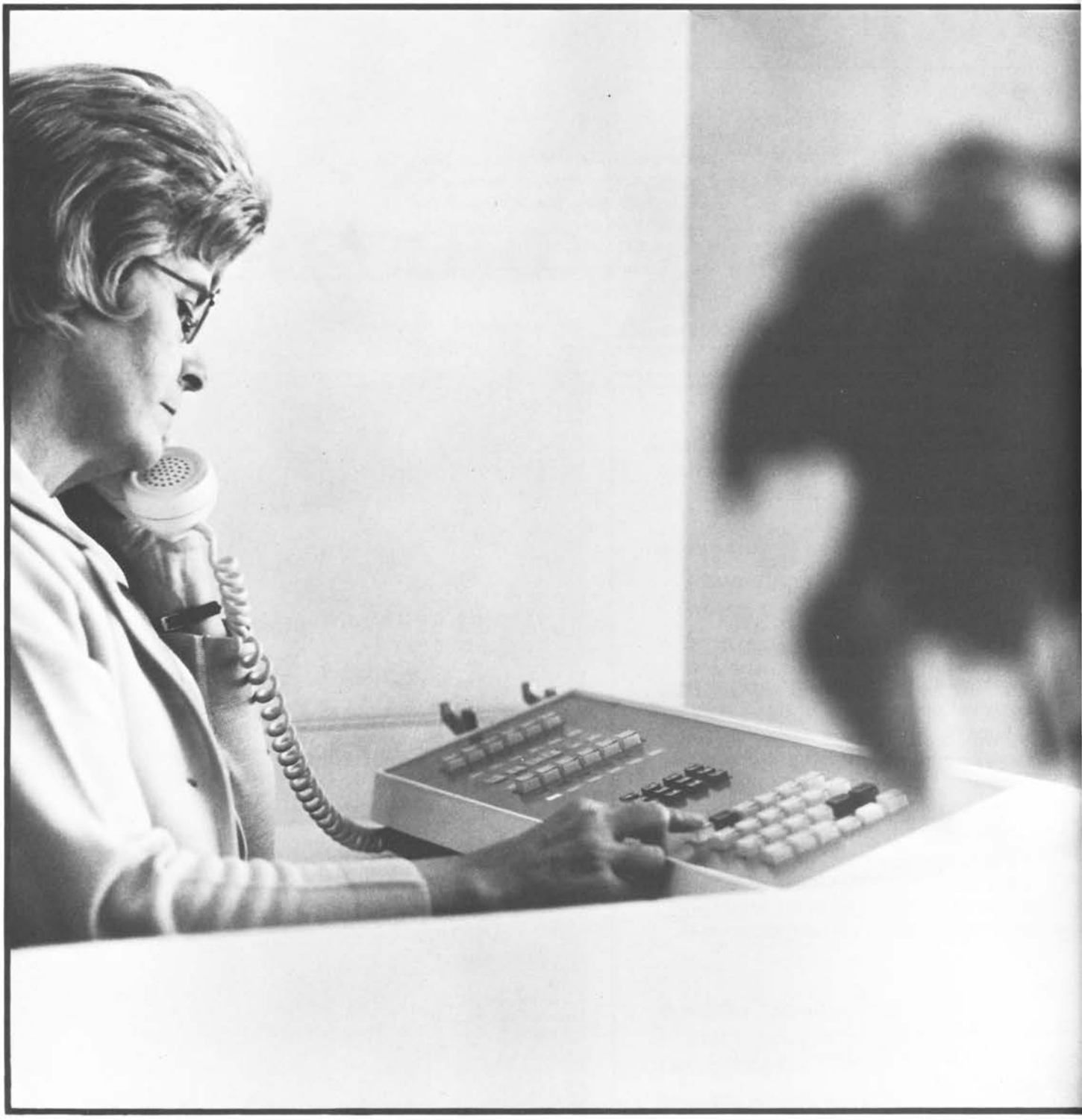

Pushbutton convenience. Receptionist Joyce Burks operates the desk-top console for the 812A PBX *system installed at Bell Laboratories' Denver location. The console offers convenient "switchboard" features such as incoming call-identification lamps, trunk group "busy" lamps, and the capability to control access to special high-use trunk lines such as Wide Area Telephone Service.*

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This new private branch exchange (PBX) uses off-the-shelf technology to provide basic PBX and Centrex services for businesses requiring up to 2000 lines. Developed at Denver, the 812A is economical, self contained, and designed for expansion of features.

