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GENERAL SWITCHING PLAN FOR TELEPHONE TOLL SERVICE

BY

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A GENERAL BASIS
FOR ROUTING AND HANDLING TOLL MESSAGES WHICH
CONSTITUTES A DISTINCT FORWARD STEP IN SYSTEMATIC
PLANNING OF TOLL SERVICE IMPROVEMENTS AND
PLANT EXTENSIONS FOR NORTH AMERICA

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A General Switching Plan for Telephone Toll Service

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This paper outlines a comprehensive plan for improved switching of long haul toll telephone traffic in the United States and Eastern Canada. A brief discussion is given of the methods of designing the toll plant to give adequate transmission efficiency for all connections established in accordance with this plan. This includes a new method of providing amplification at intermediate switching points replacing the cord circuit repeater method.

ON January 25, 1915, telephone service was, with due ceremony, inaugurated between the Atlantic and Pacific Coasts of this country. This occasion marked a great step forward both technically and commercially. Before that time, the limit of practicable telephone transmission had been about 1,500 miles. The transcontinental service was made possible by the completion of numerous important developments and particularly by the perfection of telephone repeaters and of means for applying them to long wire circuits.

Until then the Pacific States and their neighboring states had been isolated telephonically from the eastern and midwestern parts of the country. The demonstration of commercially practicable telephone circuits across the continent gave a great impetus to the idea of universal service, that is the provision of a telephone plant such that telephone service could be given at commercially attractive rates between any two telephones in the country.

In the fifteen years since the opening of the first transcontinental circuits, the ideal of universal service has to a large extent been realized. Practically all the telephones of the United States and a large part of Canada now have provision for connection with the countrywide toll telephone network, more than 99 per cent being included. To achieve universal service, however, involves a great deal more. Circuits must be provided in such numbers and so arranged that connections between any two telephones can be established quickly and without too many intermediate switching points. Also the telephone plant must be designed for such standards of transmission that these connections, when established, permit satisfactory conversation. In general, the technical advances which have been made during the last fifteen years to achieve the present standards of toll service have been described from time to time before the American Institute of Electrical Engineers, and it is not within the scope of this paper to review them.

* Presented at Convention A. I. E. E., Toronto, June 1930.

Associated with this development of the telephone plant has been a very rapid increase in traffic. Fig. 1 indicates this increase in the United States and Canada since 1915. A striking characteristic of this growth is that the increase has been much more rapid for the longest lengths of haul than for the shorter lengths of haul. For example, during the last five years in which the messages on lengths of haul up to 250 miles approximately doubled, the messages on hauls from 250 to 1,000 miles increased five times and those over 1,000 miles increased more than ten times. This characteristic is also

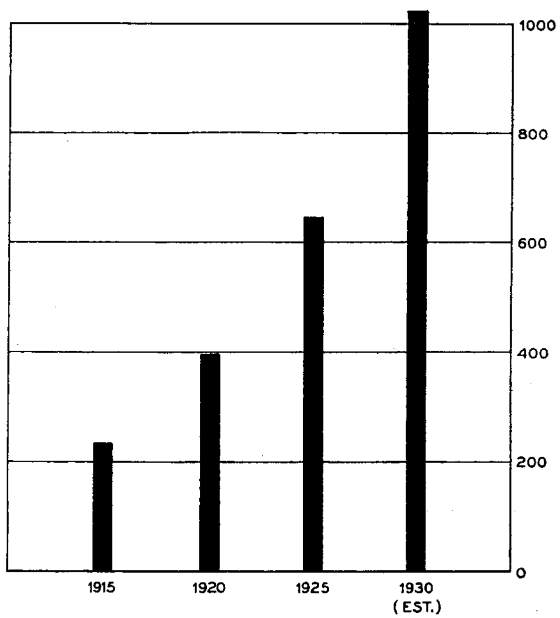

Fig. 1—Total toll messages in millions per year—Bell system.

