Locano

Organizations with telephones at several locations are often served by interconnected PBX's. But until recently, modern PBX services could not be offered between locations. A new plan, with improved signaling on trunks, extends these services to all locations.

New Switching Concept
For Multilocation Customers

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As NEW BUSINESSES AND ORGANIZATIONS are formed and others continue to grow, their needs for telephone service also increase. Today, customers having a number of different locations which must be interconnected are asking for many of the modern service features that generally have been available only to customers having one switching location. Such customers include industries with several plants or offices, department stores with branches, large medical centers, and branches or agencies of governments in different office buildings.

To meet this demand, a new switching concept—

fundamentally an expanded form of a plan termed main/satellite service—has been developed. Traditionally, main/satellite service has provided a means of interconnecting customers at different locations and concentrating their attendants at a single location. In the expanded plan, the features and the operating procedures at all locations are basically the same as if there were just one switching machine and one location.

Expanded main/satellite service is a natural step in the continuing improvement and expansion of telephone service to Bell System customers. In a normal, one-location situation, a Private Branch Exchange (PBX) or Centrex system is installed where a community of interest exists—to permit telephone extensions to share a smaller number of central-office trunks than they would otherwise require and to allow calling among extensions with an abbreviated number—say three, four, or five

Expanded main/satellite service is a new way to interconnect customer locations. Sketch depicts No. 101 ESS switch units at a main location and three satellites, with one control unit.

PACKAGE FEATURES

Series 100 PBX Service

Attendant position	Main only
Direct Outward Dialing	All stations
Station to Station Dialing	All stations
Station Hunting	Not between locations
Station Restriction	All stations
Call Transfer-Attendant	All stations
Power Failure Transfer	All locations
Night Connections	Night-service stations must be at main

Series 200 PBX Service

All series 100 features

Attendant Direct Station Selection with busy-lamp field	Stations at main only
Attendant Camp-on	All stations
Indication of Camp-on	All stations
Attendant Conference	All stations

Series 300 PBX Service

All series 200 features

Call Transfer-Individual	All stations
Add on	All stations
Consultation Hold	All stations
Trunk Answer Any Station	All stations

Centrex 1 Service

All series 100 features

Direct Inward Dialing	All stations
Identified Outward Dialing	All stations

Centrex II Service

All Centrex I features
Features added for series 300

OPTIONAL FEATURES
(available where permitted by switching equipment)

Speed Calling	All stations
Call Hold	All stations
Call Pickup	Not between locations
Call Transfer-individual-all calls	All stations
Three-way Calling	All stations
Consultation Hold-All Calls	All stations
Call Forwarding	Not between locations
Call Forwarding-Busy Line	All stations
Call Forwarding - Don't Answers	All stations
Conference Calling	All stations
Station Direct Station Selection	All stations
Lockout	All stations
Secrecy	All stations
TOUCH-TONE® Calling	All stations
Tie lines	All locations
Toll Diversion	All stations
Code Restriction	All stations
Code Call	All stations
Paging	All stations
Recorded Dictation	Between stations only with TOUCH-TONE® Calling
Busy Verification	All stations
Reserve Power	All locations

Available as options with Centrex

Attendant Direct Station Selection with busy-lamp field	Stations at main only
Attendant Camp-on	All stations
Indication of Camp-on	All stations
Attendant Conference	All stations

digits. A switching machine is normally installed on the customer's premises (except for Centrex-CO service) to handle internal calls and connect outside calls to central-office trunks. Service to these one-location systems has been expanded to the point where a wide range of PBX and Centrex features are enjoyed by many customers.

When a customer has to be served at different locations, a simple solution is the use of off-premise extensions (OPX's). Each OPX is connected to the switching machine by long cables and special circuits, and in this way, it gets the same service as is available at the main location. But as the distance between locations gets longer and the number of OPX's gets larger, the expense of the extra cabling tends to become prohibitive.

Under these conditions, it generally becomes less expensive to add a switching machine at each distant location, or satellite. The primary advantage of this scheme is line concentration (common use of trunk circuits) between locations. It also permits satellite stations to make calls within their own PBX and to reach main stations over tie trunks.

