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Fig. 1—A position at a No. 5 switchboard used with the A4A system for handling delayed calls.

Problems in nationwide dialing

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Nationwide operator toll dialing will be fully achieved only after the 4A toll switching system, now under development, is available for use. In the meantime many of the features of nationwide service are being adopted. The latest step in this direction is the A4A (advance 4A) toll switching system. Installations have already been made in Albany, Indianapolis, Baltimore, Washington, Kansas City, and Minneapolis. The A4A is an interim system that performs many but not all of the operations required to give full nationwide dialing. It will take care of the most pressing needs of the toll system, however, until the development of the 4A system has been completed.

Operator toll dialing was first employed with step-by-step intertoll equipment in isolated networks where the local dial equipment was step-by-step. The rapid growth of the toll business in recent years emphasized the need of improvements, and also of toll dialing facilities for panel and crossbar cities. The studies which followed resulted in the development of improved and longer range equipment for step-by-step areas[1] and of the No. 4 toll crossbar system[2] for panel and crossbar areas. The first No. 4 office was placed in service in Philadelphia on August 22, 1943, and has proved highly successful. Additional No. 4 systems are now in operation at New York, Chicago, Cleveland, Oakland, and Boston.

The No. 4 system introduced several desirable improvements. It was the first system using four-wire switching.[3] Transmission through the No. 4 is on a separate pair of wires for each direction of conversation. It was also the first to use multi-frequency pulsing,[4] both for operators keying into the system and for transmitting information[5] from a sender in one place to a sender in a distant place. Other features of the No. 4 provided improved facilities for handling delayed calls.[6]

Both step-by-step intertoll and No. 4 are arranged to handle direct and switched toll calls. Direct toll calls use only a single toll line. Switched toll calls without the assistance of intermediate operators are generally limited to two or three intertoll links in both systems. For direct toll calls the outward operator dials the listed directory number if she plugs directly into the toll line, but precedes the listed number by an arbitrary code if she reaches the toll line through the machine. For switched connections, the subscriber's number is always preceded by a switching or trunk group code. For each switching point, this code is a set of from one to three arbitrary digits in the step-by-

[1] RECORD, *May*, 1940, *page* 266; *May*, 1941, *page* 266. [2] *November*, 1943, *page* 101; *April*, 1944, *page* 355. [3] *May*, 1945, *page* 151. [4] *December*, 1945, *page* 466. [5] *September*, 1944, *page* 528. [6] *December*, 1944, *page* 614.

step system, and three arbitrary digits in the No. 4 system.

In both step-by-step and the No. 4 toll switching systems, the code prefixed to the subscriber's directory number represents a single toll route, and thus when a sequence of toll links is required to complete a call, the individual codes for the trunk groups involved must be combined in the proper order and dialed by the originating operator. Code 215, for example, is the trunk group code for the group from Cleveland to Philadelphia, 302 is the trunk group code for Philadelphia to Wilmington, and 17 is the trunk group code for Wilmington to New Castle, Delaware. A call from Cleveland to New Castle therefore uses the code 21530217 plus the subscriber's number. Moreover, there are many calls more complicated than this one. It can be readily imagined that very unwieldy digit combinations would be required if such a system were used with the full nationwide dialing plan, which permits a maximum of seven switches. Another objection to such trunk group codes is that a different set of code digits would be required whenever the operator selected an alternate route. Systems using codes in this fashion are thus clearly not suitable for full nationwide dialing where multi-switched calls and automatic alternate routing are essential parts of the plan.

When the desirability of full nationwide operator dialing* became clear, it was obvious that a different system would be needed. The objectives set forth for this system were the dialing of all toll calls to completion by the outward toll operators, the use of a universal numbering plan requiring a maximum of ten digits (eleven for party lines), essentially "no-delay" service, and arrangements which would place no impediments in the way of ultimate subscriber dialing of toll calls, if and when that should

*RECORD, *October*, 1945, *page* 368.

