*The TOUCH-A-MATIC® telephone set stores up to 32 phone numbers that users may call simply by lifting the handset and pressing a button. The set is now available in rotary and TOUCH-TONE® dialing versions from most Bell System Operating Companies.*

# Call anywhere at the touch of a button

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EVER SINCE the introduction of the telephone dial, people have frequently forgotten numbers or misdialed them, and in general have never been fond of the necessary dialing operation. Consequently, telephones that automatically dial numbers should be very attractive both to customers and to telephone companies. For over 40 years now, Bell Laboratories engineers have been involved in developing a variety of automatic dialers (see photo, page 4).

This long-term experience has clarified the desirable features of an automatic dialer. Human factors considerations indicate that the dialer should be a complete telephone set that is of reasonable size, requires little training or effort to record and dial numbers, displays the directory of stored numbers, and operates as a standard telephone when not used as an automatic dialer. In addition, from the standpoint of a Bell System Operating Company, it should be low in cost, and available to all customers. To be available to all customers means it must be offered in both rotary and TOUCH-TONE® dialing versions. Also, to be of use in the business community,

it must provide all of the standard key system features.

Within the past few years, development effort has resulted in the design of a family of telephones that meets these objectives. The initial member of this family is the TOUCH-A-MATIC® telephone, an automatic dialing telephone that stores up to 32 fifteen-digit telephone numbers. A person using this phone can call a stored number simply by lifting the handset, listening for dial tone, and pressing the correct memory button.

To meet the objectives of reasonable physical size and low cost, extensive use of electronic technology was required. The Touch-A-Matic telephone relies on miniature integrated circuits requiring low power and low voltage to carry out the necessary memory and logic functions. Packaged in a modern housing, this set is a distinctive addition to the Bell System family of phones (see photo, page 5).

Western Electric supplies the 32-number Touch-A-Matic telephone in four versions— rotary and Touch-Tone dialing versions of single-line and six-button key telephones— plus a rotary and a Touch-Tone adjunct dialer.

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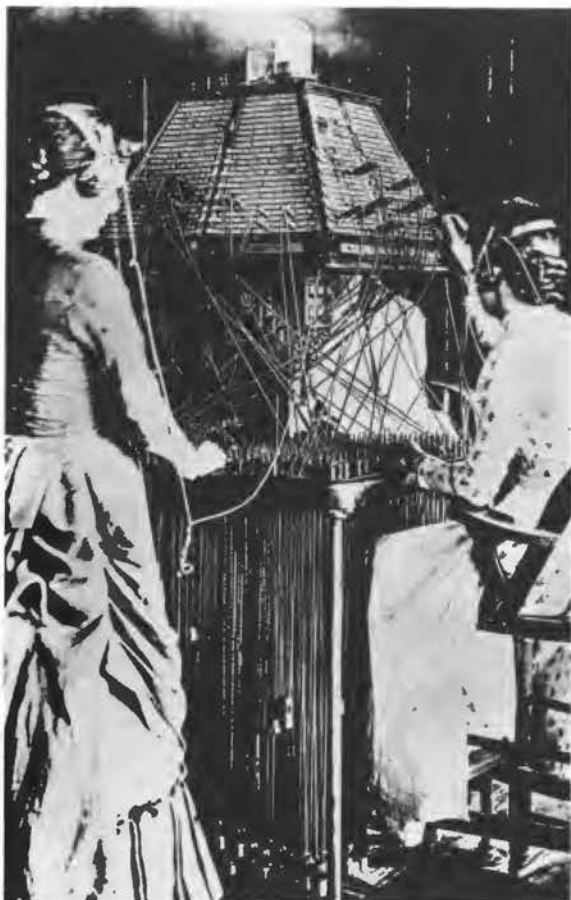
**It's come a long way, baby.** Although phone service with the Touch-A-Matic telephone is a far cry from the Bell System's earliest service, there is one striking similarity. Operator service—like that provided with this 1881 pyramid switchboard—was also a form of automatic dialing, since the customer needed only to tell an operator the name of the person he wished to call. Long before the network reached today's level of 138 million telephones, however, this method of calling became unfeasible as a standard practice. Past approaches to automatic dialing have involved the use of punched cards or magnetic tape to store phone numbers.

