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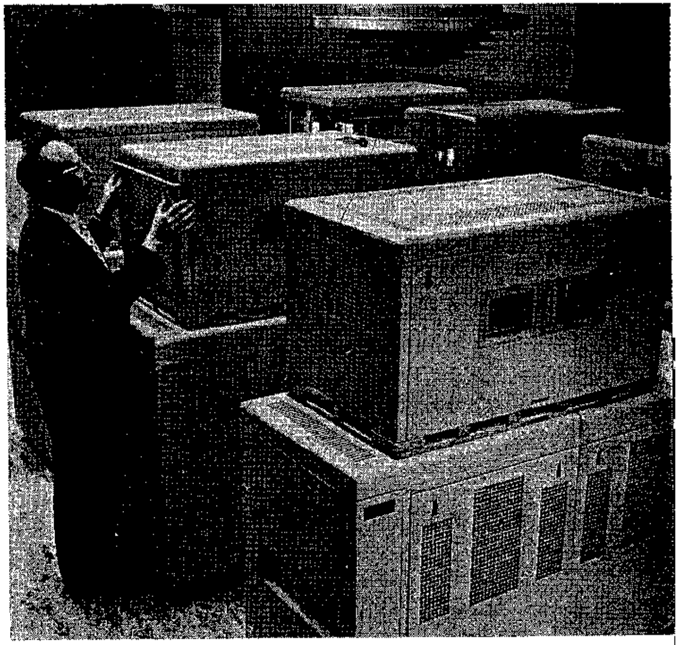

The author at a group of six card translators.

The 4A Crossbar Toll System for Nationwide Dialing

O. MYERS
Switching Engineering

Increased customer dialing in various local areas and operator dialing on toll calls between these areas are bringing nearer the long-range Bell System plan for nationwide customer dialing. To extend the provisions of this plan economically, about 70 key offices in different parts of the country are being provided with 4A crossbar toll equipment. These offices — called Control Switching Points — are being integrated by the Telephone Companies into the existing plant to serve as nerve centers of a nationwide toll network.

Operator toll dialing, already in extensive use throughout the country, is based on the division of the United States and Canada into 90 (ultimately 92 or 93) numbering plan areas* interconnected by a national toll network through some 70 Control Switching Points (CSP's). These CSP's will be the key points in the nationwide automatic switching network, initially for operator dialing, but ultimately for dialing by customers, and it is for use at these points that the 4A crossbar toll system was developed. The primary objective of its development was to incorporate certain ar-

* RECORD, *May*, 1951, *page* 197.

rangements commonly referred to as CSP features. These are automatic alternate routing, the ability to store and spill forward the digits as needed, code conversion, and six digit translation. Without the first two, nationwide dialing would not be economically possible. The other two make the 4A system more economical to operate, producing savings of such magnitude as to justify their inclusion.

The control switching points of the nationwide toll network are classified into four types which differ not in the switching equipment and circuits employed but in the size and importance of the area served, and in the part the switching equipments play in the automatic selection of alternate routes. In the order of decreasing rank the CSP's are: national center, regional centers, sectional centers, and primary outlets. There is only one national center, in St. Louis, but there are eight regional centers and a larger number of sectional centers and primary outlets. All of the CSP's which are themselves toll centers, will serve a surrounding group of toll centers of lower rank, including non-CSP's known as tandem outlets and ordinary toll centers. The tandem outlets act as traffic concentrating units, and may handle calls to and from a number of ordinary toll centers. Part of this general arrangement is shown in Figure 1.

