Bell Laboratories

RECORD

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Cover

The bald eagle, symbol of our country's pride and independence, perches behind a station set designed for the AUTOVON system. The Bell System is making a major contribution to the national defense effort by providing AUTOVON, a communication network that will link U. S. military installations all over the world.
(See the article beginning on page 106.)

Unique features to meet specific requirements for global defense are incorporated into AUTOVON, the first worldwide communications switched network. When fully operational in 1970, it will link some 1700 military installations with 2300 access lines.

AUTOVON

Switching Network for Global Defense

J. W. Gorgas

A NEW ERA in military communications began in April 1964 when the U. S. Army's SCAN (Switched Circuit Automatic Network) and the Air Force's NORAD (NORth American Air Defense) network were combined to form AUTOVON (AUTOmatic VOice Network). AUTOVON, the first worldwide switched network for private telephone and data transmission, will permit almost instant contact between military bases that may be miles, nations, or oceans apart. The system is expanding rapidly, superseding costly point-to-point and slow manually switched communications, and providing service of much higher quality.

Primarily, AUTOVON serves the Department of Defense, and other specified government activities, handling voice, encrypted voice, and data communications. It serves a broad spectrum of traffic, ranging from critical command and control communications to everyday administrative calls.

When fully operational, this global network will be divided into two parts—Continental United States (CONUS) and overseas. The users are spread over hundreds of government installations throughout the fifty states, Canada, the Pacific, Europe, and the Caribbean. By 1970, the AUTOVON network of trunks and access lines will be equal in circuit mileage to the entire Bell System toll network during the early 1950's.

The Defense Communications Agency (DCA), the agency responsible for planning, implementing, and managing AUTOVON, has established three major objectives for the network in order of priority: survivability, quality of service, and economy. The Bell System has undertaken a major role in assisting DCA in the planning, implementing, and managing of the CONUS portion of AUTOVON, and a minor role in the overseas portion. With the exception of Hawaii, the overseas portion of AUTOVON will be government-owned and maintained. Bell Telephone

The AUTOVON network, when fully operational in 1970, will link military bases and command posts (like this one at Stewart Air Force Base, Newburgh, New York) throughout the world.

	Quantity (3/1/68)	1970*	
		CONUS**	Overseas
Access lines	13,771	21,000	1924
Intertoll trunks	5722	12,000	935
4-Wire switching centers	38	74	18
Installations served	1400	1700	270

*The figures in these columns are subject to considerable revision in the future.
**CONUS is the name given to the area comprised of the 48 states, Canada, Alaska, Greenland, and Bermuda.

The growth of AUTOVON may be seen in the table above.

Laboratories has undertaken huge development programs to give the military the best communications capabilities afforded by today's technology.

The prime objective of survivability of AUTOVON communications even in the event of severe damage to communication facilities has received intensive study. The result is a new network concept, called "polygrid." Switching centers, each of equal importance, are located away from prime target zones. In contrast to the Bell System's Direct Distance Dialing (DDD) hierarchical network, where routing has to follow rigidly determined paths through the hierarchy, AUTOVON's polygrid network provides for alternate routing around disabled centers over any one of many independent paths.

To make AUTOVON possible, Bell Laboratories undertook extensive planning and development in such areas as switching, transmission, station equipment, PBX's, and signalling. Unlike the commercial Bell System 2-wire network, AUTOVON provides communications on a 4-wire basis all the way from the originating subscriber to the terminating subscriber. In the switching area alone, development of switching for end-to-end 4-wire communication required a sizeable effort. Development began in 1959 with the redesign of the No. 5 crossbar system to handle 4-wire communications. Development of a 4-wire electronic switching system (ESS) followed very soon after the No. 5 crossbar development. By mid-1968, ESS offices will outnumber crossbar offices.

