICE
<ul style="list-style-type: none"><li>● Ring-down tie line*</li><li>● Automatic tie line*</li><li>● Station tie line*</li><li>● Short-range tie line*</li><li>● Automatic ring-down tie line*</li></ul>
MISCELLANEOUS SERVICE
<ul style="list-style-type: none"><li>● Auxilliary ring up circuit*</li><li>● Add-on-conference circuit*</li><li>● Power-failure transfer circuit*</li><li>● Exclusion circuit</li><li>● Supplementary hold circuit</li></ul>

\*New 1A2 key telephone circuits since 1966

but the largest components of the former circuit. In addition to reducing the complexity of the system while increasing its reliability, this change will result in substantial annual savings.

Costs are being reduced elsewhere by replacing individual wires in panels, which hold the plug-in cards, with flexible printed circuit wiring. All in all, the design changes currently under way will reduce the cost of the 1A2 system by several dollars per line. This, plus the benefits of reduced size, better reliability, easier and more economical growth, change, and maintenance, all increase the value of the 1A2 system. While competing economically with the old system, and at the same time offering other substantial benefits, the 1A2 can also be expanded to include new services as needed.

The 1A2 key telephone system has come a long way from the first days of key telephone service. Today it is furnishing improved service at the lowest possible price. Like its 1A and 1A1 predecessors, the 1A2 system represents the continuing effort on the part of the Bell System to find the best and most economical way for serving the customer.