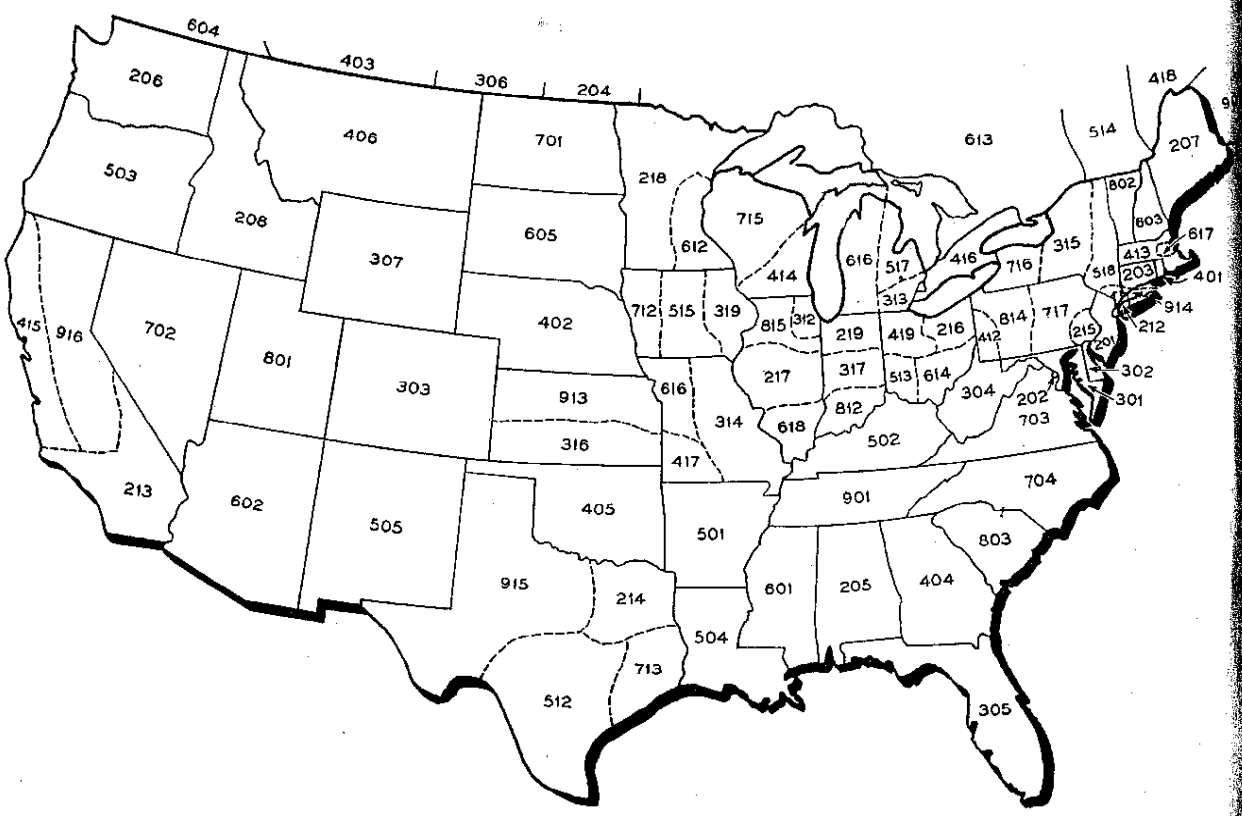

Fig. 2—Numbering plan areas and their codes that will be used for nationwide dialing.

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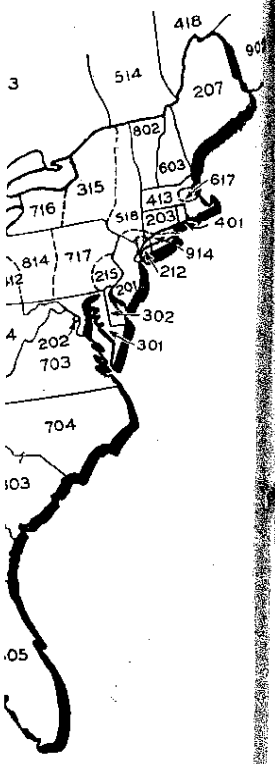

be needed. It is this sort of service that the 4A toll crossbar system now under development will give.