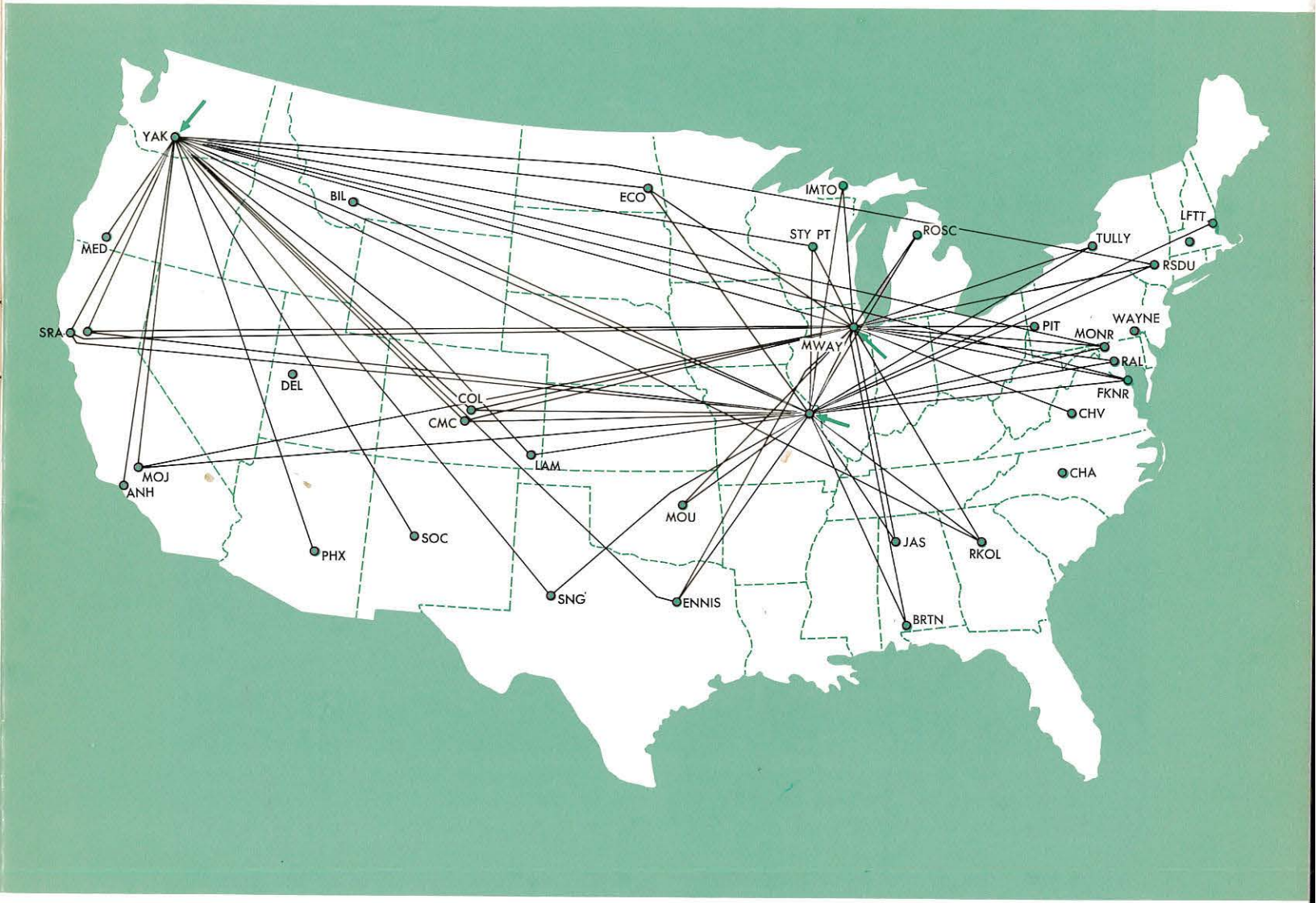
Connections between 4-wire lines are free from echo problems. A large number of 2-wire lines are also served by AUTOVON, however, and connections to these lines do require echo suppression. For these connections, a split echo suppressor (one that controls echoes from one end only) is switched in on connections to 2-wire access lines.

The primary function of AUTOVON is to complete command and control calls rapidly. As a secondary function, AUTOVON handles administrative traffic. The larger network required for administrative traffic permits more diversified services with greater economy. The demand for immediate completion of command and control calls, however, requires that precedence be given these calls. To meet this requirement, a new feature called multi-level precedence preemption was added to permit calls of higher precedence to preempt a trunk or line associated with a call of lower precedence. The feature provides five levels of precedence with four levels of preemption.