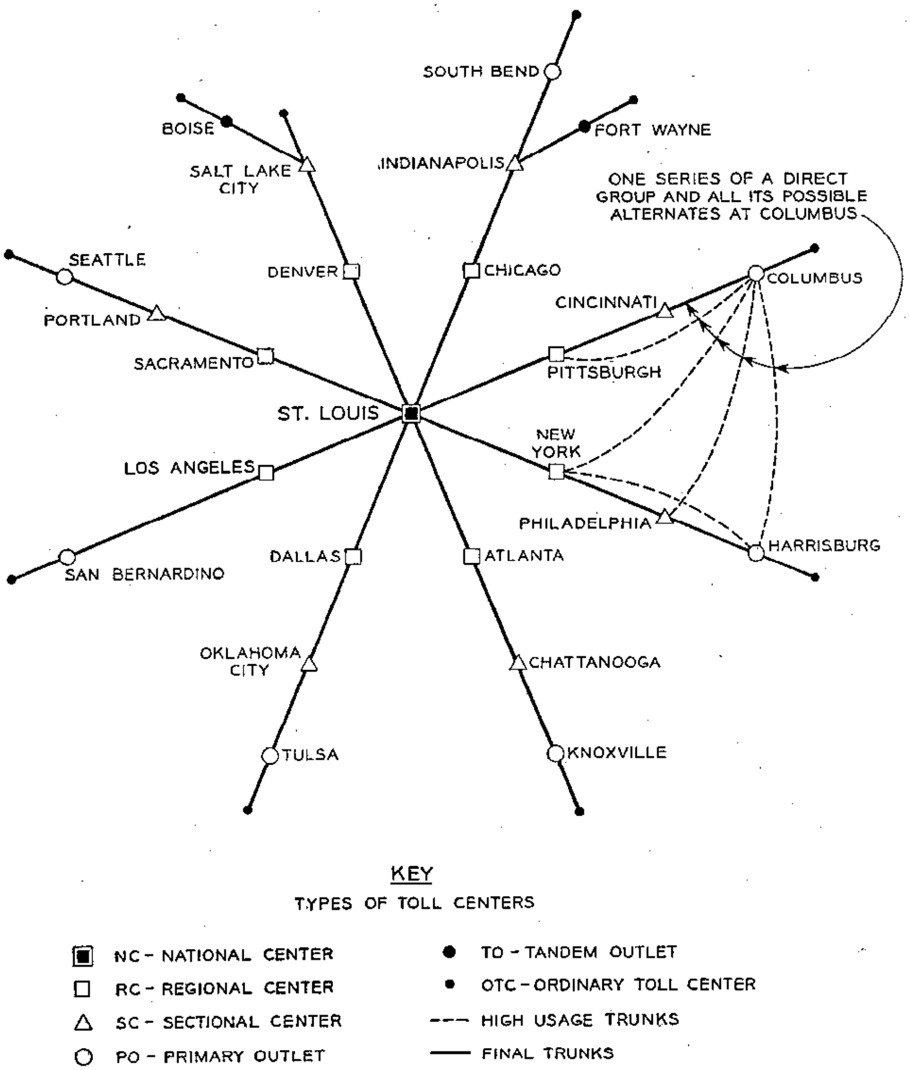

Fig. 1 — Part of the general arrangement of CSP's including tandem outlets and ordinary toll centers.

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This diagram includes the national center and eight regional centers, but there are many more sectional centers and primary outlets than are indicated. In the complete network, the ramification from the regional centers, sectional centers, and primary outlets is also much greater than shown. Each toll center, of course, serves a number of local offices.

The solid-line paths shown connecting the various toll centers in the diagram form the backbone of the national toll network. Each such line represents a group of trunks large enough to handle, with substantially no delay, all the traffic likely to be offered to it under ordinary conditions. These liberally engineered backbone routes form the last choice in the selection of an idle channel. In addition to these final groups, shown by the solid lines, there are less liberally engineered, high-usage groups which may connect any two toll centers where the traffic warrants it. A few such groups are indicated by dashed lines at the right of Figure 1. They are used for the first choice and all the other choices up to the final one.

The photograph at the beginning of this article and those in Figures 2 and 3 illustrate part of the equipment used in the 4A system. Card translators which supply information required for alternate routing, code conversion, and six-digit translation are shown on page 369 and in Figure 3.

As already mentioned, alternate routing is one of the essential features of a CSP. This ability enables the equipment to select alternate routes automatically when no circuits are available in the first choice route. Besides providing protection against complete interruption of service when all circuits on certain routes are out of service, alternate routing contributes greatly to the economy of the toll plant. Peaks of traffic are sporadic and usually do not affect all trunk groups at the same time. By providing adequately for alternate routing, it is possible to load the trunks in the high-usage groups heavily. The likelihood is small that all groups, first choice and alternates, out of a single CSP, over which a distant point might be reached, would all be busy at the same time. With liberal provisions for alternate routing it is therefore possible to use the trunks more efficiently, that is, to have about the same total number of trunks as are required for delayed service, and at the same time, to give substantially no-delay service.