illustrated in Figs. 2, 3, and 4 which show respectively the growth in the number of circuits between Toronto and Detroit 240 miles in length, Buffalo and Chicago 550 miles in length, and direct circuits from New York and Chicago to the Pacific Coast, averaging about 2,500 miles in length. This particularly rapid growth in very long haul traffic has made it practicable to establish a considerable number of long haul circuit groups and has greatly assisted in the problem of handling satisfactorily calls between widely separated points. It has led to the condition today in which 74 per cent of the long distance (Long Lines) messages are handled over direct circuits and 20 per cent with one intermediate switch.

The part of the business on which it is most difficult to give a high grade of service is naturally the scattering business between widely separated points. In these cases each item of traffic, that is the business between two specific points, is relatively small but the number of items of traffic is great. The number of messages involved in each item of traffic does not justify direct circuits and in very large

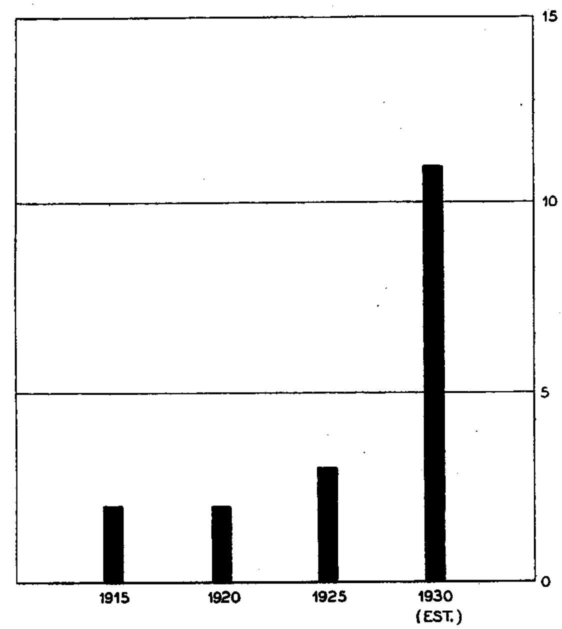

Fig. 2—Growth in number of toll circuits—Toronto to Detroit.

numbers of cases it is necessary, in order to provide a connection, to make more than one intermediate switch. This applies at present to six per cent of the long distance telephone business of the country. All measures of the quality of service—speed, accuracy and transmission—show that the difficulty of satisfactorily handling the service increases rapidly with the number of intermediate switches involved.

The development of the toll business has led to a great increase in the amount of business between large numbers of widely separated points. There has also been an extensive trend toward concentration of the plant used in handling the business in important toll offices and along important routes. The long haul toll business is now handled at about 2,500 "toll centers" out of approximately 6,400 central offices in the United States and eastern Canada. Furthermore, the technical developments in toll circuits have led to great increases in the numbers of circuits along a given route. The extension of the use of carrier telephone has increased the capacity of a 40-wire pole line from 30 circuits to 70 circuits. On the heaviest toll routes, moreover, circuits are now provided by means of toll cable construction, a single cable carrying 200 or 300 circuits. During the past year

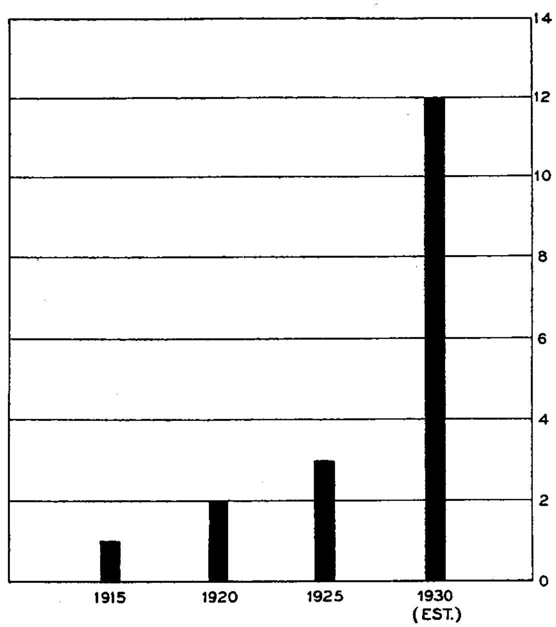

Fig. 3—Growth in number of toll circuits—Buffalo to Chicago.

