

New features and operational improvements have been added to the 770A PBX, the Bell System's most popular business communications system in its range. To keep the basic system inexpensive, the Bell Labs designers followed the policy of furnishing new features via add-on units unless the required circuitry could be designed into the system at little or no extra cost.

New Features for the 770A PBX

MAURICE A. HOFFMAN AND ARTHUR P. RYAN

WHEN THE VERSATILITY AND ECONOMY of a PBX (Private Branch Exchange) system have made it a widely used customer product, changing the system—even to add desirable new features—presents many problems. The designer has many factors to consider, from consistency of operational procedures to the compatibility of new circuits with existing systems. One of the most important factors is the impact on the cost of the basic system of each new feature—that is, how much will it cost customers who do not want the new feature but only the basic services? Keeping the added cost as low as possible was the major objective in the recent design of new features and operational improvements for the Bell System's 770A PBX.

Developed in 1971, the 770A (shown in the photograph on page 248) handles internal communications and external connections to the public telephone network for businesses requiring from 40 to 400 telephone lines. By March 1973, all standard Series 100, 200, and 300 PBX features were available, as well as a variety of options including a package of special features for the hotel/motel industry (see the table on page 244). Because of its low cost, compact equipment, and flexibility, the 770A was considered the PBX workhorse of the Bell System in its line range by mid-1973.

There were, however, increasing requests from Operating Companies and their 770A customers for additional optional features to expand the system's capabilities and its poten-

STANDARD AND OPTIONAL FEATURES PREVIOUSLY AVAILABLE FOR THE 770A PBX

Feature	Series			Optional Features	Hotel/Motel Features
	100	200	300		
Attendant Position (Console)					
Direct Outward Dialing					
Station-to-Station Calling					
Station Hunting					
Call Transfer—Attendant					
Restriction from Outgoing Calls					
Power Failure Transfer—Station					
Night Service					
Attendant Camp-On					
Indication of Camp-On					
Attendant Conference					
Attendant DSS with Busy Lamp Field					
Call Transfer—Individual					
Consultation Hold					
Add-On					
Trunk-Answer from Any Station					
TOUCH-TONE® Calling					
Tie Trunks					
Toll Restriction					
Lockout					
Secrecy					
Wide-Frequency Power Supply					
Battery Operation					
Traffic Usage Measurement					
Single-Digit Dialing for Room Service, etc.					
Mixed Length Station Numbers Access Codes					
Station Message Registers					
Message Waiting					
Direct Single-Digit Access—Station to Toll Operator, on a Permissive Basis					

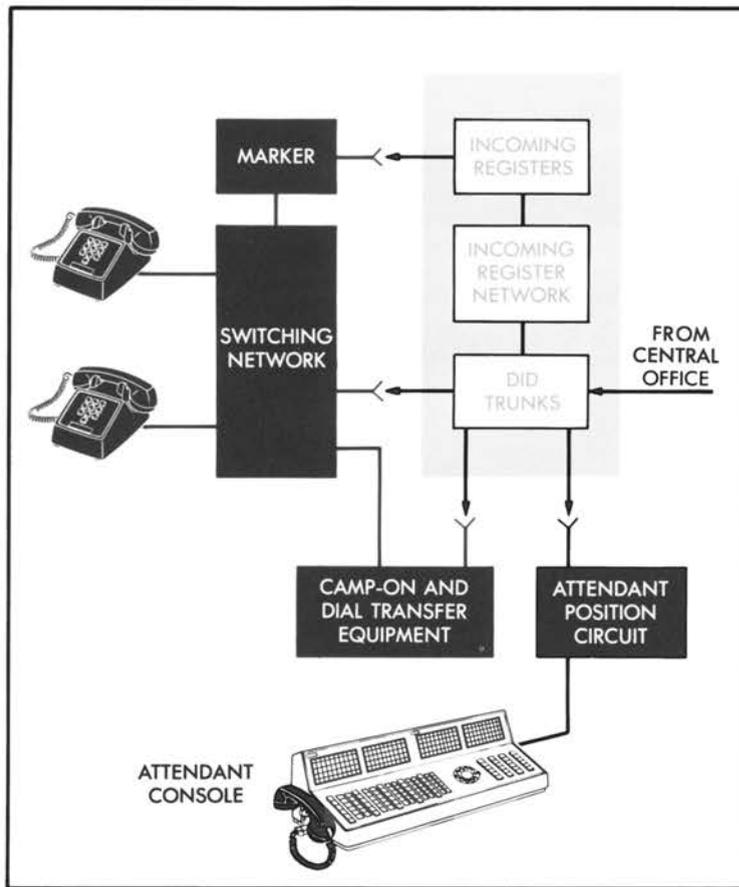
tial market. These requests were channeled through AT&T Marketing, the Western Electric Sales organization, and Bell Labs Systems Engineering to a tri-company feature committee that had been set up in Denver in 1972. Each feature request was carefully analyzed for overall feasibility and for marketability as a function of its estimated additional cost. In March 1973 this committee formulated a priority list of new features for the 770A PBX, and AT&T Engineering made a formal development request to add these features to the system. As part of this request, AT&T specified that the total new feature package would increase the price of the basic system no more than five percent.