Most multilocation customers with main/satellite service are presently served by 701 PBX machines associated with each other by means of tie trunks. This arrangement allows the customers to concentrate their attendants at one location. Attendants extend calls from there to other locations over the trunks, but the dialing plan generally requires an access code before an extension number to make calls between locations.

The major disadvantage, however, is that many of the modern service features offered to customers at a single location are not available at the remote locations. Also, attendants have only a limited capability to supervise calls at the remote locations. Another disadvantage is that switching and trunk use tend to be inefficient, and transmission tends to be poor because of the need to set up trunks in tandem—from a satellite to the main location to a second satellite—even though the two satellites may be close together.

The new, expanded main/satellite switching incorporates all capabilities of 701 PBX systems but has many others. Users anywhere in the main/satellite complex can call anyone in the complex without needing to know the location being called. Most PBX and Centrex package features are planned for all locations. Optional features are provided as a function of the equipment at each switching location. The table at left shows the range of service features presently planned.

The expanded main/satellite plan includes advantages for the telephone companies as well as

LEGEND: DID-DIRECT INWARD DIALING
DOD-DIRECT OUTWARD DIALING
LDN-LISTED DIRECTORY NUMBER
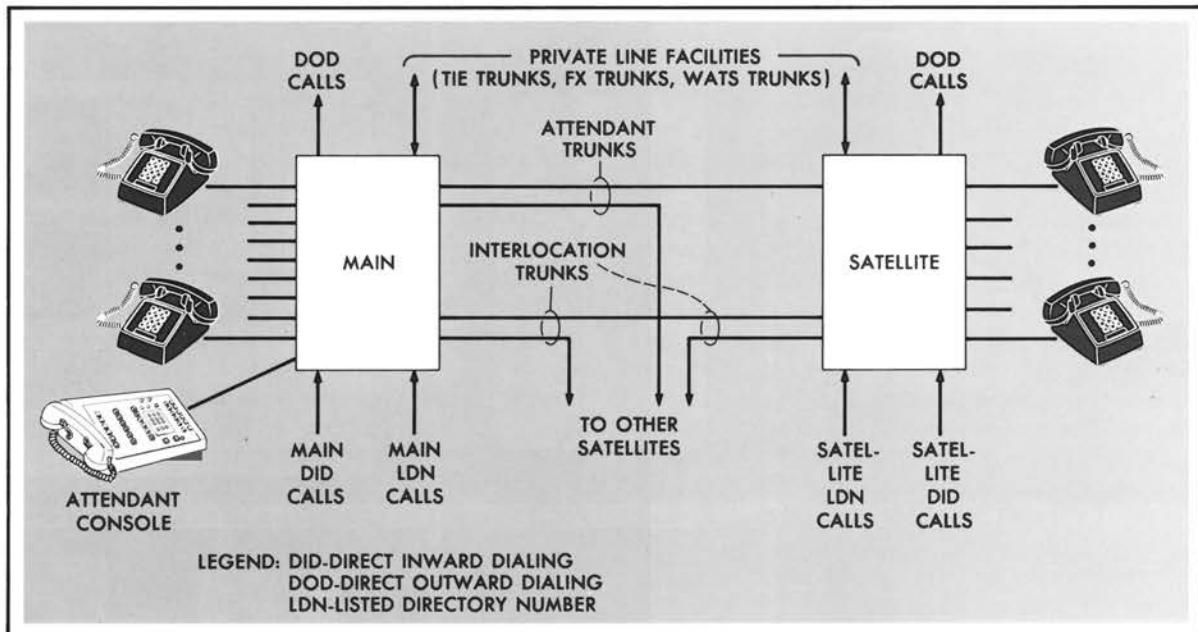
The improved signaling capabilities of a system of trunks sets the expanded main/satellite concept apart from other methods used to interconnect several customer locations. Calls between switching machines in this complex use special inter-location trunks. Attendants are centralized at the main location, and they supervise and complete calls to satellite telephones over attendant trunks. Calls into or out of the complex normally have to be routed through just one switching machine.

for the customers. Some of these are more efficient switching and the ability to offer more profitable service packages to multilocation customers. Also, additional satellites can be added into an existing plan, thereby allowing a system to grow gracefully beyond the capacity of an existing machine, rather than having to replace the machine to gain more capacity.

