Key, or push-button, telephones have made the telephone station an almost universal tool for everyday communications. The 6A Key Telephone System, recently developed at Bell Laboratories, adds significantly to the intercommunication services, traffic capacity and special features already available with station systems.

A Versatile New Intercom System

H. T. CARTER *Station Apparatus Development*

Station apparatus – the telephones in an office or home and the associated equipment on a customer's premises – has become increasingly complex and dynamic. The many "direct-wire" telephones on the desk of the busy executive of the twenties has now been replaced by a single telephone capable of providing many services formerly impossible even with a number of special-purpose telephones at one's elbow.

This increased versatility of a single telephone has been brought about by the development of station systems using key telephones (Figure 1). Basically, station systems permit the customer, by pressing the proper button, to answer or make calls on any one of several different lines connected to his telephone. The customer can also operate a "HOLD" button to hold incoming calls on certain of these lines while making or answering a call on another of the lines.

In addition to these basic services, station systems provide intercommunication, private lines which connect to similar equipment at another location, and various visual and audible signals. Using a station system, a salesman, for example, may press the button on his telephone marked "LOCAL," dial a single digit, say "8," and be connected with his sales manager. By dialing any of the eight remaining one-digit numbers (the salesman has a number and the digit "1" is not used), the salesman can connect with any of the eight other peole on his intercommunicating circuit. This very popular feature of present station systems is called "dial-selective intercommunication."

Intercommunication, as well as the other station-system facilities, is made possible by "key telephone units" as well as key telephones. The key telephone shown in Figure 1 is a familiar sight in most offices, and is characterized by a row of push-buttons on the front of the base. Key telephone units – probably not so familiar because they are generally remote from the telephones – contain the switching, signaling and transmission equipment and circuitry necessary for the various station-system services.

A recent improvement in the circuitry of key-telephone systems has made dial-selective intercommunication available for larger groups of stations and at the same time has made it more economical to install. This improvement led to the incorporation of many new station service features. Actually, the new circuit has become a comprehensive new system, designated Key Telephone System No. 6A.

In any type of telephone equipment, particularly

Fig. 1 — Speaker phone-equipped key telephone with six push-buttons and additional "pad" of keys.

station apparatus which the customer both sees and uses, improvements are generally made with a two-fold objective. To the Bell System, the redesign must mean more versatile and economical plant equipment; to the customer it must mean tangibly better service.

For the customer, the 6A system offers many entirely new and very useful communication services. One of these new services, a "long-line circuit," makes it possible to have intercom stations located beyond the fifty-ohm limit of local cable. The only practical limitation on the number and distance of these remote stations is a financial one – the cost of private lines to the distant points. Also, our same salesman, in addition to selecting stations by dialing, will be able to use "SIGNAL" buttons on his telephone and on separate "pads" of push-buttons (Figure 1) to signal stations he frequently calls. By pressing one of these buttons, he can signal his secretary. A second button may signal another location, say, the warehouse. The salesman may also use this button to call a particular person at the warehouse by "code-calling" – pressing the button in a predetermined pattern of long or short rings. By pressing a number of "SIGNAL" buttons, the salesman may also call several stations into a conference arrangement.

Two other conferencing arrangements are also made available by the new 6A circuit. A sales manager, using the "preset" conference arrangement, may set up a conference connection with his six salesmen, or any other predetermined group, by pressing the "LOCAL" button and dialing a one-digit, conference code. If he is away from the office, the sales manager can still confer with the salesmen in the office by using a new feature called "add-on," or "inward" conference. Here, he calls Salesman A and tells him with whom he wishes to confer. Salesman A then operates his "HOLD" button to maintain this connection, establishes intercom connections with say, Salesman B and Salesman C, and then "conferences-in" the sales manager by pressing the "ADD-ON CONF." key.

Important, too, to the customer, is the increase in the number of dial-selective stations to 36 – four times the present capacity. Theoretically, the maximum is ninety, but this many stations would probably overtax the traffic capabilities of the system.

Service to the customer has been extended by two other features: "camp-on" and an improved

"common-audible ringing" arrangement. If he has an urgent call to make to one of his salesmen, the sales manager can dial the salesman's station, and even though he receives a busy signal, he can "camp-on" the busy line until the system is free and automatically connects him to the salesman's station. Improved common-audible ringing permits arranging the system to have any telephone ring when any of the lines with which it is concerned – central office, PBX extensions, or other intercom lines – is signaled.