812A PBX:
Answering the Market's Call

F. Lawrence Singer

THERE'S MORE TO THE STORY of the new 812A private branch exchange (PBX) than its technology, service features, and physical characteristics. For the 812A is also a testimonial to the effectiveness of the Denver complex—the integrated product center at Denver where AT&T, Bell Labs, and Western Electric team up to identify market needs for PBXs and then design and produce new systems or new features for existing systems. In this case, the 812A advanced from design to production in a record-breaking 13 months by paralleling Bell Labs development and Western Electric manufacturing efforts (see "Development Schedule for 812A PBX," page 304). This article describes the characteristics of the 812A PBX, the technology used, and the teamwork that expedited its introduction into the dynamic customer switching market.

This newest Bell System PBX is a small telephone switching machine that handles up to 2000 lines—meeting a wide spectrum of business and hotel/motel needs—at a price and flexibility that is hard to beat (see "812A PBX Characteristics," page 306). The 812A is self-contained to save space (it does not require a separate equipment room) and uses plug-in equipment modules which allow systems to expand their capability at any time. It complements other Bell System electronic and crossbar systems in the PBX product line and should replace, for most applications, the 701B step-by-step system.

Studying the Market

The 812A had its beginnings in the summer of 1971 when AT&T, Bell Labs, and Western Electric were studying the market needs for a new low-cost PBX that could handle more than 400 lines. This need was perceived earlier by some of the Operating Telephone Companies because only two Bell System PBX units—the 701B and the 101 ESS—were available in this size. The 701B requires a large amount of floor space on a customer's prem-

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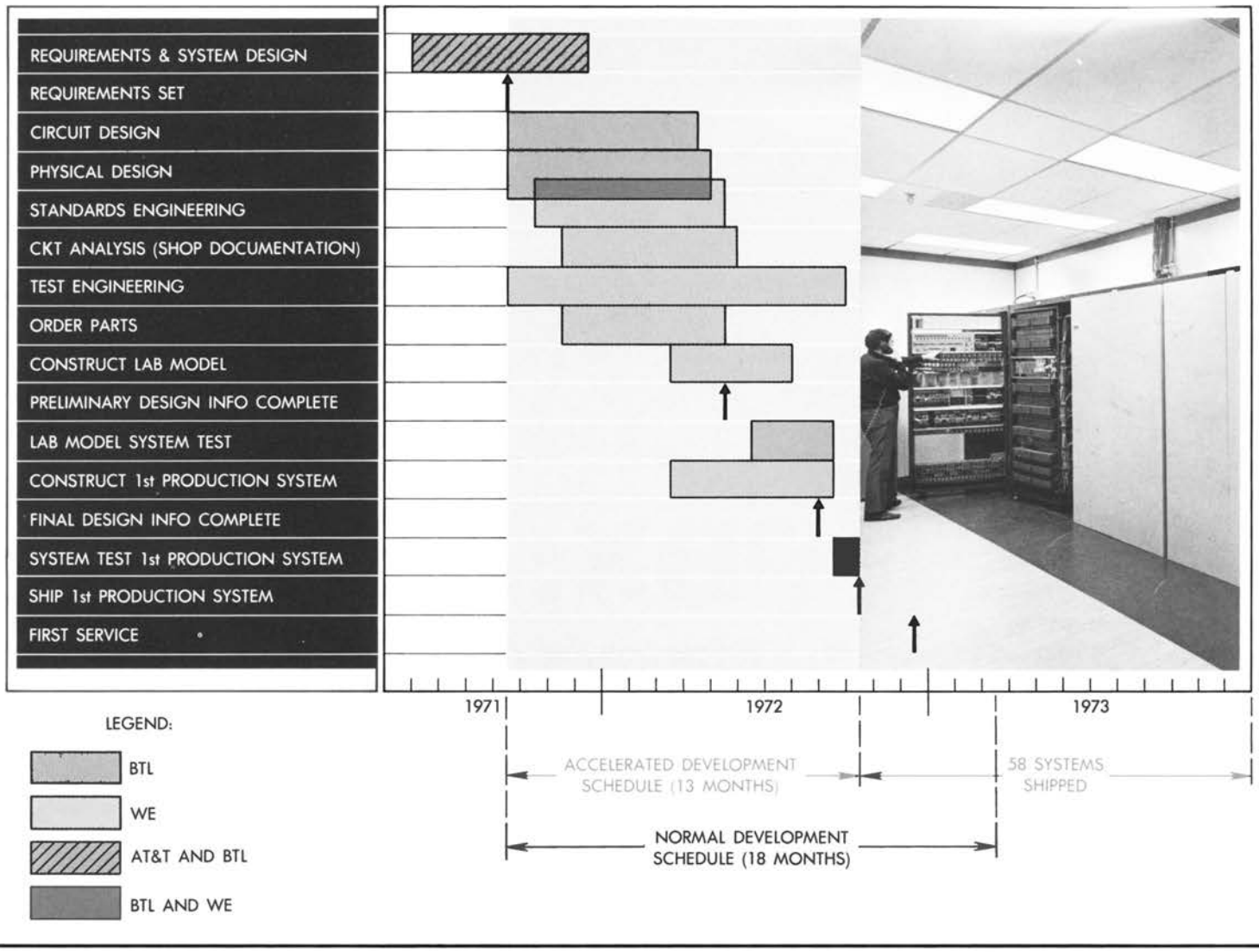