This provision of high-usage first choice trunk groups and liberally engineered final

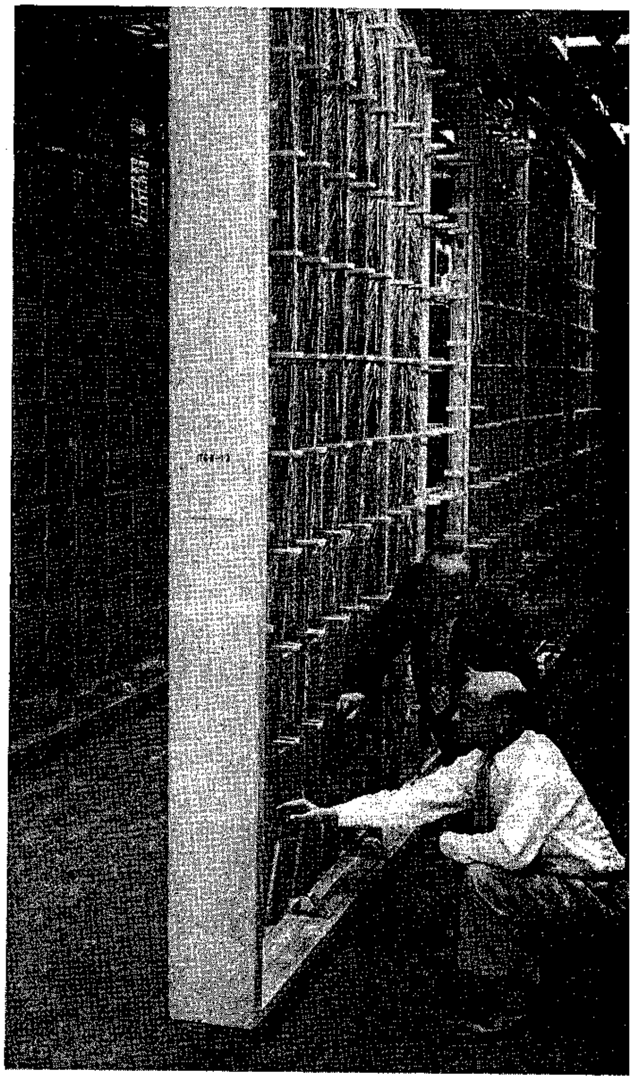

Fig. 2 – E. P. Krausche (front) and the author at a 4A junctor grouping frame.

groups that are selected on an alternate routing basis makes it essential to establish a definite order in selecting the alternate routes. The order employed is called "far-to-near" rotation. This might be more aptly described as a rotation from more direct to less direct, that is, from routes having fewer

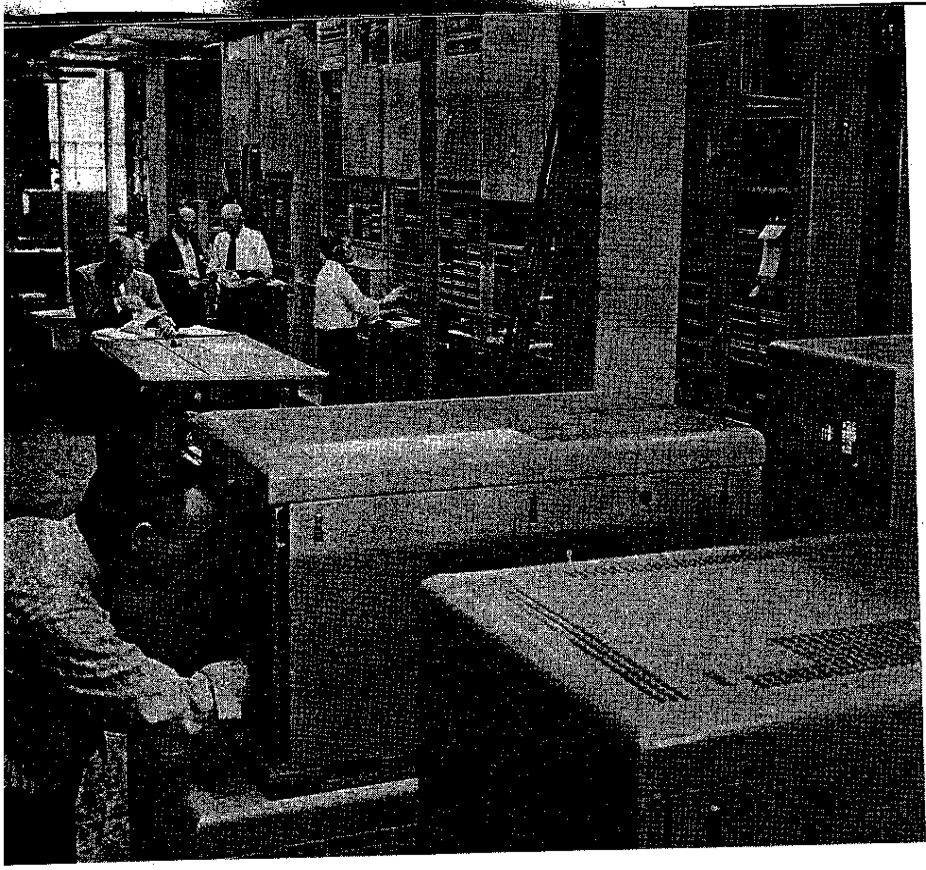

Fig. 3—Part of a 4A sectional center showing a group of card translators in the foreground and another in the background (left) with the maintenance center between them.

