PBX attendants at Chase Manhattan Bank, in New York City. The modern attractive CENTREX *office at the top, equipped with the n[illegible] now replaced the cord switchboards below.*

A new concept of PBX service for modern business was recently introduced by the Bell System. It uses telephone company equipment as a combined central office switching system and PBX.

George Spiro

CENTREX Service with No. 5 Crossbar

Private branch exchanges (PBXs) have served the diverse communications needs of business customers for many years. Originally conceived as, in effect, small, self-contained switching systems, they were designed to serve situations in which most calls were internal, with relatively few into or out of the system. That concept is still tenable for small installations. The complex operations of many of today's businesses, however, pose traffic problems that challenge the traditional PBX.

The need to alter the traditional concepts of PBX switching system design was indicated by the first market trials of direct distance dialing (DDD) service. These trials showed that it would be desirable to convert the entire telephone network to DDD operation. To accomplish this objective properly, DDD service must be furnished to all PBX stations.

At first, attendants at dial PBXs had to complete and terminate connections between PBX stations and the DDD network. Now, a more advanced type of service has been developed by the Bell System. Called CENTREX, it provides direct inward and outward dialing for any station in a PBX. Thus, while it offers all the service features required by a large, complex business, CENTREX gives PBX customers service that is comparable to individual line business service in speed, flexibility, and efficiency. To achieve this, Bell Laboratories has developed new PBX switching systems, modernized old ones, and modified the designs of local central office, tandem, and toll switching systems. This article will describe one of the most important of these developments—CENTREX service using the No. 5 crossbar system as a combined PBX and central office switching system.

The need for this new system was created largely by the concentration of many companies in metropolitan central office exchange areas. Construction has boomed since World War II, especially in business buildings. New office buildings, industrial parks, factories and airports have become familiar scenes on the country's landscape. Like small communities, these complexes have large volumes of telephone traffic, both internally and to and from distant points. And it is apparent that, like individual line customers in small communities, the businesses within these complexes will benefit from shared central office facilities. For one thing, they will save valuable office space and power. For another, their service will be improved through a central office level of

maintenance and through the ease with which central office equipment can be rearranged to accommodate new needs in business communications.

An early attempt to improve PBX service was made at the Air Force Academy in Colorado in 1958. In a communications building built by the Air Force, the Mountain States Telephone Company installed No. 5 crossbar equipment to serve both central office customers and Air Force Academy telephones. It was equipped with local automatic message accounting (AMA) and arranged for nationwide dialing. The part of the No. 5 equipment that served the Air Force Academy permitted Academy stations, all of which had 2-letter, 5-digit numbers, to receive incoming calls directly. Calls between Academy stations are made by dialing the last four digits. On outgoing charge calls—which are dialed directly and handled like calls from individual line customers—the local AMA equipment records the calling station's number.

In January 1959 a similar office was installed to serve the Dow Chemical Company at Midland, Michigan. It consisted of a No. 5 crossbar central office in an operating telephone company building about 3 miles from Dow Chemical. Operating telephone companies in several parts of the country provide this kind of service.

The features of these offices were retained in the CENTREX system. However, like many early systems, they had certain limitations which had to be overcome before the aims of nationwide DDD service could be achieved. One drawback was that these systems could serve the stations of only one PBX customer on a direct line basis. It would, of course, be prohibitively expensive to provide a No. 5 crossbar office to any PBX customer who wanted the features of the early systems. A second difficulty was that cord switchboards had to be used and attendants had to handle calls manually. Still another limitation in these early systems was that direct inward dialed (DID) calls could not be transferred from a called station to another station or to a tie line.