For the ultimate nationwide dialing system, which the 4A will make possible, the United States and Canada have been divided into eighty-eight numbering-plan areas, each with a three-digit code having a 0 or 1 in the second position. The area code for Wyoming, for example, is 307 and for southern California it is 213. The 0 in the middle position indicates that the numbering-plan area covers a whole state and the 1 that it is part of a state. These areas and their codes are shown in Figure 2. Within each numbering-plan area, each central office is given a nonconflicting three-digit code such as CH3. If a call is for a place in the same area as the originating toll center, the central office code followed by the subscriber's number is dialed. If the call is for a foreign area, the area code of the called place is prefixed. Thus a maximum of ten digits (eleven if a party digit is used) serves to designate any telephone with a unique telephone address that will direct calls to it from any place in the country.

With such a system in effect, an originating toll operator receiving a call for some distant point will dial the three-digit area code for the area in which the called office is located, the three digits for the office in that area, and then the four or five digits for the subscriber's number. When there is only one route to the called area, the first three digits will cause the switching apparatus in the originating office to select an idle trunk of a preferred group over which that area may be reached. If the selected trunk goes directly to the area dialed, the sender at the called office will then transmit only the office code and station number. If there are intermediate switching points outside the called area, however, the sender will transmit the area code as well as the office code and station number. At each intermediate office, the area code will be used to guide the selection of a suitable trunk, and will be retransmitted at intermediate switching points until a trunk to a point in the called numbering area is selected. One of the things a sender in a 4A system must be told, therefore, is how many of the digits it received it should send on, or "spill forward" as this method of transmission is called.

This is only one of the many abilities that control equipment in the 4A system must possess. If there is only one route to an

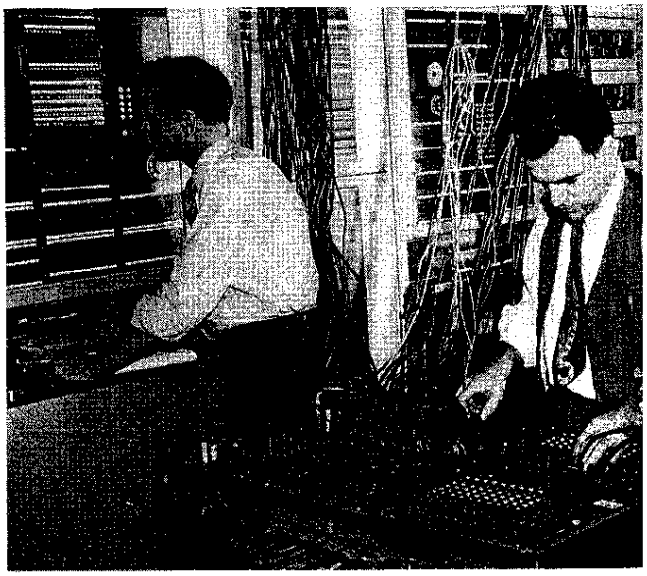

Fig. 3—Making load tests on the A4A system at Albany prior to cutover.

area, translation of the three-digit area code alone is sufficient to enable a marker to select a suitable route. Since to any one area there may be several routes by way of which offices in that area may be reached, however, the area code alone is not always sufficient. The three-digit office code that always follows the area code may also have to be translated. Once the marker has selected a suitable trunk as a result of this translation, the sender then spills forward the entire code or whatever part of it is required under the existing conditions.

It is economical in the nationwide switching plan to retain the existing step-by-step toll switching trains, which employ arbitrary trunk group codes. In such situations, the sender in the 4A office preceding the step-by-step train must drop the area code and the office code that had been used up to that point, and substitute an arbitrary code furnished by the decoder. It is necessary for the decoders, markers, and senders of the 4A system, therefore, to be able to take cognizance of all these facts, and at each switching point to send on the code required to

reach the desired destination whether it is an area code and an office code, an office code and a station number, a station number alone, or one or more arbitrary trunk group codes to switch the call through step-by-step equipment. Besides having the ability to spill forward or not spill forward all the digits it receives, it must be able to delete some digits and substitute others. It must also be able, should it find all trunks of a particular group busy, to select an alternate route when available.