to those having more switching points. Suppose, for example, a call comes into Columbus, Ohio, for completion to Harrisburg, Pa. This call could be completed over the final choice circuits of the national network via Cincinnati, Pittsburgh, St. Louis, New York, Philadelphia to Harrisburg. However, Columbus has high-usage trunks direct to Harrisburg, Philadelphia, New York, and Pittsburgh. In seeking an idle channel, the switching equipment at Columbus first tries the direct trunks to Harrisburg. If these are busy, it tries the high-usage trunks to Philadelphia, where the call would be completed over the final group to Harrisburg. Should the group to Philadelphia also be busy, Columbus would try New York. Finding these trunks also busy, it would try Pittsburgh, and on its last attempt it would test the final group to Cincinnati. This rotation thus begins with a route through the fewest switching points, Harrisburg, and rotates in substantially far-to-near order – ending at Cincinnati as the final choice. At each intermediate switching point reached, a similar search for trunks is carried out in the same order of rotation.

The final choice is always that of the liberally engineered "backbone" toll network. Should the trunks in the last group be busy, no further attempt to complete the call would be made. This is obviously the most economical procedure since it results in employing the most direct routes with fewer switches when they are available. The requirement that the order of selection always be in the same direction, however, has other very important advantages.

Using another example, suppose that the selection could proceed in either direction; that a call arrives at New York for completion to Harrisburg; and that all direct trunks between New York and Harrisburg are busy. Under these conditions, New York would select a trunk to Philadelphia. If, in attempting to complete this call, Philadelphia found all its direct trunks to Harrisburg busy, and the circuits were not arranged so that when a final group was found busy attempts to connect would cease, Philadelphia might select one of the trunks to New York so as to complete via that route. The switching system at New York, again finding all direct trunks to Harrisburg busy, would select a trunk to Philadelphia. This cycle would continue until

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all trunks between New York and Philadelphia were busy — just because of a single call to Harrisburg. Such situations are avoided by designing the circuits to rotate their selection in only one direction.

The second feature essential to nationwide dialing is the ability to store all digits received, and to spill forward as many digits, and only as many, as are needed to complete a call. A foreign area call starts out with a three-digit area code prefixed to the office code and station number. All ten or eleven digits must be spilled forward to the next switching point until the switching point next preceding the called area is reached. Here the area code is dropped. Only the office code and station number are spilled forward to that switching point.

The third CSP feature, code conversion, permits the substitution of one, two or three arbitrary digits in place of the area code or the office code or both. There are many step-by-step offices around the country that reach other offices by the use of codes that do not conform to the nationwide plan. Extensive changes and additional equipment would be needed in many places to make these offices respond properly to the nationwide codes. Code conversion makes this unnecessary. A switching system in a CSP equipped for code conversion takes care of such situations automatically. If a call coming into such a switching point is to a step-by-step office requiring special codes, the CSP ahead of the step-by-step equipment decodes the first three or six digits and substitutes the one, two, or three arbitrary digits required to reach the called office over the step-by-step trunks.

Useful by-products of this code conversion feature are the ability to use step-by-step type concentrating switches on calls to certain remote operators, thus saving trunks, and the ability to use a common trunk group to two No. 1 crossbar offices provided with multifrequency senders, and to step-by-step offices under some conditions.

Six digit translation is another feature of the 4A system. The ability to translate six digits effects economy by permitting the selection of the most direct trunk routes in many places where without it a more roundabout path would be selected. If only three digits could be translated, it would be necessary to direct all calls for a given area over the same route. This is illustrated in Figure 4 showing Scranton and Harrisburg in toll area 717 and Philadelphia in the nearby 215 area. An economical trunking plan calls for direct circuits from Philadelphia to both points. With only three-digit translation, however, the route to both places would be selected as a result of translating the area code 717 alone, and therefore calls for Harrisburg, for example, would have to be routed via Scranton. This means not only the expense of extra mileage, but also the introduction of an extra switch. With six-digit translation, the combination of area code and central office code is analyzed making it possible to select the most economical route in all cases.