CENTREX service overcomes these limitations. The No. 5 crossbar office can serve as a common switching medium for as many as 100 PBXs. Most CENTREX installations will be served by attendants using cordless consoles to which calls are automatically distributed. However, the No. 5 cross-

New compact console designed for PBXs *served by* CENTREX. *It can be conveniently placed on a desk top and used by an attendant, or by a company receptionist.*

bar system arranged for CENTREX service has a number of special service features the older offices did not have. The basic features now include:

- Direct inward dialing (DID) to extensions;
- Identified outward dialing (IOD) using AMA;
- Intra-PBX calling;
- Incoming call transfer.

The PBX attendant can handle:

- Calls to the listed directory number;
- Transfer calls;
- Dial "O" assistance calls from PBX stations;
- Conference calls;
- Tie-line calls;
- Intercepted calls.

A PBX customer can choose any combination of these features for each station in his system. For example, a station may have unrestricted dialing privileges, or it may be restricted to intra-PBX calling only, or to intra-PBX calling with access to the attendant (dial "O") to complete outward calls. There are available 20 possible variations of originating call treatment and several terminating restrictions. To make the proper distinctions between stations with different restrictions and privileges, the No. 5 crossbar equipment was modified to generate and recognize 100 class-of-service marks and 20 rate (or routing) treatments. Class-of-service marks identify the PBX; rate treatments identify the dialing restrictions for each station — each variation requires a separate rate treatment. Because any rate treatment can be used commonly by all customer groups in a central office, each customer can select freely from the 20 that are available.

With DID, a customer needs a smaller number of PBX positions, and therefore, fewer attendants. In some PBXs arranged for DID, up to 90 per cent of the incoming calls are dialed directly to the stations, thus by-passing the attendant. This leads to improved transmission, because fewer switching and switchboard circuits are involved in the connection. DID also gives faster service, because it takes about 30 seconds less time to complete a directly dialed call than one which must be handled by an attendant, a significant saving in holding time for trunks and switching facilities. Also, the fact that an attendant does not come in on the call insures the privacy of a business conversation.

IOD, in a sense, consolidates the gains the PBX customer achieves with DID. Each station receives individual line service on the No. 5 crossbar equipment, and so does not have to go through the attendant unless its outward service is restricted. Details of all charge calls are recorded by local AMA equipment and reported to the customer by individual station billing.