The adjunct, called the Touch-A-Matic dialer, has no handset but can be used with any telephone—such as a 10- or 20-button key set, a CALL-DIRECTOR® telephone, or a COM KEY™ telephone set (see photo, page 6). It may also be used to augment a Touch-A-Matic telephone when a memory capacity of more than 32 telephone numbers is desired.

The memory unit of the Touch-A-Matic telephone has 35 buttons—31 standard memory buttons, a LAST NUMBER DIALED memory button, and three control buttons.

The three control buttons—labeled RECORD, RECORD OFF, and WAIT—are located above the three-column array of memory buttons. A light-emitting diode (LED) is adjacent to the RECORD button.

To store a number in any of the 31 standard memories, the user first momentarily depresses the RECORD button. This action lights the RECORD LED and prepares the phone to accept a number into memory. The user then presses the selected memory button and dials the new number to be entered. Finally he presses the RECORD OFF button to extinguish the RECORD LED and end the recording operation. If the user wants to place a call and record the number at the same time, he simply lifts the handset before he begins recording. A new number may be stored in an unused memory location, or it may replace a number previously stored. The latter operation automatically erases the old number.

The LAST NUMBER DIALED button (the lower right button of the memory unit) provides access to a "scratch pad" memory, which stores the last telephone number manually dialed with the standard telephone dial. Storage in this memory occurs automatically whenever a number is dialed, unless the caller records the number into another memory position. This feature means that if a manually called number is busy or does not answer, or if the caller forgets to communicate part of his message, he can automatically redial the number. All he needs to do is lift the handset, listen for dial tone, and press the LAST NUMBER DIALED button.

The WAIT button is used when recording numbers that require a pause for a second dial tone. Depressing this button records a "stop" code in the train of recorded digits. The presence of this code means that, to place an automatically dialed call, the caller must wait for initial dial tone, press the memory button to dial the access code, wait for a sec-

**In its setting.** Its quietly attractive appearance makes the Touch-A-Matic telephone look at home in even the most tastefully decorated executive offices. The set is only 13 inches long by 9 inches wide and is available in black, white, beige, and green.

ond dial tone, and then press the memory button again to dial the telephone number. For those who wish an even simpler system, there is an optional dial tone detector that can electronically detect precise dial tone—the tone used for Touch-Tone calling. If the central office to which the set connects furnishes precise dial tone, the detector will recognize it and automatically trigger the dialing sequence. The caller then does not need to re-press the memory button for second dial tones.

If the Touch-A-Matic set is also equipped with an adjunct speakerphone, the user experiences the ultimate in calling ease, "one touch" calling. All he needs to do is depress the desired memory button and the Touch-A-Matic telephone does all the rest—it turns the speakerphone on, electronically detects all dial tones, and automatically dials the number. When the party answers, the user may talk "hands free" via the speakerphone. The only contact with the telephone is the initial touch of the memory button and a momentary de-

pression of the speakerphone OFF switch to terminate the call.

The Touch-Tone dialing version includes a polarity guard and has full end-to-end signaling capability for both manual and automatic dialing. This feature allows the set to be used for many data applications, such as computer connections, ordering, bank balance inquiries, and credit checking.

One very convenient feature of the Touch-A-Matic telephone is that all the stored numbers are visible at a glance. The phone's ribbed, satin-silver face plate has a clear window through which a removable directory sheet can be seen. The directory sheet is made of a durable white polyester material with a matte finish. Entries on this sheet are erasable, whether typed or written in pencil or ink. Each space is adjacent to a memory button and can accommodate two lines of typewritten pica characters, each eleven characters long. To locate the name and number of the person being called, the caller doesn't have

to consult a separate telephone directory.

In the Touch-A-Matic telephone, simplicity for the user is matched by simplicity for the installer. The set uses modular design (see *Telephone Sets Go Mod—Modular, That Is,* RECORD, *September 1974*). The housing, faceplate, base, handset, and handset cord are all easily changed items. The handset and mounting cords are plug-ended for connection in seconds. The modularity concept does not end with these visible items—inside the set, the manual dial, the memory unit, and the battery are all easily changed plug-in components.