or two the growth has been so rapid as to stimulate a very large amount of construction of underground toll conduit routes, providing in many cases for several thousands of telephone circuits on a single route.

General Toll Switching Plan

The conditions outlined above form the background which has made it both possible and important to adopt a new fundamental arrangement for the layout of toll plant and the routing of toll messages. This is called the "General Toll Switching Plan." The purpose of this plan is to provide systematically a basic plant layout designed for the highest practicable standards of service consistent with economy,

including speed, accuracy and directness of routing between any two points in the country and suitable transmission standards. This involves the layout of the plant in such a manner as to limit as much as practicable the number of switches required for providing a connection between any two telephones and the establishment of standards of design and construction providing satisfactory transmission over any route thus established. The plan is, therefore, of particular

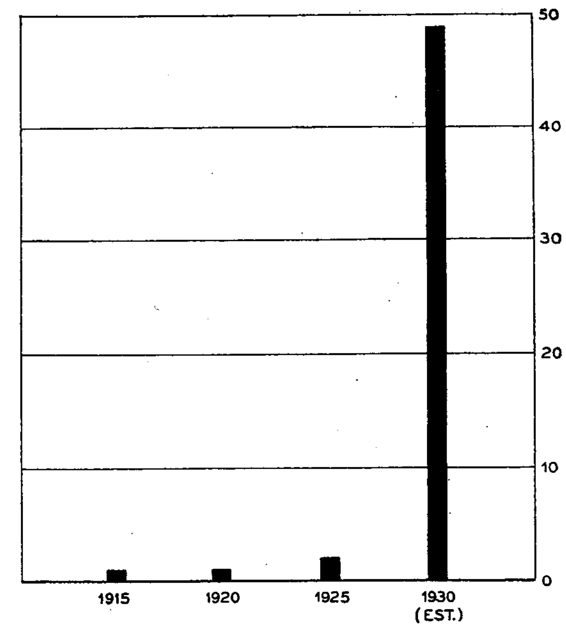

Fig. 4—Growth in number of toll circuits—New York and Chicago to San Francisco, Los Angeles and Seattle.

value in improving the service conditions of switched toll traffic, that is, traffic requiring the connection of two or more toll circuits.

The general features of the plan will be understood by reference to Figs. 5 and 6. Figure 5 shows the application of the plan to a limited operating area such, for example, as a State. Within the area are selected a small number of important switching points designated as "primary outlets." Each toll center is connected directly to at least one of these outlets and all primary outlets within the area are directly interconnected. This makes possible the interconnection of any two toll centers within the area with a maximum of two switches and within the part of the area served by one primary outlet, with a maximum of one intermediate switch.

The primary outlets were selected after a careful study of the present switching and operating conditions and the probable development of toll traffic within the various areas with a view to obtaining the minimum number of primary outlets capable of handling the traffic economically. The routings provided by the plan are supplemented by direct circuits, or by other routings where the amount of business justifies such additional circuits as indicated by the dashed lines in Fig. 5. In general the requirement is made that these supplementary routes shall be at least as satisfactory, both as regards