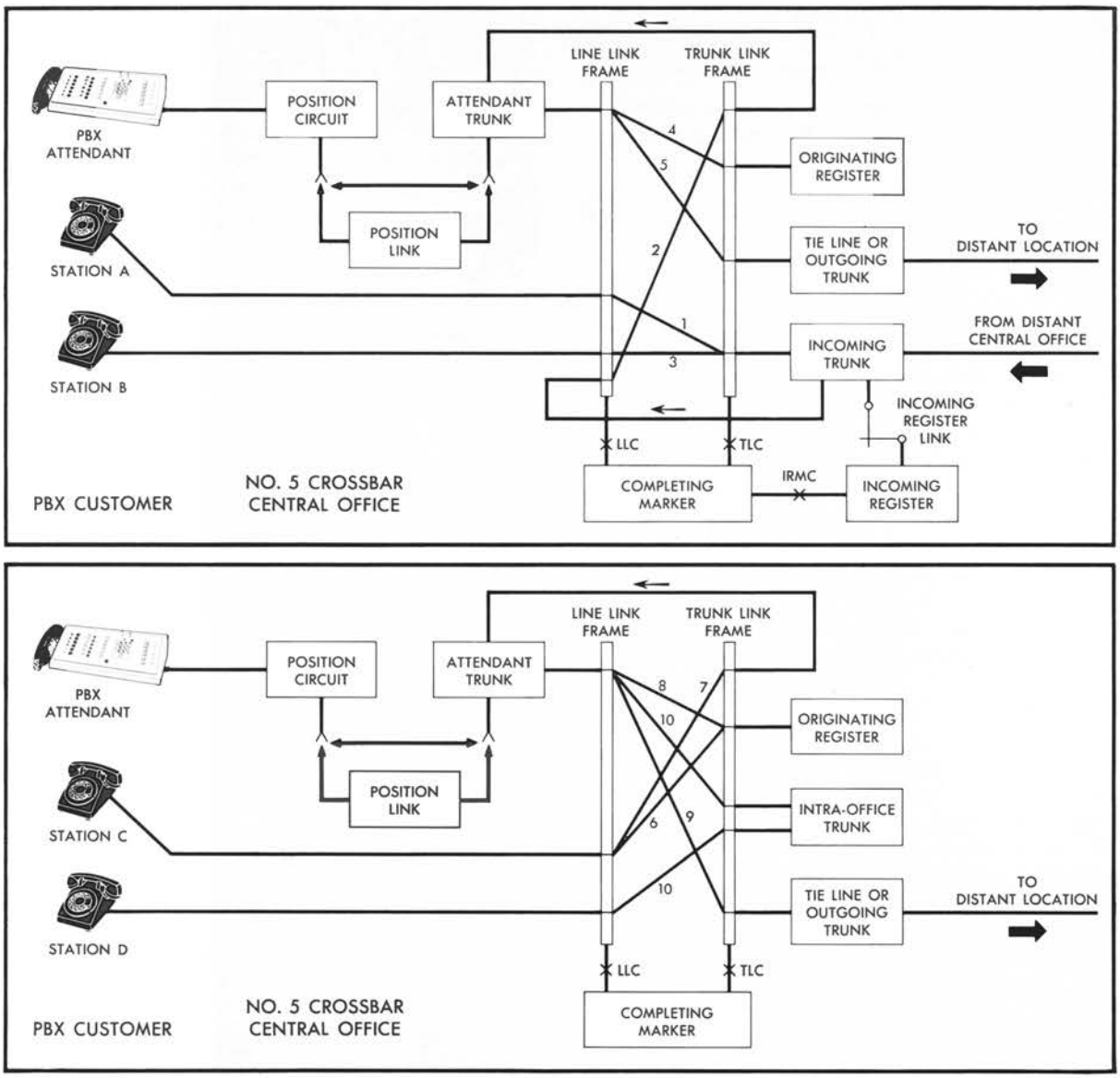
Calls made within the PBX are not charged. They are usually made by dialing the last four digits of the station number. However, because 0, 1, and 9 are used for reaching the PBX attendant, tie lines, and outside access, respectively, they cannot be used for first-dialed digits. Therefore a single office code is limited to the numbers between 2000 and 8999 for PBX stations. Some central offices will serve more than 7000 PBX stations and in these cases 5-digit dialing will be used. The third-digit of the office code, or an arbitrary digit, will extend the range of usable numbers to any 40,000 in the series from 20000 to 89999.

The No. 5 crossbar system uses only two switching frames to complete talking connections—a line link frame and a trunk link frame. CENTREX incoming trunk circuits appear on both these frames so that any incoming call to the PBX can be connected to either a station line or an attendant's trunk and, with the PBX attendant's assistance, calls can be transferred between stations.

The drawing on page 330 shows how this is done. Let us assume that an incoming call has been routed to station A over path 1. The completing marker shown in the drawing stores the class of service of station A in the trunk along with a mark indicating that the station may have calls transferred. To transfer this call to station B, the station A user merely flashes his switchhook. The incoming trunk circuit recognizes the flash, checks that transfer privileges can be exercised on the call, and instructs a completing marker to set up a connection to the attendant. This instruction is sent via the incoming register.

The completing marker now reads-out the stored class of service, say customer group 47. It then connects the incoming trunk circuit at the line link frame to the trunk link appearance of an attendant trunk circuit for the customer group. This is path 2 in the drawing. When it is seized, the attendant trunk circuit makes a connection to the attendant through the position link and position circuits. If the PBX has only one attendant position, the position link is by-passed.