There are three fundamental ways to add new feature capability to a system such as the 770A PBX without materially affecting the cost of the basic machine. One is, of course, to design the added capability into the existing equipment so that the new circuit units cost no more, or only slightly more, than those they replace. This approach usually works only for relatively simple feature additions or for basic improvements that are intended for the majority of customers. A second method is to design alternative versions of existing circuit units which incorporate the desired new feature capability and are provided only when the new feature is ordered. The original, less expensive, circuit units are retained in the product line and are provided whenever the new feature is not requested. Finally, new system capabilities can be added by means of external, plug-in circuit units designed solely to provide the new feature. These new units connect into the basic system with a minimum of modification to the existing equipment and are supplied only when the corresponding new feature is ordered by the customer. All three of these approaches were used in designing the 770A's new features and operational improvements (see the table at right).

Modifications Introduced in '73

By the end of 1973, three new features—outgoing call transfer, centrex service, and executive override/ringback—were introduced to the field. At the same time, three major operational improvements—inward restriction, recorded announcement intercept, and vacant code intercept—were added. Inward restriction and vacant code intercept followed the first design approach and were incorporated into the basic system design.

FEATURES AND IMPROVEMENTS ADDED TO THE 770A PBX SINCE MARCH 1973	
Optional Features	
Outgoing Call Transfer	Permits the transfer of outgoing calls from one phone to another within the PBX system.
Centrex Service:	
Direct Inward Dialing (DID)	Enables callers to dial directly to a PBX extension from the DDD network without attendant assistance.
Automatic Identified Outward Dialing (AIOD)	Automatically records the telephone extension from which an outgoing PBX call was placed.
Recorded Announcement Intercept	Routes inward direct-dialed calls to a no-charge announcement if the number dialed was not a working number.
Executive Override/Ringback	Enables callers at extensions with the "executive" class of service either to interrupt a call in progress or to camp on for automatic connection at the end of the call.
Centralized Attendant Service	Permits a multilocation customer to group PBX attendants at a single remote location.
Timed Reminders	Reminds attendants to reenter held calls to report on the calls' progress to outside callers.
Customer Trunk Test	Allows a customer to verify that all the PBX trunks are operating satisfactorily.
Full CCSA (Common Control Switching Arrangement) Capability	Allows a PBX system to share common-control equipment at the central office with other networks or communications services.
Operational Improvements	
Inward Restriction	Prevents certain extensions from receiving calls from outside the PBX system.
Vacant Code Intercept	Routes calls dialed to an unassigned telephone line to some kind of intercept.
Switched-Loop Queuing	Distributes calls evenly among PBX attendants.
Central Office to Tie Trunk Supervision	Furnishes lamp signals to inform attendants about the status of calls transmitted via tie trunks to other PBX systems.
Extendable Paging	Simplifies the connection of calls requiring paging.



A Direct Inward Dialing (DID) call coming in from a central office (right) to a 770A PBX is switched automatically through the incoming register network (center) to an incoming register. The interaction between the DID units (color block) and the basic system takes place only after dialing is completed, when the incoming register interacts with the marker to connect the DID trunk to the called party's line.

Outgoing call transfer followed the second approach, resulting in alternative designs for the 770A two-way central office trunk circuit. The three remaining additions were accomplished by the design of new add-on circuit units.