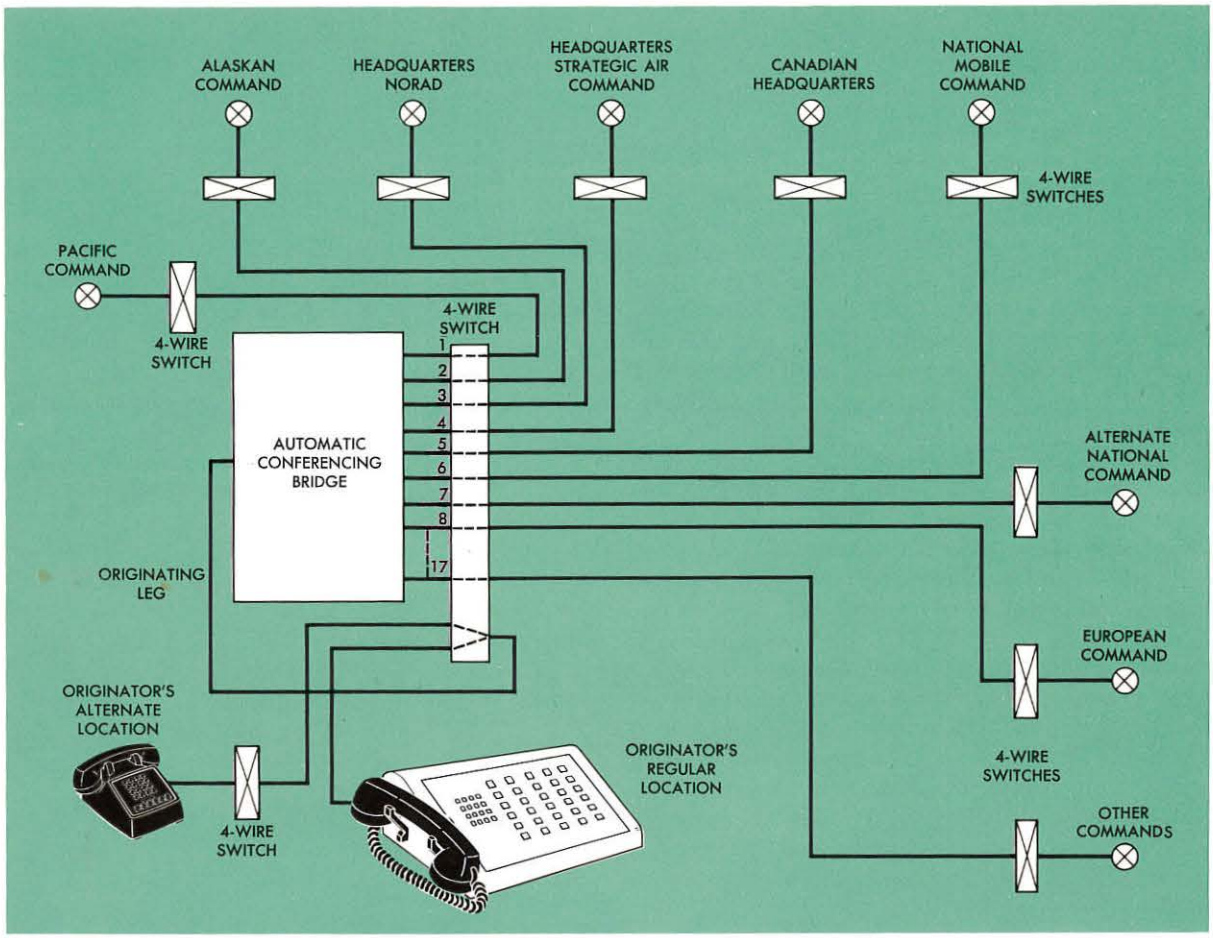
Special 16-button TOUCH-TONE® telephones were designed to implement the precedence feature. The ten basic buttons of a standard TOUCH-TONE set are retained. Two new buttons, marked with a "star" and "A," are located to the left and right of the "O" or "operator" button, respectively. A new column of four red buttons is added to the right of the existing buttons; these are designated FO, F, I, and P, from top to bottom. The P button represents the lowest precedence level which can preempt only routine traffic, while FO represents the level which can preempt any other level of traffic. (The five levels of precedence established for AUTOVON and the corresponding buttons on the TOUCH-TONE telephone are shown in the table below.)

Name	Precedence Button
Flash Override	FO
Flash	F
Immediate	I
Priority	P
Routine	None

The precedence buttons corresponding with the five precedence levels are listed in the table above.



A small fraction of the AUTOVON trunk network in the continental United States (CONUS) is illustrated in the map above. Typical polygrid trunking arrangements for three AUTOVON switching centers (arrows) are shown. The complete trunking for the other centers would be similar. The distribution of trunks is such that all switching centers are virtually equal in their routing capabilities. The extensive alternate routing permits calls to be completed over any of a number of route choices, bypassing as necessary any damaged sections in the network.