DEVELOPMENT SCHEDULE FOR 812A PBX

An accelerated 13-month schedule—from start of circuit design to shipment of the first production system—was achieved by setting firm goals early in the schedule and by close cooperation among AT&T, Bell Labs, and Western Electric personnel at Denver. Key factors included paralleling Bell Labs physical design and Western Electric standards engineering work, normally done in sequence, and using preliminary design information to build both the lab model and the first production system simultaneously. No field trial was held in the normal sense; the first production system was built and shipped to the field for regular commercial service.

ises as well as a special equipment room. The total cost of installing 701Bs by Operating Companies had been increasing sharply over the years due to the large installation effort required; also, some of the modern service features, such as TOUCH-TONE® calling, were cumbersome and costly to implement. The 101 ESS, while handling a wide range of modern "custom calling" service features, was economically feasible only in business population centers where a number of 101 ESS customers were concentrated. For customers desiring basic services only, the 101 ESS was expensive. Furthermore, no non-Bell system of this size on the market could offer customers basic PBX services at a price low enough to be attractive.

The study results showed that a new economical PBX system was needed that would offer basic PBX and Centrex services at a capacity of at least 1500

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Members of the 812A project team at Denver. During the 812A's accelerated development stage —from start of design to shipment of the first production system—project team members from AT&T, Bell Laboratories, and Western Electric met weekly to monitor and coordinate all phases of activity. Dan Callahan, AT&T Assistant Engineering Manager (left), discusses steps in the design and production phases of the 812A with Bruce Hoagland, Bell Labs Physical Designer; Dick Burtness, Bell Labs Circuit Designer; and Al Bloomquist, a Circuit Analyst from Western Electric.

lines. Such a system was considered feasible by utilizing the technology in the 770A PBX—a new attractively-priced system designed and manufactured by Western Electric for customers needing up to 400 lines.

The technical challenge, then, was to extend the design concept of the 770A to a new system for use above 400 lines. This could be accomplished by bringing in some technology from other product lines manufactured by Western Electric and combining it with much of the 770A's technology and hardware. This approach would minimize Western Electric's efforts in introducing the product line into manufacture—a decided advantage in getting this system to Operating Companies quickly.

Features and Capabilities

Before actual circuit design could begin, however, detailed system requirements had to be firmly set and decisions made on what technology and devices were to be used. This required much give-and-take among personnel in Bell Labs development, Western Electric engineering, and AT&T engineering, traffic, and marketing organizations. To meet the market needs, compromises had to be made between low cost on the one hand and ultimate system capabilities on the other. By September 1971—the start of the 812A PBX development—the final system configuration and requirements were agreed upon. The 812A would offer the following features and capabilities:

- Provide all common basic services, including PBX series 100, 200, and 300; Centrex I and II; and Hotel/Motel service. The PBX services are: (1) *Series 100*—basic PBX features such as station-to-station calling and direct outward dialing; (2) *Series 200*—special features, such as attendant camp on and attendant conference, that enable attendants to perform additional services; (3) *Series 300*—special features, such as call transfer and trunk-answer-any-station, that give station users more control without attendant assistance. The Centrex services are: (1) *Centrex I*—basic PBX features plus direct inward dialing and automatic-identified-outward dialing; (2) *Centrex II*—Centrex I features plus special features for station users. These features would be available individually, not grouped together to form various "packages." For example, a telephone company would not have to take all the features normally provided in the Centrex I package, just those that were needed.