Transfer of calls coming in to the PBX from the Direct Distance Dialing (DDD) network is part of the standard package of PBX features. In PBX systems with Series 100 and 200 features, a switchhook flash (depressing and releasing the switchhook once) during an incoming call will recall the attendant to transfer the call. With Series 300 features, a switchhook flash initiates the call transfer feature, allowing the called party at an inside telephone to transfer the call by dialing the desired extension himself.

Transfer of outgoing calls is not a standard PBX feature, nor was it a feature of the original 770A PBX. By March 1973, however, there

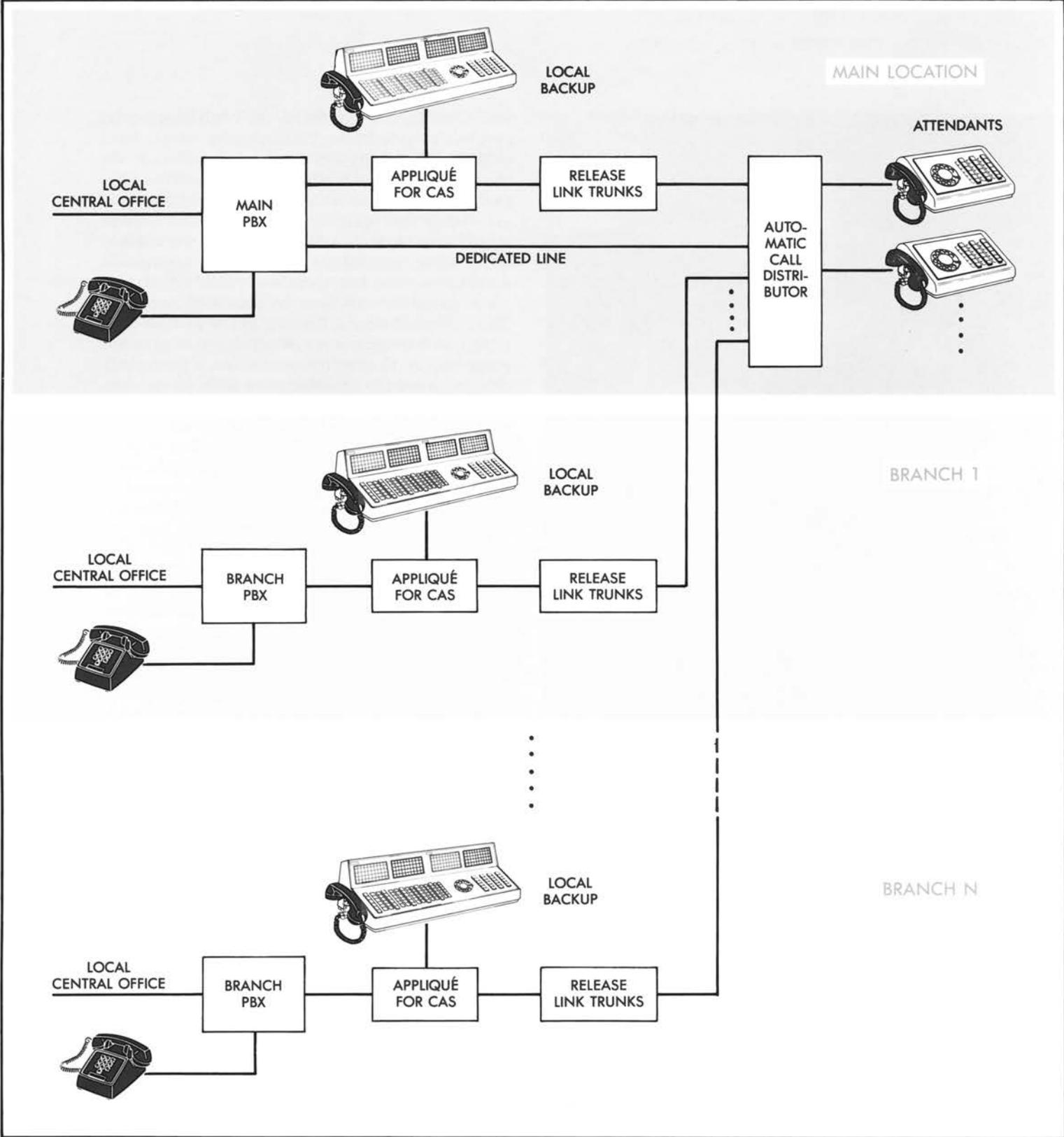
had been a considerable number of requests to add the ability to transfer calls going out to the DDD network on the same basis as incoming calls—that is, attendant transfer for systems with Series 100 or 200 features and call transfer for systems with Series 300 features. Preliminary market estimates from AT&T indicated that, if outgoing transfer were made available, between 25 and 50 percent of the PBX customers in the 770A size range would request this feature. And so one of our first objectives was to design the changes to make this feature possible.