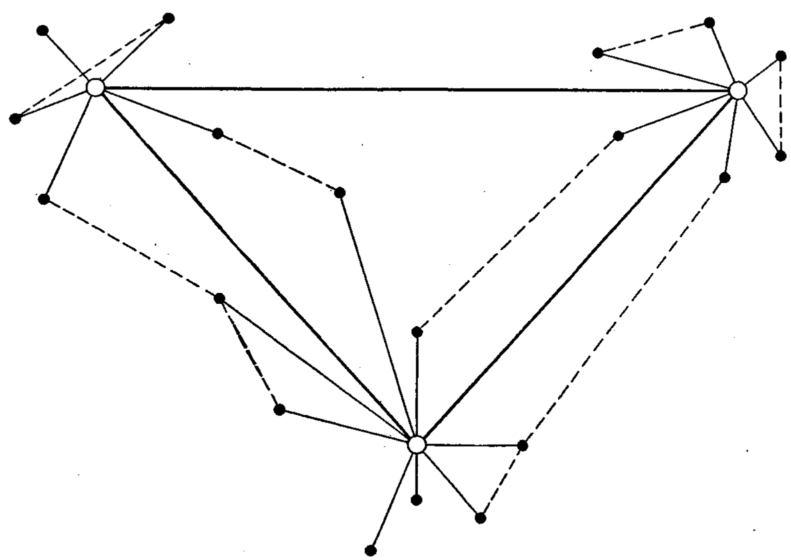

Fig. 5—General toll switching plan—application in local company area.

number of switches and transmission, as the routes provided by the fundamental switching plan. However, when the supplementary routes are used only as alternates to a primary routing they may be somewhat less satisfactory in these respects.

The tentative selection of primary outlets is shown in Fig. 7. It is interesting to note that it is found practicable to take care of switching for the 2,500 toll centers of the United States and eastern Canada by the establishment of approximately 150 of these as primary outlets.

For handling the business throughout the country eight of the primary outlets are designated as regional centers, which are indicated in Fig. 7. The method of routing calls is indicated by Fig. 6. Each primary outlet is connected with at least one regional center and with as many more as practicable. Each regional center is directly connected to every other regional center in the country. By this means, any one of the primary outlets, which are the 150 most important switching centers in the country, can be connected to any other primary outlet in the country with a maximum of two switches and within the area served by a regional center with a maximum of one intermediate switch. As an illustration of the concentration of switching which results, New York serves as regional center for the entire northeastern section of the United States and eastern Canada.

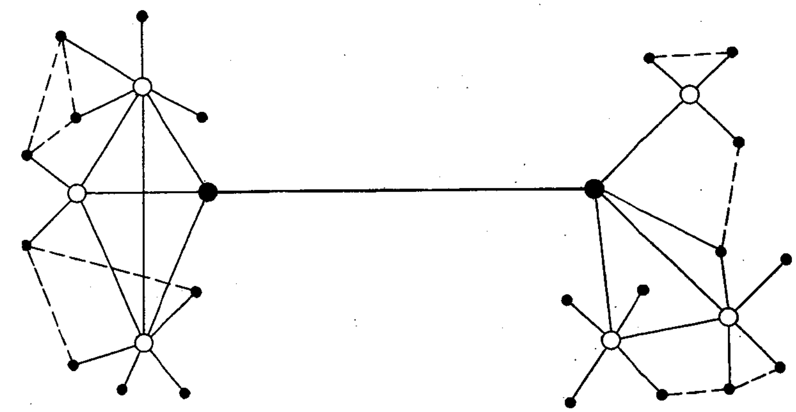

Fig. 6—General toll switching plan—illustration of interconnection of important switching offices throughout Bell system.

The extent to which intermediate switching is limited by the application of this plan is indicated by Fig. 8, which shows the maximum number of switches required under the plan between different types of toll centers. It is estimated that the percentage of long haul messages requiring more than one intermediate switch will, by means of this plan, be reduced by more than 50 per cent.