- Supply as optional features Touch-Tone calling, tie trunks, and Common Control Switching Arrangement service. A number of modern features, such as "custom calling," were excluded altogether while others, such as outgoing call transfer, were to be considered after the initial development was completed.

- Optimize the efficiency of the switching network so that it can handle as many as 1600 lines at heavy

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812A PBX CHARACTERISTICS

Size

- Up to 2000 lines, 600 trunks

Features

- PBX Series 100, 200, and 300 services (see text)
- Centrex I and II services (see text)
- Hotel/Motel services
- Standard options
  - Touch-Tone calling
  - Tie and miscellaneous trunks
  - Common control switching arrangement

Traffic Load

- Medium to heavy
  - Up to six CCS (hundred call-seconds per hour) per line

Technology

- Switching network
  - Small crossbar switches
- Common control, line group, trunk group, automatic number identification, and system monitor circuits
  - Silicon integrated circuits with diode transistor logic, dual in-line packages
- Attendant, service, and trunk circuits
  - Conventional wire-spring relays
- Interconnections
  - Wire-wrap, connector cables

traffic loads—that is, up to six CCS (hundred call-seconds per hour) per line—and as many as 2000 lines at medium loads (up to four CCS per line).

- Process up to 8000 calls per hour with the common control circuitry.
- Provide up to fourteen attendant consoles with a number of features that reduce the need for supplemental "cord" switchboard positions. These features would include lamps that indicate the source of incoming calls or busy trunk groups, and an optional capability that allows an attendant to control dial access to special high-use trunk groups, such as WATS (Wide Area Telephone Service) or FX (Foreign Exchange) trunks (see illustration, page 302).
- Incorporate three- or four-digit numbering plans for stations, with capability to absorb or insert digits for Centrex operation.
- Provide a maintenance panel—a diagnostic aid that helps locate a faulty circuit—and a means for adding a redundant common control circuit for higher reliability, when required (see page 308 for illustration of maintenance panel).

Small Crossbar Switch

By September 1971 project team members also agreed that the 812A would use the small crossbar switches operating under the direction of electronic common control circuitry that uses silicon integrated circuits and wired logic (see "Block Diagram of 812A PBX," page 307).

Crossbar was chosen because it affords the lowest cost alternative for the switching network. Furthermore, the small version of the crossbar switch has several advantages:

- Less floor space is needed on the customer's premises because the switching network occupies less than half the space required for an identical network of conventional crossbar switches.
- Switching network connections can be set up faster, allowing the common control to process more calls per hour.
- Fewer frames, connectors, and cables are needed. The savings from this feature alone nearly offset the higher initial cost of small crossbar switches.

An electronic common control was used because it could handle the expected calling rate over the 400- to 2000-line range better than electromechanical technology. The logic functions of the common control are provided by Diode Transistor Logic (DTL) integrated circuits (see page 309 for illustration of circuit pack). The most important characteristic of DTL circuitry is that it has higher immunity to externally-induced electrical noise than any other type of integrated circuit logic. This is particularly important for use in electronic circuits that control relays and switches whose windings produce electrical disturbances when de-energized. The family of DTL circuitry (plus a special-purpose circuit), developed for another PBX, were adaptable for the 812A with only minor modification.