For example, if a customer has a 3A 101 ESS switch unit and if its 800-line capacity is exceeded, it is possible to grow by adding a 2A switch unit working with the 3A in a main/satellite mode. Or if a customer has 101 ESS equipment and the capacity of the control unit is exceeded, it is possible to add a switch unit to another control unit and associate this switch unit with equipment on the first control unit without affecting service. Eventually, it may be possible to mix various types of switching machines in the most economical manner to complete a main/satellite plan.

Private-line trunks (e.g., tie trunks and FX) to destinations outside the main/satellite complex can be provided either at one location or at all locations, at the discretion of the telephone company. It is possible to hunt between identical groups at different locations. This improves trunking economy because trunk groups can be engineered according to the customer's overall require-ments rather than on a location basis.

By increasing the signaling capability among locations, expanded main/satellite service offers far more flexibility than a system using a series of interconnected 701 PBX. Signals are transmitted in both directions over versatile tie trunks, which also provide the talking connections, and all calls between switching machines use at least one of them. This improved signaling capability permits modern service features to be offered at the satellites and sets the new switching concept apart from older arrangements (see figure above).

Besides being able to transmit and receive dial pulses, the trunks can send and receive supervisory signals in the form of "off-hook" and "on-hook" sequences. These signal sequences have special meanings in the main/satellite scheme. As an example, they can be used to request dialing registers and verify that the registers are attached and ready to receive digits.