As an example of the benefit resulting from the adoption of this plan between two remote points, consider a connection which was requested between Pembroke, Ontario and St. Anthony, Idaho. Under the old routing instructions such a call required intermediate

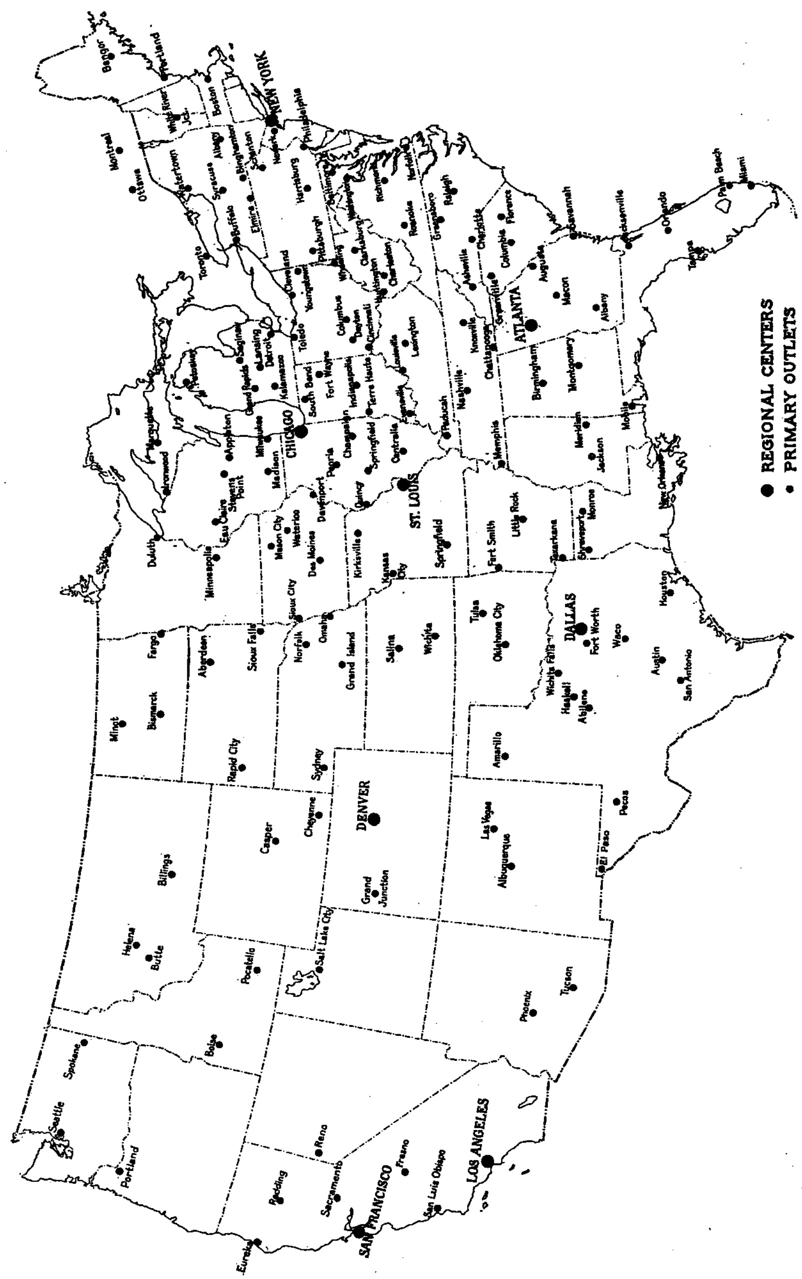

Fig. 7—General toll switching plan—location of points tentatively selected as regional centers and primary outlets in the United States and Canada.

switches at Ottawa, Toronto, Chicago, Denver, Salt Lake City, Pocatello and Idaho Falls, a total of seven. The chance of establishing such a connection within satisfactory limits of time was, of course, relatively small and the resulting circuit, when established, did not permit the conversation to be held. Under the general toll switching plan, this call will be routed with switches at Ottawa, New York, Denver and Pocatello, a reduction of three switches. Furthermore, the circuits involved in this connection will be designed with such transmission standards as to give satisfactory conversation.