Some Basic Assumptions

Because the market study showed that this new system was needed by the Operating Companies, all organizations at Denver (AT&T, Bell Labs, and Western Electric) aimed to ship the first system twelve months after the start of design—faster than any Bell PBX system yet developed. Before the design process began, however, some basic assumptions were agreed upon:

- All additional requirements that became apparent during the development process were to be scrutinized as carefully as the original system re-

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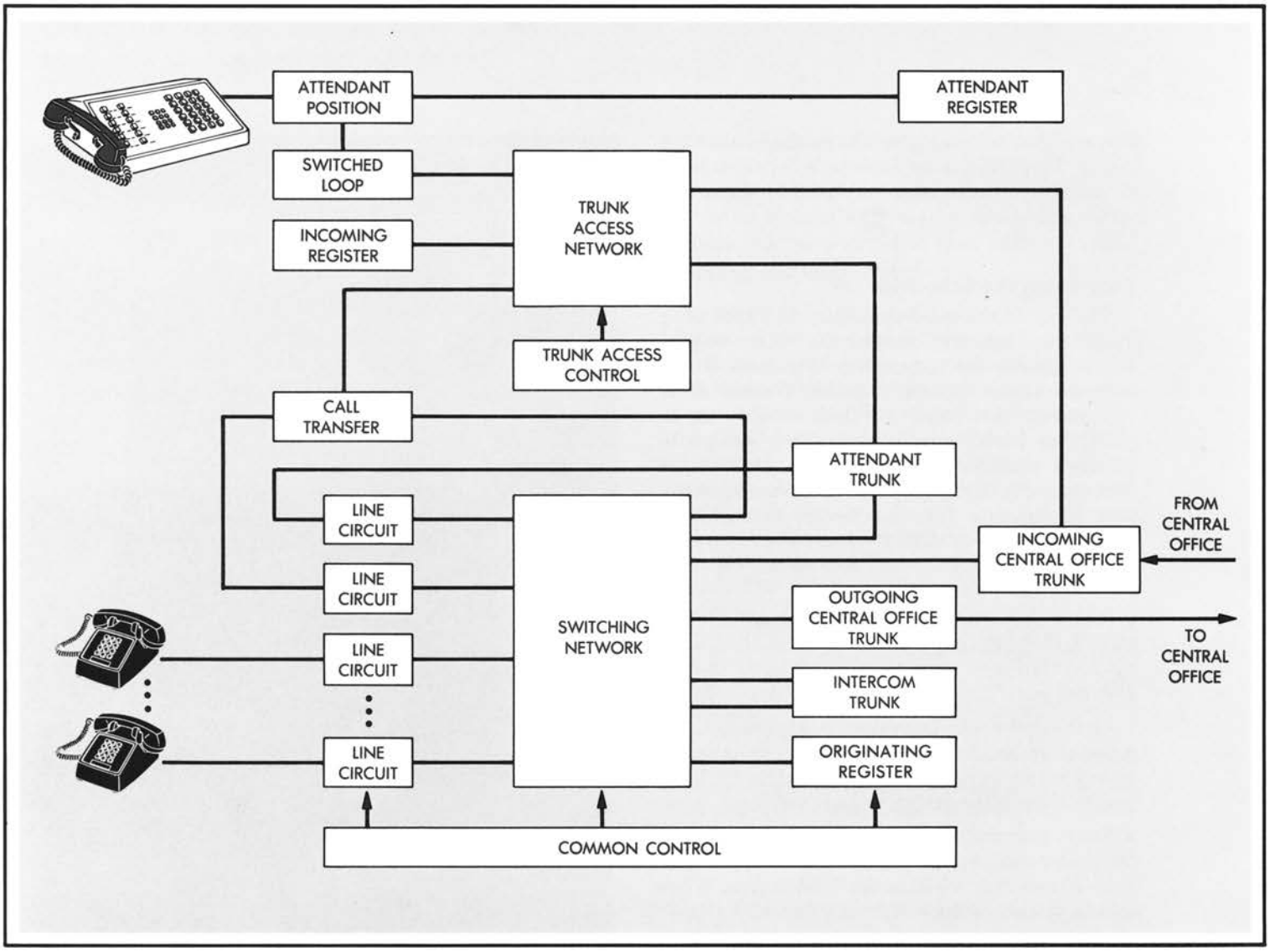

BLOCK DIAGRAM OF 812A PBX

The 812A has two switching networks, both of which use small crossbar switches: (1) the main network (bottom) which connects all stations to the registers and trunks under control of the electronic common-control circuit and (2) the trunk access network (top), controlled by an autonomous relay controller, which connects incoming trunks to switched loop, incoming register, and attendant or call transfer circuits. This arrangement reduces the amount of call switching operation controlled by the main common control, thus enhancing the total call capacity.

quirements before being adopted. This precautionary measure was taken so that the project team could evaluate how desirable each new requirement was and what effect it would have on the accelerated development schedule.