Certain of the conditions that require more or less special action on the part of the decoders and markers at the originating office are indicated in Figure 5. On a call from Cleveland to Philadelphia, for example, the outward operator probably knows that Philadelphia is in a foreign area and may remember the area code, but if she is in doubt she refers to her bulletin which tells her to dial "area code 215 + 2L +." She therefore dials 215 followed by two letters of the office name followed by five numbers. From Cleveland there are first-choice high-usage direct trunks to Philadelphia, and if these are busy, the equipment at Cleveland will try an alternate route. It is capable of trying several alternates up to and including a last choice, liberally-engineered, group. For this particular call, however, the first alternate via Pittsburgh is also the final group. If a trunk in this group is idle, the equipment will select it and spill all the digits to Pittsburgh. The Pittsburgh 4A tries the high usage direct group from Pittsburgh to Philadelphia and if this is busy, tries the group to New York. If this group also is busy, it selects an alternate route via St. Louis. From St. Louis there are permissible alternate routes to Philadelphia, made possible by use of universal destination type codes and liberal translating facilities.

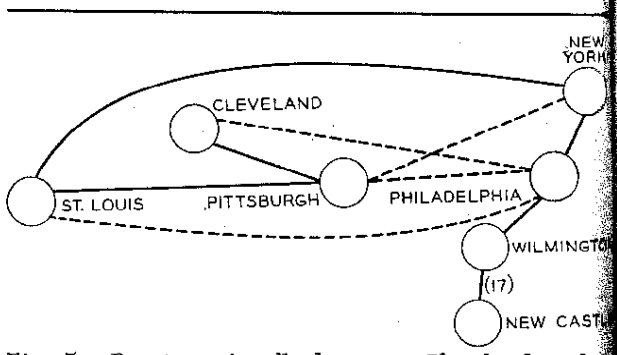

Fig. 5 — Routing of calls between Cleveland and Philadelphia. High-usage routes are shown dashed and final routes, solid.

The use of code conversion may be illustrated by a call from Cleveland to New Castle, Delaware. Since subscribers in New Castle have only four-digit numbers, the operator at Cleveland consults her bulletin and finds that the office code for toll dialing purposes is 638. She thus dials the area code 302 followed by the arbitrary national office code 638 followed by the numerical digits. The code digits dialed serve to reach Philadelphia, but from this point the arbitrary trunk group code digits 17 are required to drive the step-by-step switches at Wilmington to select a trunk to New Castle followed by the numerical digits to drive the switches at New Castle. The Philadelphia 4A must therefore drop the first six code digits and substitute 17. The code conversion feature of the 4A system permits it to do this.

The determination of what code information to use in the immediate 4A office and what to send ahead to the succeeding office which may be one of several kinds is one of the basic problems of the 4A system. The examples cited above could be supplemented by many others. However, these are

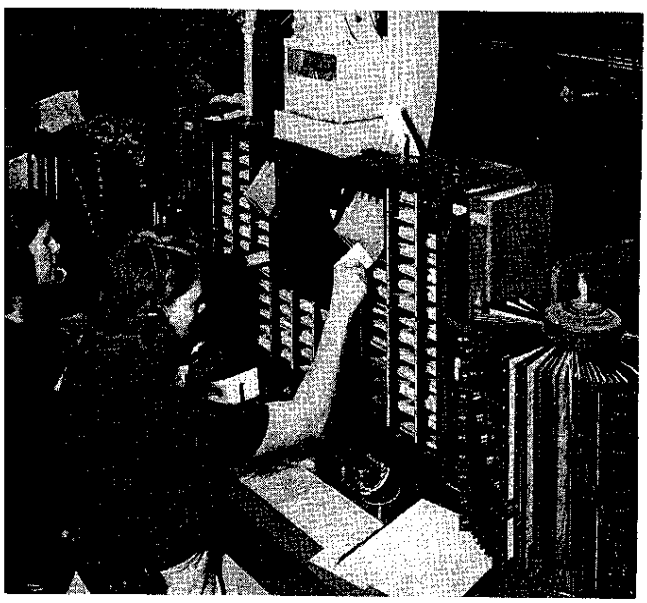

Fig. 4—A ticket filing and rate quoting position in an A4A office.