Outgoing transfer requires new circuitry to prevent the central office from interpreting the open circuit of a switchhook flash as a disconnect. This function is accomplished by the addition of a relay and a timer to the two-way central office trunk circuit. This trunk circuit must be furnished in large numbers—an average of approximately 20 per system—and consequently represents a large portion of the total system cost. Since at least 50 percent of expected customers will not need the outgoing transfer feature, we furnished two versions of the trunk circuit, one with the modifications and one without. Systems requiring outgoing transfer are equipped with the more expensive trunk circuit, while systems not requiring this feature continue to use the previous, less expensive circuit.

Centrex Features

A second feature requested by AT&T Marketing was centrex service on the 770A PBX. This service includes two basic features not offered in the PBX packages, Direct Inward Dialing (DID) and Automatic Identified Outward Dialing (AIOD). Preliminary work on 770A system design indicated that these features could be added by means of external (“add on”) feature circuits, without substantially changing the basic system. And so development began on both features.

With DID, it is possible to dial PBX extensions directly from the DDD network without assistance from the PBX attendant. Since the impact on the basic system was to be minimal, the DID arrangement was designed as a completely autonomous switching system connecting incoming DID trunks, through a separate network, to incoming register circuits used only for DID calls (see the illustration above left). With this arrangement, the operation of the basic system was left virtually unchanged, with only minor modifications required in one



Centralized attendant service allows a customer with PBXs at several locations to group all the attendants at any one of the locations. A typical three-location complex is shown here, although up to 16 individual locations may be arranged in any one complex. The PBX at the same location as the Automatic Call

Distributor and the attendants (upper right) is designated the main PBX. Attendants originate calls through a dedicated line port on the main PBX to reach any telephone in the complex via interlocation tie trunks (not shown). Two new circuits were designed to provide this service.



Introduced in 1971, the 770A PBX furnishes from 40 to 400 telephone lines in 40-line modules. With plug-ended line and trunk circuits and plug-in crossbar network units, it is designed for customers with fast-growing communications needs.

circuit. Furthermore, systems arranged for DID service are capable of working with PBX trunks as well as DID trunks to provide special services.

The second centrex feature, AIOD, requires an interface between the PBX and the central office billing equipment. The interface makes it possible to record the number of the PBX extension from which a call was placed so that the call can be billed to that number, rather than to the listed directory number as is done with PBX service. This feature was furnished through the use of the Automatic Number Identification (ANI) circuit used in other PBX systems, along with a new ANI interface circuit designed for the 770A PBX. Only minor modifications were required in existing 770A

PBX circuits to provide the ANI interface circuit with the necessary data leads.

Executive override/ringback is similar to the centrex features already described in that the necessary additional equipment is supplied only when this feature is ordered. Some minor modifications to the basic system were also required to provide the necessary "executive" class of service, but these were made with almost no additional cost to the basic system. The new unit offers, for any given PBX installation, either executive override or executive ringback. With executive override, a person at a telephone with the executive class of service is immediately connected to any line in the same PBX even if the called party has a call in progress. With executive ringback, the person cannot interrupt a call, but he or she can "camp on" a busy line and hang up. As soon as the call in progress is finished, the new call is automatically connected, and both parties are rung.

Restriction and Intercept Capability

These first three major additions to the features of the 770A PBX—outgoing transfer, centrex capability, and executive override/ringback—were made available to the Operating Companies in the latter months of 1973. Introduced during this same period were three significant operational improvements—inward restriction, recorded announcement intercept, and vacant code intercept. Of these, the first two are essential to centrex operation. Inward restriction prevents certain selected telephones—typically those in lobbies, hallways, warehouses, and the like—from receiving calls from outside the PBX system. This restriction is particularly desirable in systems where incoming calls to PBX extensions are dialed directly by the calling party and cannot be screened by an attendant. Recorded announcement intercept prevents unnecessary toll charges by routing incoming direct-dialed calls to a no-charge announcement if the number dialed was incorrect or unassigned. The announcement, which is provided only in centrex systems, directs the caller to the PBX's listed directory number for assistance from the attendant.