To— / From	Same Regional Area				Another Regional Area			
	Regional Center	Primary Outlet	Toll Center Directly Connected to Regional Center	Toll Center Directly Connected to Primary Outlet	Regional Center	Primary Outlet	Toll Center Directly Connected to Regional Center	Toll Center Directly Connected to Primary Outlet
Regional Center	0	0	0	1	0	1	1	2
Primary Outlet	0	1	1	2	1	2	2	3
Toll Center (directly connected to Regional Center)	0	1	1	2	1	2	2	3
Toll Center (directly connected to Primary Outlet)	1	2	2	3	2	3	3	4

Fig. 8—Maximum number of switches under general toll switching plan.

The routes provided by the plan for countrywide service are also supplemented by more direct routes of equivalent or better service characteristics in cases where the amount of business is sufficient to make this economical. Furthermore, the routes to regional centers are, in some cases, supplemented by alternate routes through what are called "secondary outlets." These are distinguished from the primary outlets in that they do not necessarily have direct circuit connections to all toll centers in their areas but serve a useful purpose as an alternate route for the toll centers connected to them.

The essential features of the general toll switching plan from the standpoint of the interconnection of the switching offices may be summarized as follows:

Regional Centers

Regional centers are switching offices strategically located to cover the various parts of the country and completely interconnected with direct circuits, thus forming the basis of a countrywide toll network.

Primary Outlets

Primary outlets are switching offices having direct circuits to one or more regional centers and each having direct circuits to all toll centers in the area for which it is the primary outlet. Also, each primary outlet is connected to every other outlet within as large an area as practicable, usually within a State.

Supplementary Offices
Secondary Outlets

Secondary outlets are switching offices having direct circuits to one or more regional centers and are intended primarily to furnish alternate routes for toll centers for reaching the regional centers, thus providing a greater degree of flexibility in the plant.

Secondary Switching Points

Secondary switching points are additional switching offices intended to provide routes which are more direct thus reducing back haul for intra-area business.

Transmission Considerations of General Toll Switching Plan

An important part of the development of the plan was the determination of proper transmission requirements such that any toll connection established in accordance with the plan would have satisfactory transmission efficiency.

Before the perfection of telephone repeaters, the provision of satisfactory transmission efficiency depended largely upon limiting the total attenuation loss of the complete circuit. At the present time the perfection of repeaters has practically removed that limitation. For example, the attenuation in a New York-Chicago circuit in cable is such that without the use of repeaters the ratio of input power to output power for speech currents transmitted over the circuit would be 10^{46}, while by the use of repeaters at the terminals and at 17 intermediate points the ratio actually is 10.

The removal of the limitation formerly set by circuit attenuation makes possible the increase of the efficiency of circuits to the limit determined by some other characteristic of the circuit. There are various things which under different conditions may determine this limit. One is the effect on transmission of echoes, namely, portions of the speech currents reflected back from the distant end of the circuit or from intermediate points. Another is the distortion due to the building up of greater transmission gain at certain frequencies than at others, which effect may result if repeaters introduce too

great an amplification into the circuit. As an extreme case, this might result in a sustained oscillation or singing on the circuit. Other effects which may be important are those of crosstalk between telephone circuits, or of noise induced in the telephone circuits from outside sources, both of which are increased by increasing repeater gains. On the longer connections, echoes are almost always the controlling factor, whereas on the shorter connections, such effects as crosstalk, singing and noise generally are limiting. A reduction in any of these effects generally involves more expensive types of construction.

The difference between the attenuation loss of the circuit and the total transmission gain introduced into the circuit by repeaters is spoken of as the net equivalent. For long telephone circuits it is generally economical to provide sufficient repeater gain so that the circuit can be operated at the minimum net equivalent permissible, this minimum equivalent being determined by the transmission factors just mentioned. Therefore, in establishing satisfactory transmission efficiencies for the overall toll connections in accordance with the toll switching plan, each link must be designed on the basis of the minimum working net equivalent which it will contribute to an overall connection made up of several circuits switched together.