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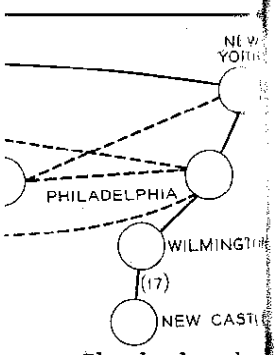

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quite typical and adequately illustrate the complicated nature of the code handling required. There are very many such coding problems encountered in nationwide dialing. They have all been studied and can be handled by the features which permit variable spilling (skip no digits, skip three digits, and skip six digits) plus code conversion. For alternate routing it is also necessary for the switching circuits to be able to determine when an area code has been dialed and what the area code is at the far end of the trunk used for alternate routing.

ment of the 4A system, it became evident that the work could not be completed in time to take care of the most necessary needs for new toll switching facilities. As a result, it was decided to get out an interim design to provide much needed additional toll dialing facilities until the 4A became available. This interim system is the A4A, already referred to. Besides giving some of the features to be provided by the 4A, it is designed to be readily converted to provide all of them when they become available. Until the completion of the 4A, the A4A will be installed instead of the No. 4 system.

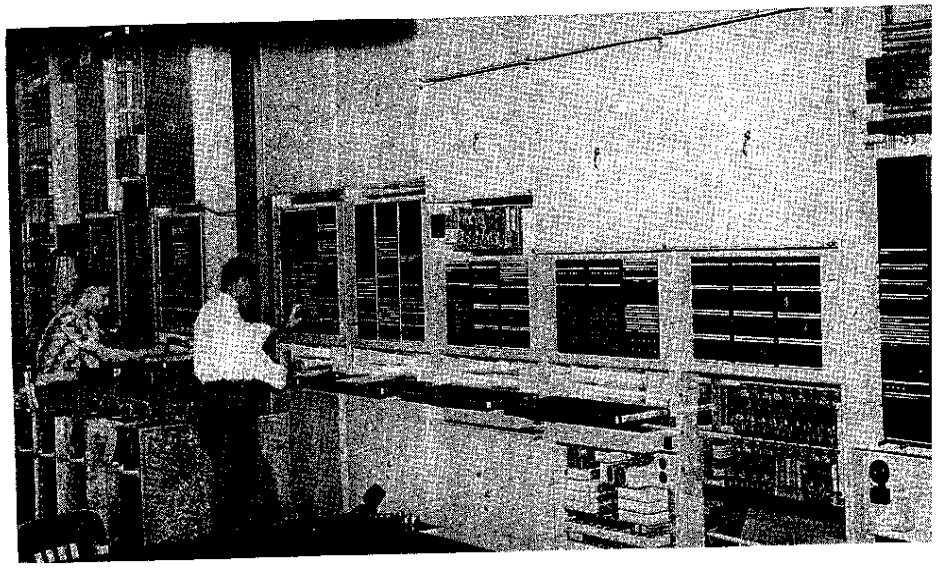


Fig. 6 — A maintenance center in an A4A toll office.

Destination type codes have two major advantages. They permit a universal coding scheme with a maximum of eleven digits, and they make automatic alternate routing practicable. To determine routing data from a destination type code, however, it is necessary to make a translation. In the 4A system this may be a translation of the area code alone, the area code plus the central office code or the central office code alone. The code digits translated are determined by the amount of information required to advance the call along the desired route. For example, if all calls to an area use the same route from a given 4A, then the area code alone determines the route. If there is a choice of routes into an area then both area and office codes are required. If the call has advanced to the called area then generally the office code alone suffices.

During the early stages in the development of the 4A system, it became evident that the work could not be completed in time to take care of the most necessary needs for new toll switching facilities. As a result, it was decided to get out an interim design to provide much needed additional toll dialing facilities until the 4A became available. This interim system is the A4A, already referred to. Besides giving some of the features to be provided by the 4A, it is designed to be readily converted to provide all of them when they become available. Until the completion of the 4A, the A4A will be installed instead of the No. 4 system.

