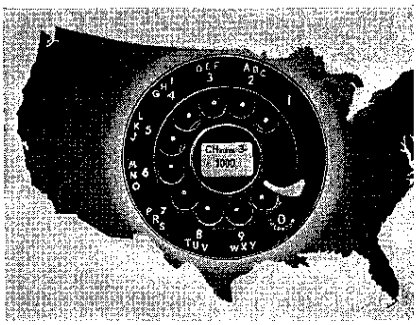
Nationwide dialing by telephone customers is the ultimate realization of many of the Laboratories current planning and development activities. A most fascinating aspect of this program is that its eventual achievement literally places a multi-billion-dollar continent-wide mechanism of extraordinary complexity and versatility at the fingertips of customers.



Switching at Its Boldest

J. MESZAR *Switching Systems Development II*

Like other digital systems, a telephone switching system is an information processing machine. It receives and stores information, and manipulates this information toward a useful end in accordance with the rules of logic built into it.

In spite of a relatively recent start in the outside world, the capabilities and ramifications of such machines have already acquired impressive proportions. Well-known examples are the large-scale digital computing machines that furnish answers to mathematical problems previously beyond the resources of human calculators. Also in operation are railroad and airline seat-reservation systems and other similar automatic inventory systems that keep accurate track of thousands of items and furnish instantaneous answers to complicated inventory questions. Public demonstrations have been given of automatic printed-page typesetting systems, and power-tools controlled by instructions recorded on paper. Studies are being made of automatic air traffic control systems, and there are visions of fully automatic factories, of machines for weather predicting, for library searching, for language translating.

Striking as are the outside examples of digital systems, a modern common-control dial central office is as yet unsurpassed in scope of concept, in amount of mechanized intelligence, and in versatility of actions. This machine is an exquisitely organized system of component units, accepting and executing orders of thousands of its customers for telephone connections. Each end-product of this machine's labor – an established telephone connection – appears like a simple accomplishment, but those who have looked "under the hood" appreciate the fact that this end-product is the result of a series of split-second internal actions of a high order of mechanized intelligence.

Even an over-simplified non-technical account of these actions for establishing a straightforward intra-office connection will evoke respect for the accomplishments of this machine. In an instant, when one of its thousands of customers lifts his telephone handset, component units of the dial central office locate and identify his line, attach themselves to it, give him the signal to proceed with his order, count the dial pulses and spins, store the identity of the requested telephone, determine how and where to get access to it, locate and test the numerous transmission paths leading to it, select and link up the most appropriate combination of these paths, and then ring the called telephone, if it is not in use. It usually takes less than a second to establish the requested connection after the identity of the desired telephone has been dialed. Also, while the series of actions just described is taking place to establish one telephone connection, additional groups of component units in perfect teamwork promptly execute similar orders received at random from others among the thousands of customers. Further, while certain groups of component units set up connections, different ones in precise coordination record on paper who calls whom, and when each conversation starts or ends, so that customers can be properly billed for services rendered. Even more: as part of their work, all these control units also check the validity of their own actions, and in case of trouble they record the circumstances

and will then start afresh to put the call through.

One could enthusiastically elaborate further on the intricate dynamics of a modern common-control dial central office. However, such a central office is not the theme of this article. It does not merit the title: "Switching at Its Boldest." This title signifies an objective of switching technology which is far more astonishing in scope and in implementation than is a central office. The machine earning this title is the over-all telephone switching mechanism which is now being fashioned for nationwide dialing by customers.

There are many important, though prosaic, facets of customer nationwide dialing; some, for instance,