To dial automatically and retain numbers in memory, the set requires commercial power. This is furnished by a small transformer that plugs into a wall outlet and converts the 120-volt alternating current to 13.5 volts. A power supply in the set rectifies, filters, and regulates this input voltage to provide the direct-current voltages required by the phone's electronic components. This power supply circuit generates the pulses needed to guarantee the correct dialing rate during automatic dialing.

The battery—actually four rechargeable nickel-cadmium batteries connected in series—can maintain the stored numbers in memory for a minimum of 24 hours. This is necessary because, without backup power, a short commercial power failure—even as short as a fraction of a second—could result in the loss of stored numbers. Although automatic dialing during a power failure is not possible, a caller can always use the Touch-A-Matic telephone as a normal telephone by dialing manually. The battery cells are trickle-charged continuously so they are always fully charged and ready in case of a power failure. An interlock feature has been included to keep the set from dialing automatically unless the battery is plugged in—and thus ensure that the installer will plug in the battery before leaving.

The Touch-A-Matic telephone's center of operations is the memory unit (see photo, opposite page), with its integrated circuits. These circuits—one for logic, one for dial-interface, and eight for memory—are all flat packages with leads on two sides (so-called dual in-line packages). Manufactured by Western Electric in Allentown, these packages contain nearly all the circuitry needed for automatic dialing and for interfacing the memory with the telephone dial.

Most of the circuits consist solely of metal-oxide-semiconductor (MOS) transistors appropriately interconnected to perform specific logic functions, such as those performed by simple logic gates, more complex shift registers, or counters. In all, there are more than 15,000 transistors on the ten silicon integrated circuits. Only a few other components—capacitors for the logic circuit, for example—are required, and these are manufactured on the same circuit during the same fabrication process used to make the transistors.

MOS technology was used because of its low cost, low power requirements, small size, and high reliability. Changes in technology now being implemented are expected to reduce the size of the circuits even further and therefore substantially reduce costs.

Each of the eight memory circuits (see photo, page 8) can store four telephone numbers, one in each of four 60-bit registers. In the 60-bit registers, four bits are allocated for each digit, allowing a maximum of 15 digits in each stored telephone number. The 15-digit capacity allows ample digit space

**Mirror image.** The memory unit of the Touch-A-Matic telephone consists of both a button and contact spring assembly (top) and a printed wiring board (PWB) assembly (just underneath), both shown suspended over a mirror so that the undersides of the assemblies can be seen. When a user touches a memory button, a contact spring beneath the button makes contact with a gold-plated pad on the top of the epoxy glass PWB. The pads are connected directly to the silicon integrated memory circuits and other electronic components on the underside of the PWB. The circuits connect to the remainder of the set via the connector pins, which are on the component side of the PWB.

for an outside-line access code (one digit), a wait code (one digit), a long-distance access code (up to three digits), and an area code (three digits), plus the standard seven-digit number. Each memory circuit also has access logic, which indicates to the logic circuit that a specific memory location is being used to record or call a number. Once the depression of a memory button is detected, the logic circuit locks out all inputs from any other memory locations until the set completes the dial-

ing of all the digits in the first location.

The logic circuit is designed to control the flow of information between the dial and the memory. It has four major sections: in-out, counter, clock, and control. The in-out section consists of a four-bit shift register and digit translating logic. When a user is recording a number, the in-out section translates each digit from the dial-interface circuit into a four-bit word and shifts it for storage to an activated 60-bit shift register on a memory