At this point the attendant takes over and supervises the transfer. First, she operates a key which signals the incoming trunk circuit over path 2 to release the connection to station A over path 1. Then she keys the last four digits of station B's number into the incoming register. Again, the completing marker matches class of service marks to see that station B is in customer group 47. If the classes agree and station B is



Routing calls over the No. 5 crossbar system to a PBX. *The top half of the drawing shows how calls may be dialed directly to a station and how they may be transferred to another station with the attendant's assistance. The bottom half shows how the attendant may assist in completing calls.*

idle, a connection is made over path 3. When the connection is made and conversation begins, the attendant releases path 2 and all the equipment involved in transferring the call. The call can be transferred from station B to any other station in the group, and from that station to any subsequent one. Charges are made from the time the first station called answers until the calling party disconnects.

Incoming calls may also be transferred over a tie line to another location or to an outgoing trunk to a distant location. This operation is the same as the one described for transferring a call between stations in the same office up to the point where the attendant releases station A. In transferring to another location, however, station A can stay on the connection. Call transfer then proceeds pretty much as before, except that the attendant keys the distant station's number into an originating register rather than an incoming register. This is shown in the drawing above as path 4 from the attendant's trunk over the line link frame to the register. At this point, the completing marker sets up the call to an outgoing

trunk or tie line over path 5. The incoming call is connected over paths 2 and 5 to the distant location and stations A or B can be bridged on the connection over paths 1 or 3.

On a call to a tie line, the marker matches class of service to restrict the routing to a tie line that belongs to customer 47. On an outward charge call, AMA records are used to bill the call to customer 47.

There is no charge for calls between stations in one customer group, hence they are not transferable; each call is dialed. To make certain that all non-charge calls are confined to the single customer group, class-of-service matching takes place on all intra-PBX calls.

Probably the largest volume of traffic handled by the PBX attendant in a CENTREX served office consists of calls to the listed directory number. Incoming calls are routed to the attendant over an incoming trunk using an incoming register and a completing marker that recognizes it as a call to the listed directory number. A cross office connection to the attendant trunk is established with the incoming trunk at the line link frame. The drawing opposite shows this connection as path 2. A distinctive lamp signal on the attendant's console indicates that the call is to the listed directory number, and she answers with the company's name. The attendant can extend the call to any station in the group (path 1 to station A in the drawing) or she can complete it to an outgoing trunk or tie line (paths 4 and 5).

Key pulsing and control are the same as those used in transferring calls. The completing marker matches classes of service to confine calls to stations or tie lines of the group. Any PBX station can initiate a transfer request.

The drawing opposite also shows how the attendant assists stations in placing calls. Say that station C has received dial tone from the originating register over path 6. If the station C user wishes attendant assistance, he dials "O" and the completing marker connects him to an attendant trunk (path 7). The attendant can now complete the call through an originating register (path 8) over a tie line or outgoing trunk (path 9) or over an intra-office trunk (path 10) to another station (say, D) in the group.

Calls dialed to stations which have been temporarily disconnected or whose numbers have been changed are also routed to the attendant. These intercepted calls are controlled through cross-connections in the central office. Vacant or disconnected numbers in a customer's series are routed to an announcement.

To help the attendant handle these calls efficiently, Bell Laboratories has designed a new cordless console (see photograph on page 328) with illuminated keys and a pushbutton keyset. A large customer may need several consoles, and in this case a distributor or position link circuit in the central office directs calls to the various positions.

Crewmen working on a CENTREX *exchange being installed for the New York Telephone Company.*

A modified 608A switchboard may be used in place of the console. However, at this board attendants must answer, initiate, or complete calls with cords. Thus, the 608A switchboard is bulkier and less efficient than the console.

Today there are more than 6700 Bell System PBX customers with 200 or more stations. CENTREX service should appeal most strongly to these customers because of its economic benefits and because of the improved speed of communications it offers. A number of additional features such as inward dialing to PBX satellites, station controlled dial transfer, add-on conference calling, and dial hold are being studied and developed. All of these are directed toward still further mechanization of PBX service and, hence, to the fastest and most reliable service that can be developed.