- All technology used in the 812A design had to be available off-the-shelf so that Western Electric in Denver could start manufacture immediately upon release of design information. The project could not wait for the design of new devices.
- Retooling had to be avoided. To make up a PBX unit, relays, crossbar switches, and circuit packs would be manufactured on existing facilities, tests would be conducted on existing facilities, and units installed on available 770A-type frames and cabinets.
- To make functional changes more easily during early design phases, the input and output leads of all logic circuits were brought out to the terminals of the packs. Functional wiring was then done on

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the connector terminals located on the back of the frame. This practice—a departure from the functional circuit pack philosophy used in other 800 series PBXs—also reduces the number of circuit pack codes that need to be designed and stocked.

Shortening the Schedule

Analysis of the normal process of introducing a newly-designed PBX showed that there was no way to achieve the 12-month goal without taking some short cuts. Both Bell Labs and Western Electric agreed and committed themselves to go as quickly as possible from preliminary design to standard manufacture. Specifically, this meant that many of the process steps which are normally done in sequence (physical design to standards engineering, for example) would have to be done concurrently. Some of the steps taken to shorten the schedule:

- Preliminary parts lists were prepared by Bell Labs early in the design process. These lists were used by Western Electric to order parts for the first five PBXs.
- As the first preliminary design information was released by Bell Labs, PBX equipment units began to be built on existing Western Electric facilities —even though the design had not yet been tested.
- While the production units were being made, the preliminary design was being checked using a simple laboratory model of the 812A system. When system testing of the model was completed, design changes were then made to the production units.
- Members of the project team—AT&T, Bell Labs, and Western Electric—met weekly to monitor all steps in the design and production process.
- Preparation of Bell System Practices (BSPs) began with preliminary design information so that a set of BSPs could be shipped with the first PBX unit. Frequently, BSP writers got information directly from the designers because the design process had not advanced far enough to prepare formal schematic drawings or circuit descriptions.
- "Hands on" training courses were prepared by Bell Labs for plant personnel in the Operating Companies and for installers at Western Electric. A course was also prepared for equipment engineers to assist them in ordering equipment and specifying options. At the same time, Western Electric's engineering organization at Denver prepared a computer program for mechanizing the ordering of the various 812A configurations needed by customers. Before the first system was shipped, Mountain Bell installers and engineers participated in the first "user" training course.

Maintenance panel. Larry A. Hendren, Communications Serviceman from Mountain Bell, monitors a test call being processed by an 812A PBX installed at Bell Labs' Denver location. This panel helps a craftsperson locate problems quickly and efficiently.

Circuit pack for 812A PBX. Silicon integrated circuits are used in the 812A electronic common-control circuit, line supervisory circuits, automatic number identification circuit, and the interface between the common control and traffic circuits. All circuits are packaged on printed wiring boards for plug-in mounting.