Historically, intercommunication has been one of the basic services of the telephone. The demand for services in addition to a telephone line with simple extension-stations resulted in the development of many special circuits designed to meet specific requirements. Different circuits were often developed in different localities to meet almost identical service requirements. The more popular of these circuits were eventually standardized and made available to all customers as "wiring plans." These wiring plans were quite inflexible, however, and continuing requests for additional combinations of service features led to the development of "Key Telephone Systems."

The designation "key telephone" for what is popularly known as a "push-button telephone" has been retained to avoid possible confusion with telephones equipped for push-button dialing. The term key telephone also more logically includes telephones or auxiliary "key boxes" that may use key types other than push-buttons.

The original key telephone system, No. 1A,* was developed at Bell Laboratories in 1938. In 1952, the 1A1 system† was designed to furnish services similar to those of the 1A system for medium- and large-size installations, and to make the installing of key telephone systems easier and more economical. The first key telephone systems that offered intercommunication services were generally equipped for push-button signaling with buzzers, although a few used automatic signaling when only two stations were involved. The 1A1 circuit introduced dial-selective intercommunication between as many as nine stations, a service later incorporated into the 1A system also.

This service has become even more popular than originally anticipated. Figure 2 shows how sharply the use of key telephone systems has increased in the past few years. Field experience with the new dial-selective intercommunication feature, however, indicated the desirability of some changes. Rearrangements and expansions of station-system installations frequently called for connecting stations of 1A systems to intercommunicating circuits of the 1A1 system, but the dial-selective signaling circuit was not compatible. In addition, the circuit limited the dial-selective feature to nine stations, and there were frequent requests for increasing the number of stations that could be dialed.

A redesign of the intercommunicating circuit, therefore, was recently undertaken to expand the dial-selective feature, and to simplify installations. The redesign also made it convenient to offer the new features already mentioned. As the design developed, the new circuit became so comprehensive that it no longer seemed a logical part of the 1A and 1A1 Key Telephone Systems, since it could actually be used as an isolated system with conventional single-line stations.

The basic unit of the new 6A system, and of the earlier dial-intercommunicating circuits as well, is the selector circuit (207B key-telephone unit). This unit appears in the right foreground of the photograph on page 81. Physically, this selector circuit consists of a ten-point selector switch with four wire-spring relays, and the associated circuits. These circuits furnish pulsing, timing, control, and talking-battery supply for the minimal nine-code dial-selective system of the 1A1 and 1A key telephone systems as well as the 6A system.

With the 6A system, the minimum service can be expanded, either in number of interconnecting codes or additional service features, by adding key-

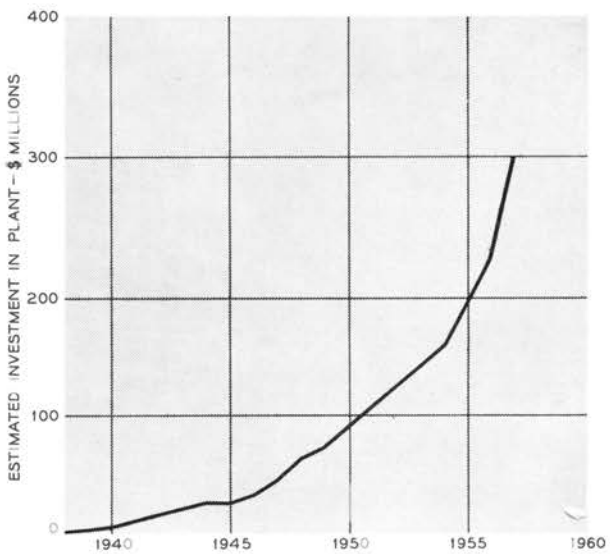

Fig. 2 — Line chart showing increased Bell System investment in key telephones since 1938.

* RECORD, *June*, 1940, *page* 315. † RECORD, *April*, 1956, *page* 210.

telephone units – the building blocks of the system – and by optional wiring. Through the use of these modules, the 6A system offers three grades of service, each geared to a different level of intercommunication requirements.

"Selector Only" service offers a "farm line" arrangement – a single circuit for both selection and talking – similar to the simplest service available with 1A and 1A1 systems, plus most of the *new* features of the 6A system as optional additions. It is designed for small or low-traffic installations requiring only minimum intercommunication facilities. Typical applications are large residences and small businesses with one or two central-office lines and several intercom stations.