The establishment of satisfactory and economical transmission requirements for the toll circuits laid out in accordance with the plan involves the following steps:

a. The establishment of satisfactory overall net transmission equivalents.

b. The coordinated design of all classes of toll circuits, and of the subscribers' circuits, toll switching trunks and tributary trunks connected to them, in such a way that the desired overall transmission standards will be given at a minimum total cost when suitable transmission gains are provided by repeaters in the toll circuits and at toll switching points.

c. The economical and satisfactory distribution of transmission gain, permitting all toll circuits to be operated at their minimum net equivalents when this is desirable.

The overall transmission equivalents to be given under the plan are based on standards which have heretofore been used for a large part of the toll business but which it has been impracticable to meet in many cases between widely separated points. With the means now available for operating circuits at their minimum working net equivalents, it was found that satisfactory overall transmission equivalents could be provided under the plan even for the maximum number of switches using standards for the construction of toll circuits very comparable with those already applied to new circuits. Expressed in terms of the transmission reference standard, the plan set up gives a maximum of 25 db overall equivalent within one interconnected area (two intermediate switches) and a maximum of 31 db between any two telephones of the United States and eastern Canada.

In order to determine the most economical distribution of these overall equivalents, a study was made based upon the estimated total number of toll circuits of each class in 1932 and their distribution by length. It is also necessary to include the corresponding estimates for the plant between the toll office and the subscriber, the loss in this part of the plant being on the average about half of the overall net equivalent of the connection.

Based upon these estimates, it was possible to determine, by an economic study, the distribution of the overall minimum net equivalent between these various parts of the circuit which would give minimum total expenses. The toll terminal losses and the minimum net equivalents for toll circuits established in this way are shown in Fig. 9.

Classification of Toll Circuit Involved	Minimum Working Net Loss of Toll Circuit—db	Maximum Via Operating Equivalent —db	Transmission Margin—db
Toll Center to Primary Outlet	3.0	4.0	+ 1.0
Toll Center to Regional Center	3.5	4.0	+ 0.5
Primary Outlet to Regional Center	3.5	3.0	− 0.5
Regional Center to Regional Center	4.0	3.0	− 1.0*
Primary Outlet to Primary Outlet	4.0	3.0	− 1.0
Toll Center to Toll Center	6.0	6.0	—
Direct Toll Circuit (for terminal use only)	9.0	—	—
Toll Terminal Loss	7.0	—	—

* Circuits equipped with echo suppressors may be designed with greater negative margins.

Fig. 9—Transmission design data of general toll switching plan.

In addition to the circuits involved in multi-switch business, the studies connected with this plan necessarily include circuits used for terminal business only, and others for which switching is limited to a single intermediate switch at points where transmission gain is not required. These circuits are associated with the plan because the portions of the circuit between the toll center and the subscriber are common for these circuits and for circuits directly involved in the general plan. Design standards for these classes of circuits are also shown in Fig. 9.

Provision of Transmission Gain at Intermediate Switching Points

The third step mentioned previously is the determination of the best distribution of repeater gains to permit the individual circuit to be operated by itself or in conjunction with other toll circuits at approximately the minimum net equivalent as determined by the several effects mentioned previously. In so far as the gain of repeaters permanently inserted at intermediate points in a toll circuit is concerned, this is a matter of economical design of the circuit and has been adequately covered in other papers. We are interested here, however, in considering the provision of gain at the intermediate switching points when two toll circuits are connected together.