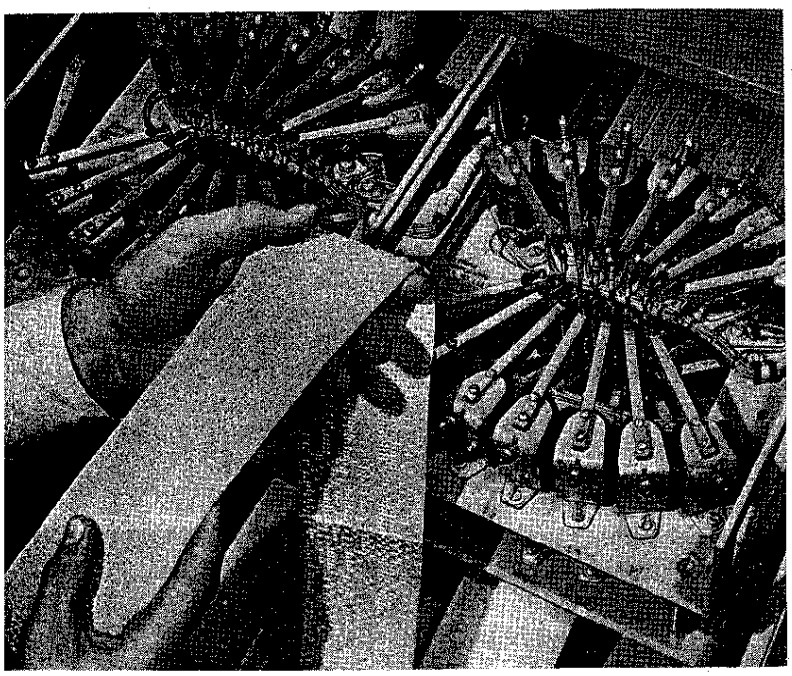


Fig. 1 — As one of their functions, telephone switching machines record data to compute charges for their services.

think of it in terms of seconds saved per average long distance connection; others look at it in terms of dollars of annual operating economy. Still others stress the aspect of greater customer convenience, increased service reliability, and so on. However, at least philosophically, these are not the imaginative views of customer nationwide dialing. For some of us the most exciting aspect of customer nationwide dialing is that it literally places at the fingertips of the telephone customer an automatic mechanism whose magnitude, complexity, and built-in intelligence are unique on a grand scale.

The typical customer doesn't have any idea of this mechanism whose sole reason for existence is to do his bidding. He has a little instrument, the telephone set with its dial, with which he gives his orders to the machine. However, the contrast between this little instrument and the mechanical giant it sets into motion in the hidden world inside telephone buildings is sharp in the extreme.

In fact, even we switching development people who have been sculpturing this mechanism over the years, are hard put to visualize it in its full dimensions. Most of us are so engrossed daily in chipping away at individual stone blocks that we do not lift our eyes to behold the cathedral. Most of the time our attention is focused on the internal workings of building blocks such as a register, or a translator, or a connector, or some other unit. When a situation so requires, our mental grasp can, and does, of course, expand to cover the whole central office mechanism – but not much more. One reason for this boundary is, of course, the limitation of our technical comprehension. A central office represents probably the largest switching entity within which our mind – with intense concentration – can still visualize the direct interplay of component trunks, link controllers, senders, markers, etc. However, there is another reason for this limitation and that is rooted in the history of telephone switching. Until relatively recently, our central office machines had only the ability to set up connections within their respective local areas, and customers needed the services of operators if they wanted connections much beyond such areas. These trained, intelligent human beings acted as the higher echelon switching systems linking the central office machines of the country into a coordinated whole. Then came the Englewood, N. J., trial, and by now approximately a dozen commercial extensions of this experiment. Like a stone hitting a window, these experiments shatter our provincial switching outlook. The realization suddenly dawns on us that the central office machine is a totally inadequate concept for the mechanism that is already at the fingertips of some of our customers. This concept of a switching mechanism larger than a dial central office was, of course, valid and necessary even prior to customer nationwide dialing. However, with customer nationwide dialing the valid and necessary concept suddenly expands to extraordinary proportions – it becomes that of a multi-billion-dollar mechanism, physically dispersed over the whole continent, but unified and integrated to function as a single automatic entity.

Trying to form a full mental picture of this con-

tinental mechanism in action would indeed tax our powers of imagination. However, we can attempt to visualize it in terms of the artist's sketch which portrays a recognizable face with a few strokes of the crayon.