Two or three types of trunks are used to interconnect main and satellite locations. One type is used for intercom calls and one or two types for attendant calls. The main purpose of the "attendant trunks" is to permit the attendant to supervise and complete calls that involve an incoming trunk and a satellite. The procedures she follows are identical for all calls; it isn't necessary to
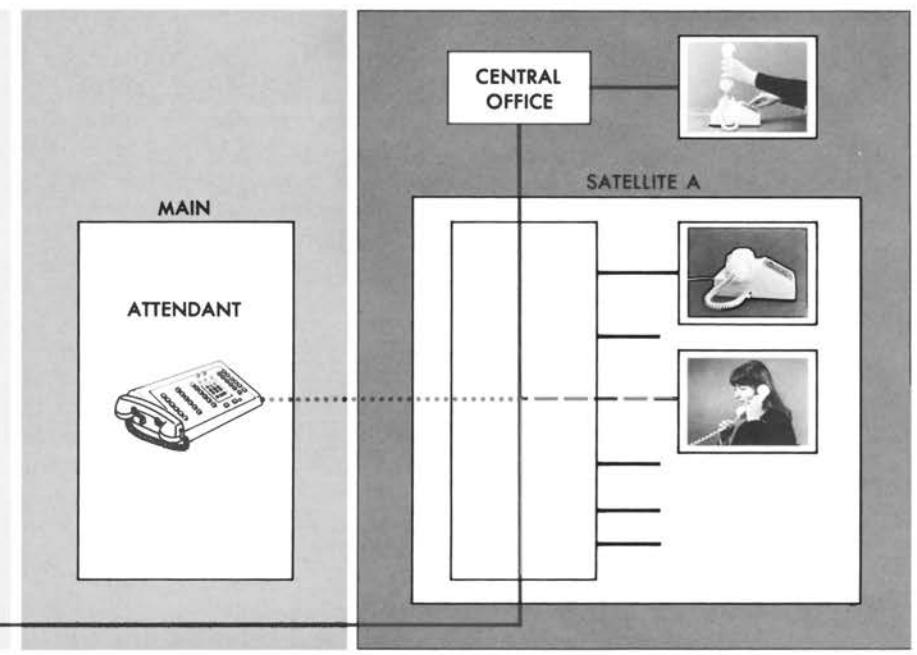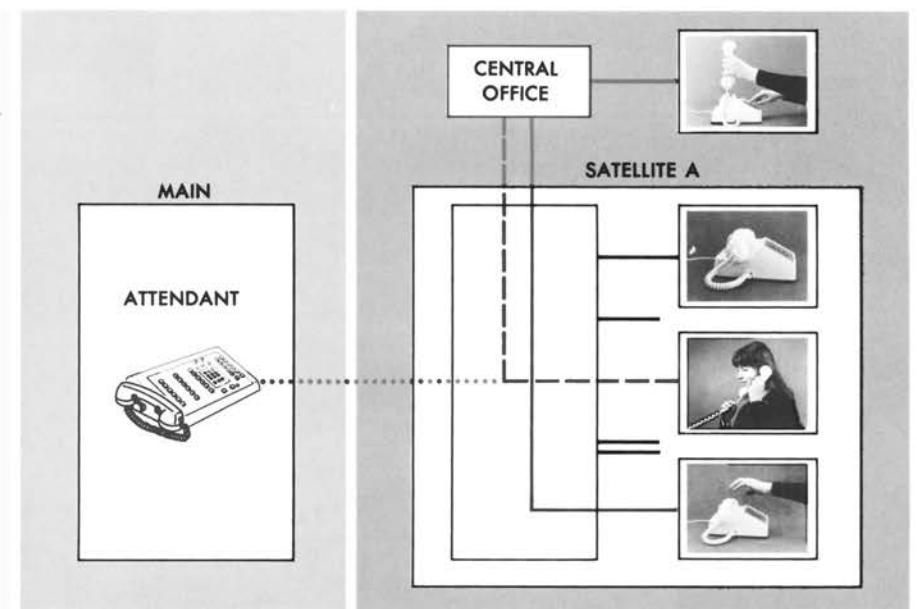
With expanded main/satellite service, central office trunks can be routed to each satellite, and a separate telephone number can be listed for each location. A Direct Inward Dialing (DID) call to an extension in Satellite A (assume Centrex service) is handled by one switching machine (solid line, upper sketch) without involving the main switch. Calls to a satellite's listed number go directly to the satellite, from which they are extended to the main over special attendant trunks (dotted line, upper sketch). Then to complete calls to satellite stations, the attendant dials the numbers. When someone answers, the attendant trunks are released, and the Central Office (CO) party is connected directly to the satellite station (dashed line). This is the so called "release link operation." Attendant call transfer is illustrated in lower sketch. Assume the previous call is still connected and the station user signals the attendant to have the call transferred to a station at satellite B. The satellite switch establishes a connection over an attendant trunk to the attendant who then dials the new number. The call is routed back to satellite A and over a trunk to satellite B. When answered, a direct connection is made through satellite A to satellite B (solid line). The attendant must release from the call, either before or after it is answered, for release link operation to be effective.

know where any particular extension is located.

An important addition to this technique is a new operating feature known as "release link operation." It is standard with No. 101 ESS and No. 5 Crossbar Centrex systems in a main/satellite configuration, and it is under development for No. 1 ESS Centrex systems. With release link operation, the attendant can complete or supervise certain calls involving a satellite station, then release the attendant trunks when she is finished. The final talking path is reestablished within the satellite switch, freeing the attendant trunks for a subsequent call. Release link operation offers several advantages: switching arrangements are kept simple, transmission quality is kept high because tandem connections through the main switch are avoided, and trunking efficiency is increased because trunks are not held for the entire call.

With present No. 101 ESS arrangements and release link operation, a separate telephone number can be listed in telephone directories for each customer location. This permits calls to be routed directly to the desired satellite from the central office, rather than through the main location. The figure on the opposite page shows this and helps to explain how release link operation works.

When an outside call appears at a satellite switch and has to be completed by an attendant, it is routed to the main over one of the attendant trunks, all of which are identified on the attendants' consoles with respect to their source. Thus, she can answer the call in an appropriate manner for the satellite location in question ("Good morning, suburban branch," for example).