The A4A can spill forward all the digits it receives, it is arranged for one-digit code conversion, and it provides for a limited amount of alternate routing. The provision of the spill-forward feature in the A4A, which permits it to send ahead everything it receives, makes possible the use of over 200 destination type codes. These codes have been temporarily assigned to frequently called dial cities on a systemwide basis. For example, the present system code for Akron, Ohio, is the arbitrary 042, and for Toledo, Ohio, it is the future area code 419. In a number of cases the system code assigned to a city is the area code which will be used for the numbering area in which that city is located when the nationwide plan is introduced. This permits the present use of the ultimate codes on a large number of calls. An outward operator in Chicago, for

example, making a call to a New York City office via the Chicago No. 4, dials the ultimate area code 212 followed by the office code followed by the numerical digits.

A typical code layout for a few places reached from the Albany A4A system is shown in Figure 7. Calls for Toledo can be automatically alternate routed via the Cleveland No. 4 and calls for Akron take a first choice route via Cleveland and an alternate via New York. The codes shown in the diagram are all systemwide codes representing cities. For the call to Toledo from the Albany A4A, the operator dials or keys 419, the systemwide code for Toledo, followed by two letters and four numbers normally listed in the directory at Toledo, a total of nine digits. If the direct trunks from Albany to Toledo are busy, Albany will automatically try the trunks to Cleveland and select one if it is idle. It can do this for two reasons. Cleveland, although a No. 4 office, also uses the systemwide code 419 to reach Toledo, and Albany being A4A can spill forward the code 419 to Cleveland for use there after using it at Albany to try first a direct route and then to select the trunk to Cleveland. Of course, Cleveland being a No. 4 office uses up the first three code digits and therefore cannot send the first three digits ahead. Since Toledo needs only two letters of the office name and four numerical digits, and since these follow the code digits which will be absorbed, they can be sent by the Cleveland No. 4.

Another example of A4A coding is also illustrated in Figure 7. Calls from Albany to Akron take a first choice route via Cleveland and an alternate via New York. Here also, since the call originates at an A4A office which can spill forward what it gets, and since first choice and alternate routes are each via single No. 4 which uses a systemwide code for the called point, the destination type of code can be used. Whenever two No. 4's follow in tandem, or step-by-step follows a No. 4, trunk group codes are used.

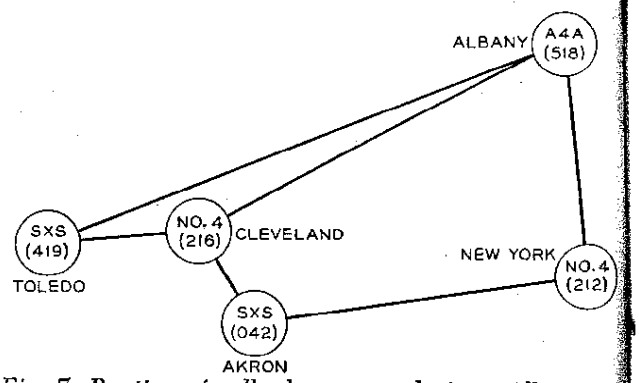
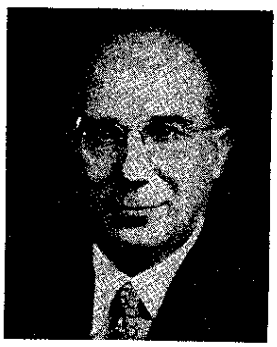


Fig. 7—Routing of calls that are made from Albany to Toledo and Akron.

The problems of routing discussed above are representative of those solved in setting up the nationwide toll dialing plan. It is obvious that the goal of having all toll calls handled on a dial basis entails a tremendous effort. Nevertheless the improvements in service and the economies that will result over present methods of handling toll calls will more than justify this effort.



THE AUTHOR: After receiving a degree of B.Chem. from Cornell University in 1921. OSCAR MYERS joined the Installation Department of the Western Electric Company where he installed and tested panel central offices until 1924, when he joined the Technical Staff of the Laboratories. At first he was with the circuit laboratory, where he tested various circuits, including the decoder sender, and the toll key-pulsing system. In 1929 he transferred to the sender design group where he worked on senders, decoders, and test circuits. In 1932 he took part in the fundamental design work of the crossbar system. Subsequent to that time he engaged in crossbar development and design, in connection with common-control circuits for both local and toll crossbar systems. For the past several years he has been in the Switching Engineering Department engaged in fundamental planning for nationwide dialing.