The physical components of this continental mechanism are, of course, the galaxy of dial central

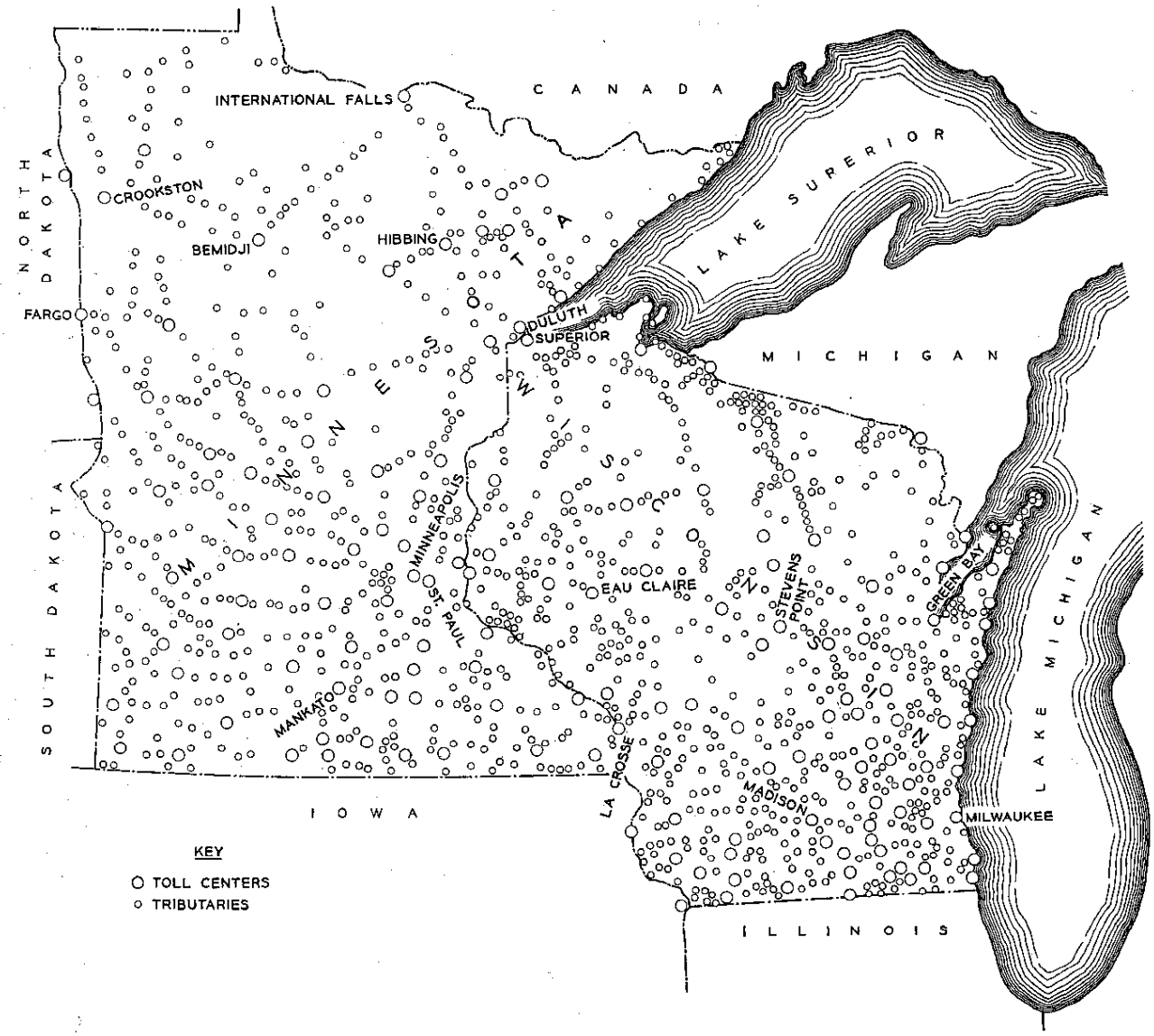


Fig. 2 — In a typical section of the country, the small circles represent tributary telephone offices at any one of which long distance calls originate and terminate. The large circles are long distance operating centers located throughout the section.

those that receive and obey instructions one small step at a time; there are those that can memorize and execute complete orders. There are component machines that have the flexibility and vigor of youth, and there are those that follow the grooves of age. There are machines that receive orders in only one "language," and there are those that can

office machines installed in cities and towns throughout the length and breadth of the continent. One of these typical component machines includes hundreds of tons of intricate switching equipment, and the continental mechanism will eventually comprise thousands of such component machines. These component machines are of great variety. There are

readily respond to commands in several "languages." There are machines that communicate directly with the customers, and there are those that deal primarily with other machines with higher echelon responsibilities. These component machines of the continental mechanism are knitted together by a superb network of wires, coaxial cables, and radio