A department store with its main store downtown and some branches in the suburbs serves as a good example of release link operation. People calling the store normally want the nearest branch rather than one at a more distant location, especially if it means paying toll charges.

With a main/satellite plan, calls from the local area are normally made to the local branch store. Each branch could have a different listed directory number (LDN), but calls made to any of the LDN's reach the same attendant(s) at the main store. Callers are then connected to the desired department at the local branch, or they can be connected to an extension at any other branch if that is necessary. Store personnel can call any extension at any branch at will.

A number of large organizations presently have expanded main/satellite switching with 101 ESS equipment. The first installation was at Sears Roebuck & Company in Denver in September 1969. This customer is provided with Centrex II service for 1400 extensions divided among three satellites and a main switching unit, all serviced by one control unit. Eli Lilly and Company in Indianapolis has No. 101 ESS main/satellite service with four switching units at three locations and two control units.

Similar systems use No. 5 Crossbar equipment in a Centrex I-CO configuration. Such a system for the General Services Administration in Washington, D.C., has some 40,000 lines at 14 locations. Release link operation is included, and attendants are concentrated at the main location.

Expanded main/satellite service is only available at this time with No. 101 ESS and No. 5 Crossbar systems (see table below). As the need arises, other systems can be developed to allow the use of different types of switching equipment at various locations serving one customer.

Until now, expanded main/satellite service has been fully developed—with all service options—only for No. 101 ESS equipment, and subsequent

	STATUS OF SWITCHING MACHINES FOR EXPANDED MAIN/SATELLITE SERVICE		
For Main	For Satellites		
	No. 101 ESS	No. 5 Crossbar Centrex	No. 1 ESS Centrex
No. 101 ESS	Available (all PBX and Centrex packages)	(See Note)	(See Note)
No. 5 Crossbar Centrex	(See Note)	Available (Centrex 1)	Under Development (Centrex 1)
No. 1 ESS Centrex	(See Note)	Under Development (Centrex 1)	Under Development (Centrex 1)

Note- Other PBX and Centrex systems and combinations of systems are presently being considered for Expanded Main/Satellite Service.