The intermediate class of service – the "Single Talking Link" arrangement – provides all of the features of "Selector Only" service plus flashing line lamps to indicate incoming calls and an "automatic cutoff" feature which gives the customer privacy on established connections. With automatic cutoff, if Salesman A, for example, is talking to Salesman B, a third party on the intercom circuit could not interrupt this connection by merely pressing the "LOCAL" button.

This class of service also permits signaling over the talking pair, which generally simplifies installation. The single talking link is intended for small- and medium-size installations that have associated central-office and PBX lines. Probable uses of this class of service would include elaborate residence installations, small businesses, groups of stations served by a PBX, schools and motels. The circuit apparatus required for a typical single talking link installation is shown in Figure 3.

Fig. 3 — Typical station-system installation for single talking link class of service with twelve stations and some associated 1A1 system equipment.

The third class of service – the "Two Talking Links" arrangement – gives all stations on the system access to two talking paths in addition to all the features of the single talking link. Because of the normal statistical distribution of calls, the two talking paths, or links, are capable of carrying about eight times the traffic of the single talking link. The customer establishes calls on the primary link in the usual way. If the secondary link is idle, his call is transferred to it, leaving the primary link and selector available for new calls. If the secondary link is busy, however, the customer's call remains on the primary link until the secondary link is freed. When this happens, the call automatically transfers from the primary link to the secondary link, making the primary link available once more.

With the two talking-link arrangement, it is possible that the called stations may be busy on the secondary link, so it is necessary to supply a busy tone. The tone is generated by a vibrator and is interrupted by the lamp-flashing relay. Another option of this class of service is camp-on. Busy-tone and camp-on are also features of the single talking link, and are particularly desirable when long-line circuits or other stations without signal lamps are part of the installation.

The two talking link circuits will serve larger groups and heavier traffic in much the same situations as the single talking link arrangement. It is designed to be used extensively with push-button signaling for executive intercommunicating service (Figure 4), and for installations making considerable use of special arrangements for connecting central-office or PBX lines to stations not arranged to pick them up directly.

Any major addition to existing telephone service also affects closely associated systems. Station systems have had to operate on 14-to-26-volts dc supplied over feeders from a 24-volt battery in the central office. The scarcity of feeder cable pairs, however, has meant that in many cases it has been necessary to substitute local rectifiers such as the 101G power plant. The power arrangements usually used with older installations would be inade-

Fig. 4 — A. F. Bennett using an experimental modular key telephone for executive intercommunication.

quate for many of the 6A system installations. Major economies in the 6A system – particularly in the number of components – were achieved by designing the system to operate on 20- to 26-volts dc. To do this it was also necessary to develop a new rectifier power-plant (101J) for the larger station-system installations. New station systems will be designed to operate in this more limited voltage range, so other regulated power plants are also under development for the newer arrangements.

Most stations of a 6A system will probably have one or more lines of 1A1 or 1A systems which will have to be picked up, and for which a ringer is needed. The new common-audible circuit has been equipped with diode logic-circuits that permit as many common-audible ringers on a system as desired, without mutual interference. A maximum of two were previously available. Ringing requirements, particularly for conferences and multiple common-audible signals, also made it necessary to develop a new frequency generator (107C) with more power than the existing (107B) units.

In telling the story of how an existing system was redesigned to meet the changing needs of telephone customers, there seems inevitably to be a paragraph which starts, "Still under development . . . " In the present case, two additional features currently under development are an arrangement to permit a particular off-premise station to make and receive calls over a central-office or PBX line, and a trunk circuit to permit two-way dialing to or from another 6A installation or PBX. Still in the investigation stage are a method for automatic answering at a speakerphone-equipped station, provisions for various paging arrangements, and audible ringing-tone for the calling stations.

Large-scale production of all the key telephone units of the 6A system started early this year. To the key systems already in use, the 6A circuit adds an extremely flexible intercommunication system, adaptable to a variety of special control functions.

THE AUTHOR

H. T. Carter was born at Zanesville, Ohio. He attended Muskingum College and Ohio State University where he received the B.E.E. degree in 1930. He then joined the Development and Research Department of the A.T.&T. Company, and his work there and after transfer to Bell Laboratories in 1934 was primarily concerned with field studies of the performance of station instrumentalities, and the development of special testing equipment for such studies. During the war years, he designed transmission measuring systems and apparatus for the underwater sound-reference laboratories and field laboratories. Mr. Carter transferred to the station systems group in 1949, and he has recently been responsible for the circuit design of all station systems except those designed for military applications.