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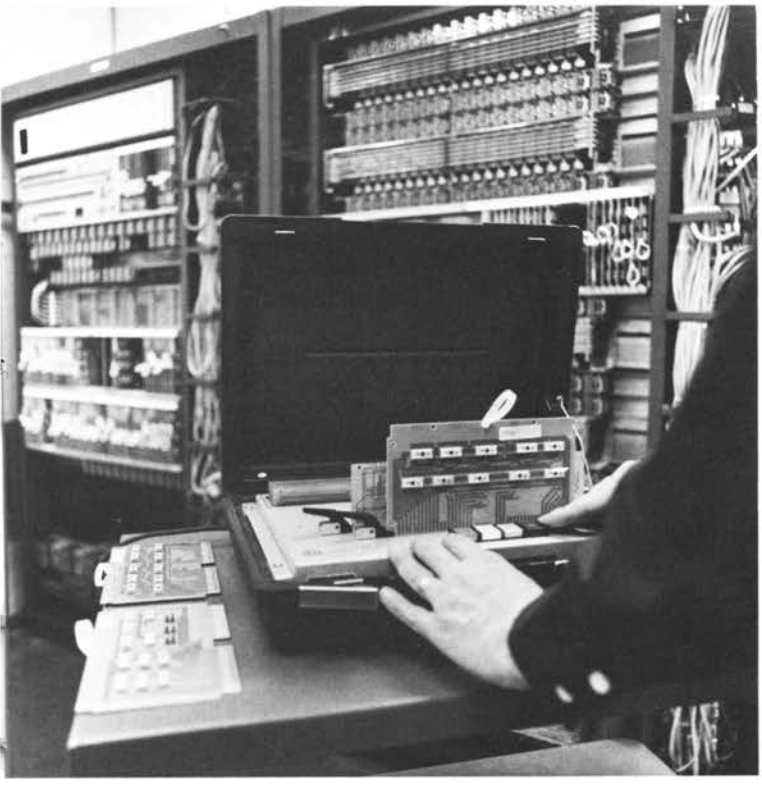
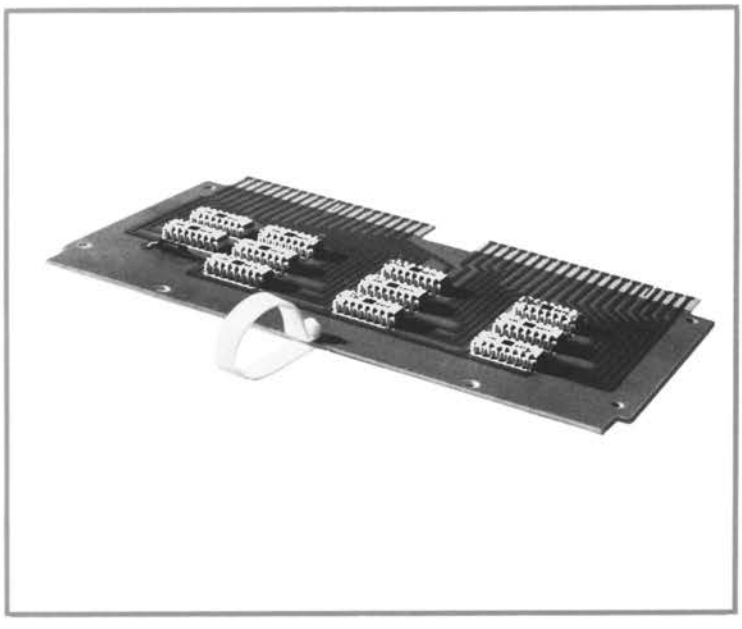


Testing circuit packs in the field. Craftspeople can check whether circuit packs are good or bad by plugging them into this portable test set and pressing the "test" button. A lighted lamp indicates whether the circuit pack "passes" or "fails."



• A normal field trial was not to be conducted. Instead, the first production system was built and shipped to the field for regular customer service. Bell Labs, at Denver, would be the first customer.

Shipping the First Unit

By September 1972, system tests on the laboratory model had progressed far enough to validate the fundamental design concept. Changes were then made to the preliminary design, and final design information was issued to Western Electric. On October 15, 1972—less than 13 months after start of development—the final test was completed on the first 812A system and the unit shipped to Mountain Bell.

Mountain Bell cut the system over in December 1972, providing Bell Laboratories with Centrex I service. The cutover was smooth and commercial service was off and running. The system has served excellently ever since. Because the first system was located at Denver, Bell Laboratories could conveniently observe installation and maintenance procedures, and try out changes or additions to improve the equipment.

As with any new system, design problems have been uncovered and design changes have occurred since the first system was shipped. While these problems and changes can be cumbersome to handle in the field, the total number of field changes is not significantly higher than that found in a "classical" development process which takes much longer. AT&T, Bell Labs, and Western Electric are following up the 812A installations in the field to uncover design problems, monitor installation and troubleshooting procedures, and incorporate design improvements. For example, AT&T monitors and evaluates the performance of all customer installations, most of which received on-site attention in 1973 from either Bell Labs or Western Electric engineers, or both. And to make sure that reports from the field are not overlooked, 812A project team members meet weekly.

Of the 58 systems shipped during 1973, eleven have had special assemblies added by the Operating Companies to meet specific customer needs. In addition, several new standard features have since been incorporated because of widespread demands in the market. AT&T continues to monitor and follow up all systems in the field so that new features can be provided as needs arise.

The installed price of the 812A has attained its original goal of providing basic PBX and Centrex services at low cost. In fact, one thing is certain: the 812A is the lowest-priced system available within its line range and capability. □

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