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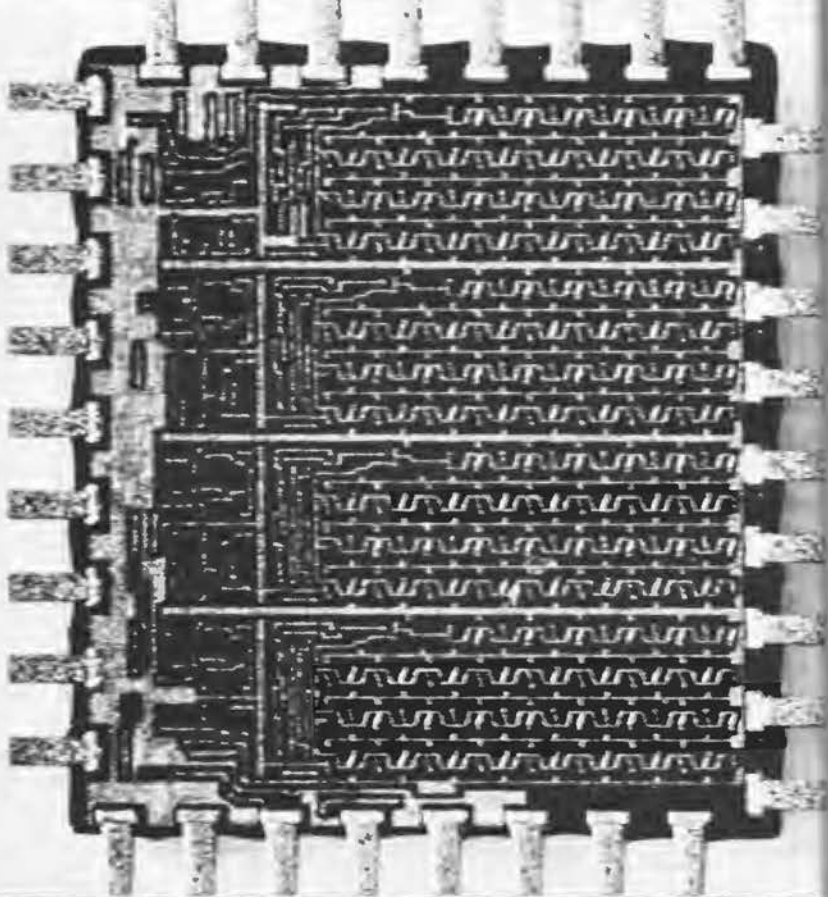
**Memory circuit.** The four memories on this silicon integrated circuit divide it horizontally into four equal areas, each capable of storing the telephone number at its left. The memory circuit shown contains ove 1800 transistors yet measures only about one-tenth inch on a side.

circuit. When the user is making an automatically dialed call, the order is reversed—the stored four-bit words are shifted from a memory circuit shift register into the in-out circuit, where they are read and translated to the proper code to drive the interface circuit.

The second section of the logic circuit, the clock section, generates the pulses used to shift words between the memory and the in-out circuits. The third section, the counter section, has two counters, one to count bits per digit and the other to count digits per number. The final section, the control section, is the basic interface between the user and the logic. It monitors clock rate and operational conditions (such as record/call and switch-hook on/off). It also drives a common switch relay, the "one touch" calling circuit used with a speakerphone, and the RECORD lamp.

The dial-interface circuit differs depending on whether it is for a rotary or a Touch-Tone calling model of the Touch-A-Matic telephone. In the rotary set, this circuit consists of two counters and some control logic. One counter counts clock pulses from the power supply to

time various functions such as "make" and "break" periods for dial pulses, while the other counter counts the pulses. In the Touch-Tone dialing set, the dial-interface circuit provides solid-state frequency switches to tune the oscillator for Touch-Tone dialing.

These memory, logic, and dial-interface circuits were designed specifically for the 32-number Touch-A-Matic telephone. However, they have already proved useful in the recent development of the Touch-A-Matic 16 telephone for single-line customers, and they may find future use in automatic dialing phones with repertories greater than 32 numbers.

An early version of the Touch-A-Matic telephone was tested in 1971 in a field trial in Cincinnati, Ohio. Later it was completely redesigned to improve manufacturability, achieve lower cost, and correct a few human factors problems. The redesigned set was first introduced by Illinois Bell in the Sears Tower in 1973, with company-wide introduction in 1974. It is now available from most Bell System companies and has been enthusiastically received wherever it has been installed.  □