The ability to set up preset conferences automatically is one of the features available in AUTOVON. A typical call array for automatic conferencing is shown above. Up to 17 conferees can be reached automatically. Manual conferencing is also provided for AUTOVON users.

Administrative calls are made on a routine precedence level and require no special action. Authorized AUTOVON station users place higher precedence calls, however, by pressing the appropriate precedence level button prior to dialing the call. The call is "tagged" with the appropriate precedence level, and central office control equipment searches for an idle trunk. If no circuits are available, a call of lower precedence is automatically preempted. An access line or interoffice trunk so tagged, however, cannot be preempted by a call of equal or lesser precedence. A signal lamp at the called telephone flashes at a distinctive rate to alert the user of a priority call. A special "precedence" ringing signal also alerts the called party. A unique tone notifies users when they are preempted by calls of higher precedence.

The AUTOVON numbering plan is similar to the familiar DDD numbering plan. Area codes are assigned for large areas of the world in AUTOVON. Separate area codes are required for CONUS, Europe, Alaska, the Pacific, and the Caribbean. A call to Europe will be placed from CONUS, for instance, by dialing a 3-digit area code ahead of the normal 7-digit European station address.

Unlike the DDD numbering plan, however, two codes may be prefixed to the 7- or 10-digit station address. The first prefix is the priority digit mentioned above. The other is known as the routing code (two digits). This innovation labels the call to insure that the grade of trunking required is established throughout the connection. Currently, two grades of trunking are provided: voice grade and special grade. The special grade trunk provides delay and amplitude equalization required for high-quality digital transmission for data and encrypted-voice communication.

The routing prefix is added by dialing "1" followed by a second digit. The currently assigned numbers for the second digit are:

9, 8, 7	Unassigned.
6	Off-hook service, special grade—not dialable.
5	Off-hook service, voice—not dialable.
4, 3, 2	Unassigned.
1	Special grade.
0	Voice grade.

To place a call, 4-wire AUTOVON users, after receiving dial tone, first indicate a precedence level (if required) with one of the special TOUCH-TONE dial buttons. Next, a routing code may be dialed for special-grade transmission. The called network address (7 or 10 digits) is then dialed. AUTOVON processes the call unless the user has dialed a precedence level or a network address which is denied his line. (The user is so notified by a tone or recorded message.)

In addition to the precedence preemption feature, AUTOVON provides certain subscribers with "off-hook" service. These "hot lines" were first used on automatic switched networks when the NORAD network went into service in November, 1963. With these lines, the mere lifting of the handset or the operation of a single push-button is all that is needed for these subscribers to be automatically connected to their hot line "mates." A preprogrammed precedence level is automatically assigned to their calls. Service on these lines is so rapid that the user may not be aware that his call is switched.

Another, more complicated feature incorporated into AUTOVON is the ability to set up preset conferences automatically. A conference originator keys a number representing the desired set of conferees that he wants to reach. The addresses of the conferees, stored in memory, are reached automatically. Currently, up to 17 conferees may be included in this manner. New arrangements under development will increase the number of conferees and allow random addition or removal of conferees. When the conference number is received by the switching machine, special equipment associated with a full 4-wire conference bridge begins immediately to establish calls to the conferees. A predesignated precedence level is also assigned automatically, and in a matter of seconds the conferees are brought together on a high-quality conference circuit. If the equipment fails to complete a call to a particular address, it tries again, substituting a preselected alternate address on the retrial. Other types of semiautomatic and manual conferencing are also provided for AUTOVON users.

Another feature that contributes to the reliability and survivability of AUTOVON is dual homing for selected subscribers. In this case, the subscriber is served by two or more AUTOVON switching centers. Dual-homed subscribers have a single address. In this case, AUTOVON centers are programmed to deliver a call via the serving center which affords the most direct route. If the call cannot be completed through that center, AUTOVON routes the call to the other center.

AUTOVON's requirements have been a real challenge to the telephone industry. The Bell System and independent companies have welcomed the challenge and have done their part to provide the most sophisticated communications network possible with current technology.

The future of AUTOVON seems certain to bring more exciting challenges to the communications industry. Already it is clear that encrypted voice requirements will expand rapidly, introducing such things as wideband switching, wideband trunking, and digital transmission, with consequent changes in all parts of AUTOVON. Automatic conferencing will become more sophisticated and will be applied to secure voice more freely than now. Mobile command posts will require new homing and addressing arrangements. Satellite circuits will be commonplace and woven into the complex. Extreme speed in communications will be possible with new signaling techniques. AUTOVON will provide our government forces with an increasingly potent communications tool.