LEGEND

———————	DIGIT & DATA TRUNKS
— — — — —	CO, FX & TIE TRUNKS
————————	INTER-SWITCH UNIT TRANSMISSION LINKS
– – – – –	ATTENDANT LINKS
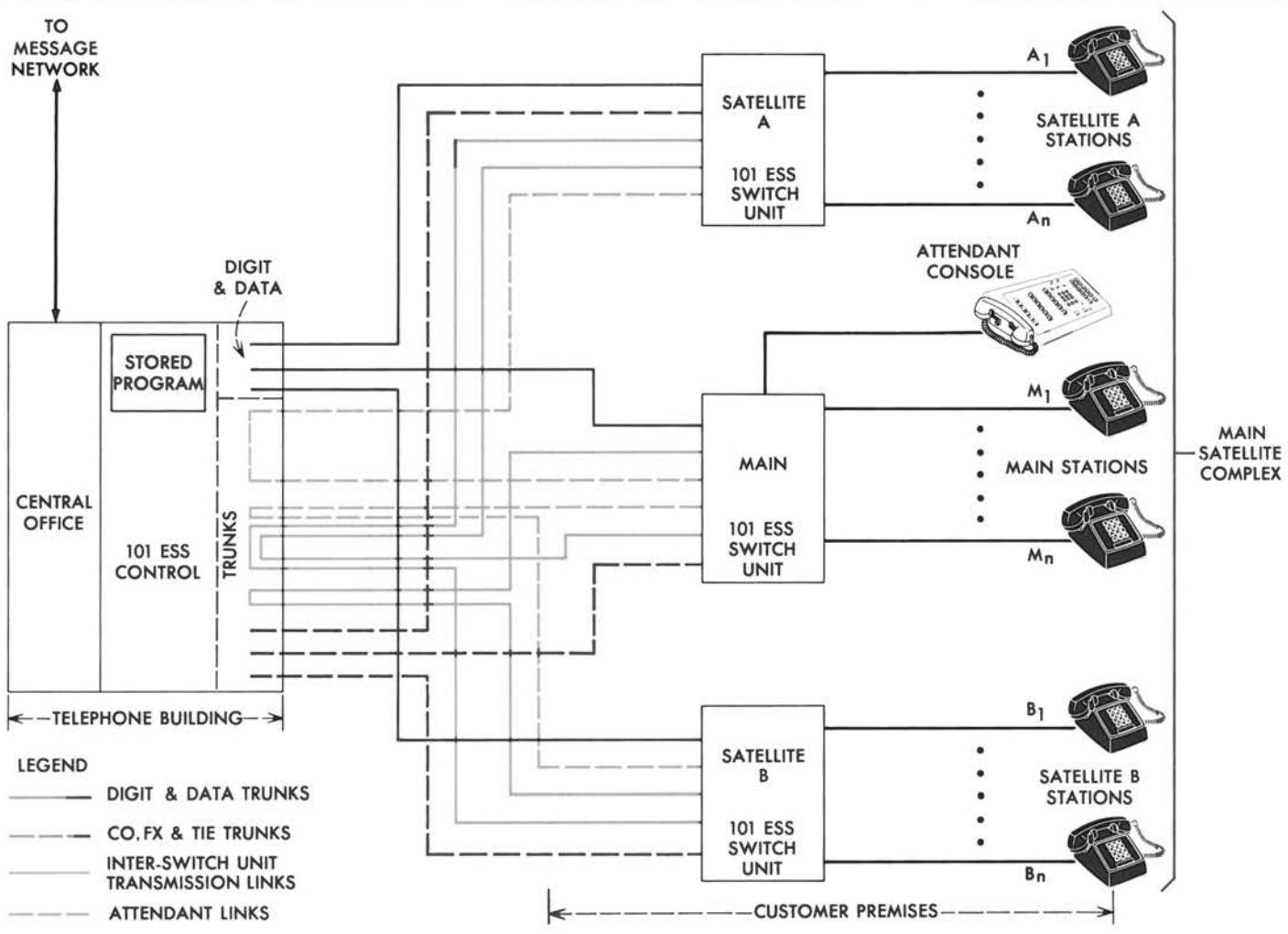
Expanded main/satellite service has been fully developed for systems with No. 101 ESS equipment. Here, a main and two satellites are joined through one ESS control unit; more than one control unit could be used as well. Each switch unit is connected to the control unit by digit and data trunks, plus various outside trunks including central-office, foreign-exchange, and tie trunks. In addition, each satellite is tied to the main switch by attendant links (ATL's), and all switch units are interconnected by inter-switch unit transmission links (T-links). ATL's and T-links serve as talking paths and also transmit signals.

descriptions refer specifically to this system. In accordance with normal terminology for No. 101 ESS systems, the interlocation trunks are called T-links (for transmission links), and the attendant trunks are called ATL's (for attendant transmission links).

ATL's are the same as T-links except that they work in pairs—one to the attendant and one away from her—and dialing capability is required only in the half serving the direction from the main to the satellite. One half of the ATL pair is always used by a satellite to gain access to the attendant. When the attendant completes the call to an extension in the satellite, the other half of the pair is automatically used as a return path to the satellite switch unit.

As in any No. 101 ESS system, all transmission paths for station-to-station and station-to-trunk calls are connected within each switch unit. Each switch unit contains a scanner which checks the status of all connected stations and trunks in sequence. Changes in status (off-hook and on-hook) and dialing information are reported to the control unit at the central office over digit and data trunks (see figure above). As a result of digit or data messages received from switch units, information in memory circuits, and requests from the central office, the control unit determines what

To see how calls are processed between No. 101 ESS switch units in an expanded main/satellite plan, consider a station-to-station call between satellite A and Satellite B in the figure on opposite page. When extension A_1 goes off-hook (the receiver is lifted) intending to call extension B_1, the scanner in satellite A reports the change of state to its control unit. Since call-store records show that A_1 is not involved in a call, the control unit directs the switch unit to connect A_1 to a digit trunk. A_1 gets dial tone and dials the digits for B_1's extension.