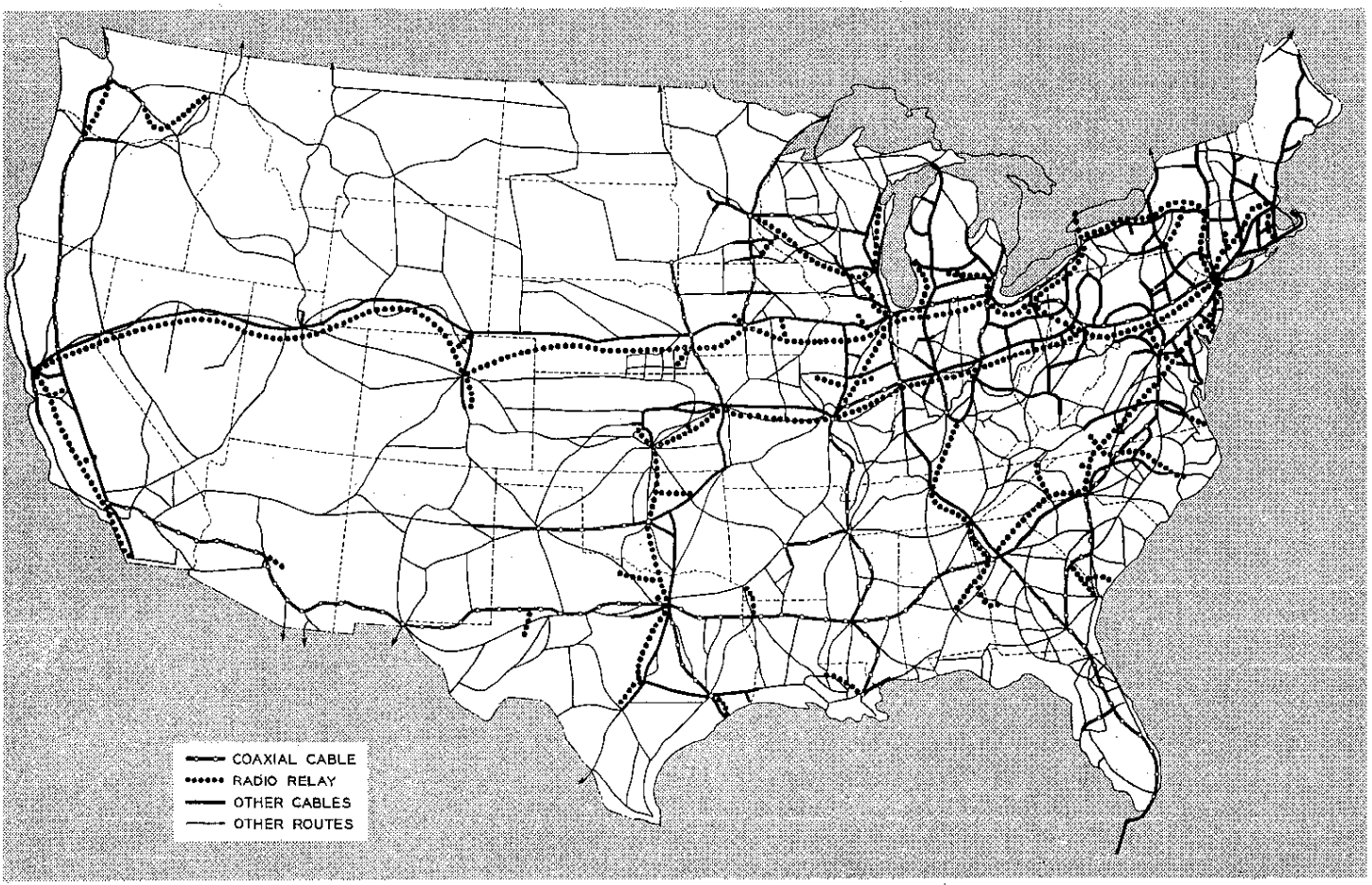


Fig. 3 — In the intricate network of telephone highways and byways, there are many alternate patterns of linkages between the points of origin and destination.

links. The full structure of this continental mechanism is some years away; its vigorous integration has just started, but already a mother in Englewood, for instance, spins her little dial and immediately hundreds of relays go into a huddle in the Englewood No. 5-type central office, crossbar switches snap in the Pittsburgh A4A-type toll office, signal tubes throb in the Oakland No. 4-type toll office, a marker hustles in the San Francisco tandem office, brushes slide over terminals in a panel-type central office, and about the time this sentence is finished, the telephone is ringing in her daughter's home close by the Golden Gate. A slightly different spinning of her dial would bring into play, within seconds, component branches of the continental mechanism in New York, Chicago, Milwaukee – or in Pittsburgh, Cleveland, Detroit and their suburbs.