Vacant code intercept directs calls that have reached an equipped but unassigned telephone line to the attendant, to reorder tone, or—in centrex systems—to a recorded announcement. As previously mentioned, inward restriction and vacant code intercept were in-

corporated into the basic system design. Recorded announcement intercept is provided by an operational add-on unit that is connected via the DID switching network.

In 1974, the remaining development and design effort came to fruition in the release of four other major feature packages and three additional operational improvements. The feature packages were centralized attendant service, timed reminders, customer trunk test, and full CCSA (Common Control Switching Arrangement) capability. Since each of these features would be ordered by only a small percentage of 770A customers, each was designed as a new add-on equipment unit. The three major operational improvements are intended for use with most 770A PBX systems and were, therefore, designed into the basic equipment with emphasis on adding as little as possible to the cost of the system.

CAS and Timed Reminders

Centralized attendant service (CAS) is primarily for department store chains or other multilocation businesses. The design was done in conjunction with a similar design for the 812A PBX, which serves customers requiring 400 to 2000 lines (see *812A PBX: Answering the Market's Call*, RECORD, November 1974). As shown in the illustration on page 247, centralized attendant service allows a customer with a multilocation business to group all the necessary PBX attendants at one location, which may be quite remote from the individual, unattended PBX systems. The primary advantage of this arrangement is that, since a single group of attendants is considerably more efficient than several smaller groups, CAS reduces the number of attendants needed and thus the customer's payroll.

Two new 770A circuits were designed for this feature. One, the appliqué circuit for CAS, serves as a cabling interface between the existing 770A attendant position and the second new unit, the release link trunk circuit. The release link trunk is a two-way decoder. For one direction of transmission, it translates the call information signals generated by a PBX into audible tone signals that can be sent to an attendant over a single two-wire or carrier circuit. Calls to the attendant location are switched to the individual attendants by a call distributor modified to indicate the origin of the call so that the attendant can give an appropriate response to the caller. In the other direction of transmission, call control signals

generated by the attendants are transmitted back to the PBX system in the form of fixed-interval switchhook flashes and audible signals from a TOUCH-TONE® telephone pad. These signals are translated by the release link trunk circuits to recognizable call control signals. Because they essentially simulate standard attendant consoles, release link trunk circuits can be connected to a standard 770A PBX with a minimum of modification to the basic system.

Another new 770A feature—timed reminders—comes into play on incoming calls that the attendant has placed on hold, extended to a telephone that has not yet been answered, or camped on to a busy connection. Timed reminders automatically reroute such calls back to the attendant after approximately 30 seconds. This feature allows the attendant (actually *forces* the attendant) to reenter the connection to reassure the outside caller that his call has not been forgotten. If the caller wishes, the attendant may release the previous connection and try some other extension. Timed reminders was developed in conjunction with centralized attendant service to give the attendant control over extended but unanswered calls. To make it applicable to installations of the 770A PBX in general—those using direct trunks as well as those that employ switched loops—we designed two alternative arrangements. In switched-loop systems, this feature is provided by a modification of the basic switched-loop circuitry, whereas in direct-trunk systems it is provided by optional add-on units.

The third new feature added in 1974 is customer trunk test. This feature makes it possible for customers to select and connect to each individual trunk circuit in the PBX system from either the attendant position or any predetermined PBX extension. In this way, customers can verify that all their outgoing trunks are working satisfactorily—especially special-service, high-usage trunks such as WATS (Wide Area Telephone Service) trunks, foreign-exchange trunks (those connected directly to remote exchanges to furnish the equivalent of local service to distant areas), and tie lines (circuits leased full time to connect two customer locations). For maximum usefulness, we added a maintenance access port so that telephone craftspeople can use the customer trunk test as a maintenance aid. Like timed reminders, the customer trunk test is furnished by a new add-on unit (the trunk selector circuit), which is installed only

when a customer requests this feature.