One control unit can serve both satellites, as illustrated, but for this example assume that each satellite has a separate control unit. Control unit A determines from the dialed number that A_1 wants an extension in satellite B. An idle T-link is selected and seized, which transmits an off-hook supervisory signal to satellite B. The signal starts a similar call-origination sequence in satellite B as the previous one in satellite A. Control unit B directs switch unit B to prepare to detect digits from the T-link and when ready, transmit a momentary off-hook (wink) signal. This tells control unit A to start outpulsing digits to satellite B. Control unit A then sends a data message to satellite A which identifies extension A_1 and directs satellite A to connect the T-link and extension A_1 together.

If control unit B determines that B_1 is idle, switch unit B is directed to connect B_1 to a ringing circuit and the T-link to an audible ring tone. When B_1 answers, an off-hook signal is returned to satellite A; this is called answer supervision. The path is then completed from A_1 to B_1.

As a further example, assume that A_1 is still talking to B_1 and wishes to add a third party—B_2—to the connection. A_1 flashes the switch hook, and control unit A recognizes it as a request for second dial tone. Control unit A then interrogates satellite B, by a momentary on-hook (flash) signal on the T-link, to determine if add-on should be allowed. The flash is detected at satellite B, where a check is made to see how many lines are connected to the T-link.

If only one extension is connected to the T-link at satellite B, the supervisory response is an on-hook indication back to satellite A. This indicates that the add-on request should be allowed. Extension B_1 is put on hold, satellite A gives dial tone to A_1, and the dialed digits are transmitted to satellite B.

After dialing, busy testing, and ringing, a talking path is established between A_1 and B_2 over the T-link. Another flash at this point by A_1 is a request to get B_1 back into the connection. The satellite A side of the T-link is flashed and recognized at satellite B, which sets up the three-way connection between B_1, B_2, and the T-link, to which A_1 is already connected.

action (switching, signaling, etc.) is necessary.

In a main/satellite configuration, all information necessary to call between switch units is sent over T-links or ATL's; no exchange occurs between control units or between portions of one control unit serving two or more switch units. This allows each switch unit to remain autonomous, and it permits existing No. 101 ESS software and hardware to be used with minimum change. Similarly, it lays the groundwork for other types of PBX and Centrex equipment to operate in the complex.

Processing of the switch units continues in its normal sequence; there is no need for a control unit to interrogate call records or do any translation for any switch unit other than the one being processed. For a detailed description of how calls are set up between switch units, see the box above.

Modern service features such as add-on (bringing another extension into a call involving a trunk) are available at the satellites by virtue of the T-links. For an add-on request, the system determines whether add-on should be allowed (only three parties may be joined, and only one outside trunk is allowed). If add-on is permitted, the final three-party connection is made. It is possible to add an extension *at a different location* in a main/satellite complex onto an existing trunk-to-station call. This feature has been made possible by the signaling capability of the T-links.

"Busy verification" and "Camp-on" are more difficult features to provide in a main/satellite arrangement. Busy verification allows an attendant to bridge onto a busy station and verify that a call is actually in progress. Camp-on allows the attendant to attach an incoming call to a busy extension so that when the called party terminates the call in progress, he is rung automatically by the incoming (camped-on) call.

A satellite must be able to distinguish a busy-verify or camp-on request when it is received over a T-link. When these features apply, the main switch unit routinely inserts dummy codes before all busy-verify or potential camp-on calls dialed by attendants so that the satellite can automatically identify each type of call.

These descriptions show how expanded main/satellite service works in a No. 101 ESS system. Present arrangements will only allow all features with this type of equipment, although release link operation with a No. 5 crossbar system is already possible. A study of a mixture of different systems functioning together in an expanded main/satellite arrangement is underway. The main change needed in existing systems to permit this arrangement is a revision in trunk circuits and translation in order to handle and interpret the increased volume and variety of signaling messages.

The basic purpose of business communications is to allow people separated by distance to work together effectively. Expanded main/satellite telephone service, making it easier for these people to talk to each other, is a step in that direction.