Imposing as is the physical size of this continental mechanism coming into being, it doesn't serve as a true measure of switching at its boldest. A far more fascinating and significant aspect is the great resources of mechanized intelligence and versatility that are being embodied in this mechanism. Telephone customers by the tens of millions are spread over the vastness of this continent – in the modest homes of little villages, and in the soaring steel hives of the big cities; in the lonely farm houses of the Mid-west and in the humming seaports of the Coasts; in factories, mountain camps, gasoline stations, and so on. The telephone identity of any of these customers will be given to the continental mechanism as a simple number of 10 digits or less. The task of the mechanism is to accept any one of these numbers, dialed by the customer, then search for the destination it represents, and link together swiftly and with precision appropriate sections of telephone highways and byways to form a continuous private voice-path from the point of origin to the point of destination, wherever on the continent these may be.

The audacity of this continental mechanism's task stands out even more when one is reminded

that in the network of telephone highways and byways there are a great many traffic lanes and a great many alternate patterns of linkages between the points of origin and destination. The number of available traffic lanes and the patterns of linkages are forever changing. The continental mechanism has to have, therefore, up-to-the-minute knowledge of this complex and changing network within its collective memory to utilize its rich routing possibilities; it must be able to take instantaneous bearing of the available links leading progressively toward each call's destination; it must have enough built-in intelligence to choose and connect the most preferred combination of these links. And the mechanism will, of course, have to perform this intricate task without the benefit of any human assistance. In fact, one of the truly intriguing aspects of this continental switching mechanism will be that it will connect in a few seconds two telephones thousands of miles apart without any human being knowing what the geography of the connection is. The customer requesting the connection won't know, the people who maintain the mechanism won't know, and even the engineers who designed the mechanism won't know what route a specific call took, and what cities it went through to get to its destination. The planning and designing engineers and the maintenance craftsmen will, of course, know what rules the mechanism follows in reaching its decisions while working on a customer's request. But the application of these rules to the well-nigh infinite variety of instantaneous telephone traffic conditions of the country is the machine's own function and responsibility.

One's respect for the versatility and knowledge of this continental machine is further enhanced by the realization that, to establish a connection, its branches communicate with each other in one of several machine languages; that they may have to substitute for, delete, or add to the information they themselves receive in order to reach the call's destination; that they have to self-program all their actions; that they are called upon to record in a permanent form, adequate data for customer billing; that they have to handle irregular situations resulting from telephone traffic congestions, customer errors, internal failures, and so on.

Above everything else, however, the facet of this continental machine that kindles the imagination most vividly is its dynamic aspect. This machine will have tens of millions of customers, all of whom will give their orders when and as they please. Some of the orders will be simple — they merely want to talk to their nearby neighbors. Others, in contrast, will require searching far and wide, and some will necessitate spanning the continent to bring the desired voices. All the orders pouring into the mechanism from these millions of customers in the East, in the West, North and South, and in between, have to be executed promptly, without confusion. It is a refreshing mental exercise to close one's eyes and make an attempt to visualize this mechanism as it performs; a giant robot with limbs stretching over the continent, serving the whole nation with its brawn and brain, weaving a constantly changing pattern of nearby and far-flung telephone connections.

It is not out of order for us telephone people to express a little pride in this robot. Men, as creators and builders, are proud of the many obvious triumphs that they have fashioned out of metal for use by society; the great ships that carry commerce,

THE AUTHOR

JOHN MESZAR, Director of Switching Systems Development II, joined the Laboratories in 1922 as a technical assistant in toll switching circuits. Five years later he became a circuit design engineer for toll switching systems, and in 1936 became supervisor of his group. During the war he was supervising instructor in the Laboratories' School for War Training, later returning to circuit design supervision, with particular attention to the automatic message accounting system. Mr. Meszar received his B.S. degree in E.E. from Cooper Union in 1927. A member of the A.I.E.E., he is Secretary of the Institute's Communication Division Committee.