Finally, full CCSA capability also became available in 1974. This means that PBX systems, with dedicated-access lines and trunks, can share common-control switching equipment (located at the central office) with other networks and communications services. Although CCSA access has been furnished in the past with tie trunks, some standard PBX services such as attendant recall, camp-on, and dial transfer could not be used on CCSA calls. The new trunk circuit designed for this feature handles these services, as well as all Series 200 and 300 features, and a new trunk junctor circuit connects the CCSA trunks to the central office trunks for on- and off-network access. CCSA capability has been added with virtually no increase in the cost of the basic 770A PBX system.

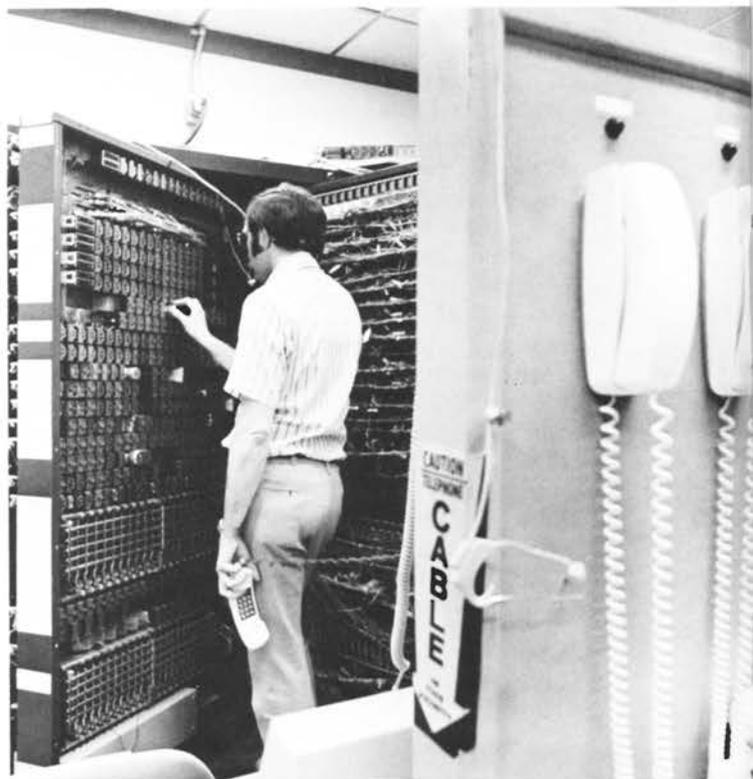
Three Requested Improvements

Most of these new features were initiated by the tri-company marketing study. But the three major operational improvements made in 1974 were prompted by direct requests from several Operating Companies. These changes were made to improve the efficiency of PBX attendants in handling certain kinds of calls.

The first, switched loop queuing, guarantees an equal distribution of incoming calls in a switched-loop PBX system to the two or three attendants handling calls. This change, which required extensive modification of the existing circuitry and a new optional circuit unit, also guaranteed the queuing of incoming calls on a "first come—first served" basis.

The second improvement, central-office-to-tie-trunk supervision, requires a fundamental, nonoptional modification of the 770A trunk circuitry. The purpose of the change is to furnish lamp signals to inform a PBX attendant about the status of calls extended via tie trunks to telephones in other PBXs. Without this change, the attendant must periodically check to see whether the called party has answered. With this change, a lamp lights to tell the attendant that the party has answered.

The final major improvement enables PBX attendants to complete calls requiring paging much faster than with older systems. Previously, after receiving a request for paging, an attendant would place the caller on hold, page the called party, and then wait for the called party to telephone and report the number of the PBX extension he was calling from.



At the Denver laboratory, Ken Franklin troubleshoots a 770A PBX frame that has been modified to incorporate some new features.

After asking him to hang up, the attendant would reenter the held call and connect the caller to the reported extension. In contrast, extendable paging allows the attendant to connect the calling party to the line port of a new line-to-trunk junctor, page the called PBX party, and then release from the call. The paged party then calls the trunk code of the junctor circuit and is automatically connected to the caller without further attendant assistance. A lamp signal tells the attendant when the paged party has responded. Any number of junctor circuits may be provided, each having a separate dial code.

The features and operational modifications described here are only a few of the many improvements designed by Bell Laboratories engineers and subsequently incorporated into the manufactured product. With these changes, the 770A PBX was able to maintain its strong position in the customer systems market throughout 1974. For the future, it promises to be an economical PBX with a wide variety of features designed specifically to meet the needs of Bell System customers. □