Six-digit translation in combination with the code conversion feature also makes it possible to enter a toll center served by

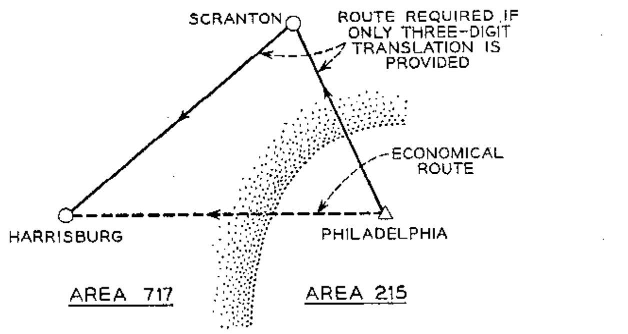

Fig. 4 — Economical routing made possible by the six-digit translation feature of the 4A crossbar toll system.

step-by-step equipment and substitute the arbitrary route codes for the complete area served by it in place of the nationwide dialing type of destination codes. This is illustrated in Figure 5, which shows three typical digit combinations as they might be dialed by an operator under the nationwide dialing plan and as they might be converted by a 4A system to fit the arrangement of a step-by-step toll center serving several tributary offices.

Prior to the development of the 4A system, the No. 4 toll crossbar system was

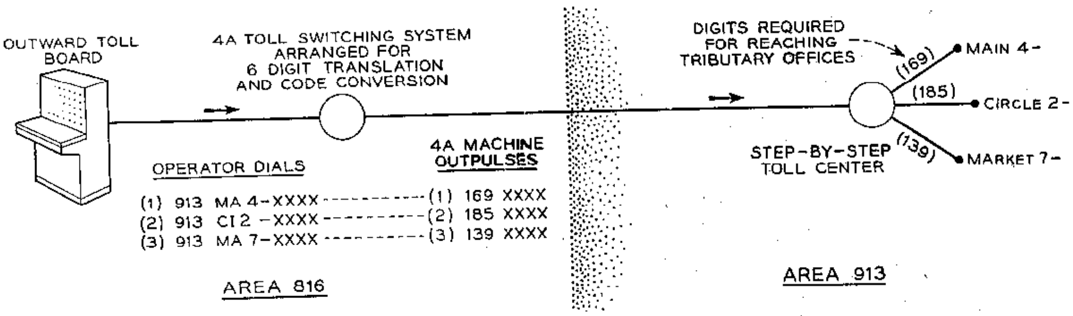

Fig. 5 — Typical three-digit combinations as they might be dialed by an operator and as they might be converted by a 4A system.

placed in service in six cities. The A4A, in service in 13 cities, followed the No. 4 but preceded the 4A. This A4A system includes limited alternate routing features, and the ability to store and spill forward digits as needed. Similarly, with minor modifications already made or projected, the No. 4 crossbar system will include these same features. Both A4A and No. 4 provide for a maximum of three alternate routes with up to 40 trunks per alternate, whereas the 4A provides for five alternate routes with up to 160 trunks per alternate.

The features of automatic alternate routing and the ability to spill forward the required digits are economically essential to a nationwide dialing plan. However, by providing all the CSP features, including code conversion and six-digit translation with which the 4A system is endowed, the resulting switching network will be considerably less costly to operate. Consequently, information is being made available to permit all the described 4A features to be added to either the A4A or No. 4 systems in the field. After this is done the A4A will be identical to the 4A and the No. 4 will be similar to the 4A except in certain details. The converted 4's will be coded 4M.

As planned at present, the 4A will be used at about 50 CSP's. At the remaining potential CSP's, the existing A4A or No. 4 systems will be converted to become the equivalent of the No. 4A.

THE AUTHOR: OSCAR MYERS spent three years with the Installation Department of the Western Electric Company before joining the Laboratories in 1924. Until 1929 he was a member of the circuit laboratory, engaged in testing circuits including the panel decoder sender and the toll key-pulsing system. Transferring to the sender design group, he worked on senders, decoders, markers and test circuits. In connection with common-control circuits for both local and toll crossbar systems, he became interested in crossbar development, participating in the fundamental design work of crossbar systems. More recently he has been associated with the Switching Engineering Department, concerned with fundamental planning for nationwide dialing. He is currently engaged in engineering study and planning work for toll systems. Mr. Myers received the B.S. degree in chemistry from Cornell University in 1921. He is a member of the A.I.E.E.