As indicated previously, echo effects are usually controlling on the longer connections, whereas crosstalk, singing and noise will usually control on the shorter connections. This is due to the fact that for the great majority of toll circuits the echo effects on individual circuits increase more rapidly with length than do crosstalk and noise. Singing tendencies also increase at a rapid rate with increase in length on two-wire circuits but tend to be independent of length on four-wire cable and carrier telephone circuits which are used to a large extent to provide the circuits between the primary outlets and regional centers and between the regional centers. Furthermore, when two or more toll circuits are connected together, the echo effects of the individual circuits add together almost directly, whereas the effects of crosstalk, singing and noise increase at a much less rapid rate. The result of these general considerations is that when a toll circuit is switched to another toll circuit, the overall combination can, in general, be operated at a lower net equivalent as determined by echo effects than the sum of the two circuits when operated individually in which case the minimum equivalent is determined by the crosstalk, singing and noise effects. Therefore, it is necessary in the case of connections built up by connecting together a number of toll circuits to introduce repeater gain at the intermediate switching points. If gain were not introduced at intermediate points, it would be necessary in order to obtain the same overall results on connections involving more than one toll circuit to design and build a considerably more expensive type of toll circuit plant in which the crosstalk, singing and noise effects would be greatly reduced.

In the past, gain was inserted at intermediate switching points by the use of cord circuit repeaters. These familiar devices consisted of telephone repeaters inserted in the cord circuits and associated by means of double plugs with the toll circuits and with individual balancing networks designed for each toll circuit. By this means intermediate gains of from 4 to 10 db were inserted at the switching points when connection was made between two toll circuits.

The use of cord circuit repeaters has been an outstanding element in the provision of improved transmission on switched connections. It has, however, some disadvantages which have increased in importance with the increase in transmission efficiency of circuits and with the rapid development of toll business. The routine for inserting the cord circuit repeaters when needed is necessarily somewhat cumbersome, involving considerable expense for operators' labor and for increased use of the toll circuits by operators. Furthermore, under practical conditions it was found to be not possible to insure that the cord circuit repeaters would always be used when required by the routing instructions.

Recent developments in the types of toll circuit have greatly increased the numbers of toll circuits provided with repeaters at their terminals as a part of the most economical design of a circuit. When such repeaters are available, the desired switching gain can be obtained by making use of the gain available in these repeaters. The great increase in the number of terminal repeaters required for other reasons, important reductions in the cost of repeaters and the savings of operators' labor and circuit time have made it practicable to adopt a plan of providing, at certain points, terminal repeaters for every circuit, thus doing away entirely with cord circuit repeaters at these points. With the terminal repeater arrangement, the insertion of transmission gain on switched connections is done automatically by taking out of each circuit on such connections a section of artificial line. This is, of course, the equivalent of increasing the gain of the terminal repeater.

Satisfactory transmission results for all connections under the general toll switching plan involve the insertion of repeater gain on all connections switched at important switching points. This will be carried out by the terminal repeater plan just described. The artificial lines or pads which are cut out of the circuit on switched connections have losses of from 1 to 4 db, depending upon the circumstances of each case. This means that when two toll circuits are switched together, from 2 to 8 db is automatically subtracted from the connection at each switching point. The arrangement is indicated schematically in Fig. 10. The design of each circuit must, of course, be such that when either end of the circuit is connected to a subscribers' station, the repeater gain at that end will not be greater than that permissible under the terminating condition, but that when two or

more of such circuits are connected together for a long built-up toll connection, the complete circuit will operate at as nearly as practicable its minimum working net equivalent. While under these conditions the permissible values of the pads associated with the terminal repeaters naturally vary in individual cases, it has been found possible to work out for general use a series of values which should give satisfactory results. These are indicated in Fig. 11. It will be noted that these values are such that a circuit switched at both ends to other toll circuits is operated at either .5 db or 1 db less than its minimum working net equivalent, this deficit being made up by a corresponding margin at the ends of the circuit. For example, by reference to Fig. 11, it will be noted that whereas the design values of the three intermediate links of a five-link connection equate to 11 db, these links will contribute a total loss of only 9 db. On the other

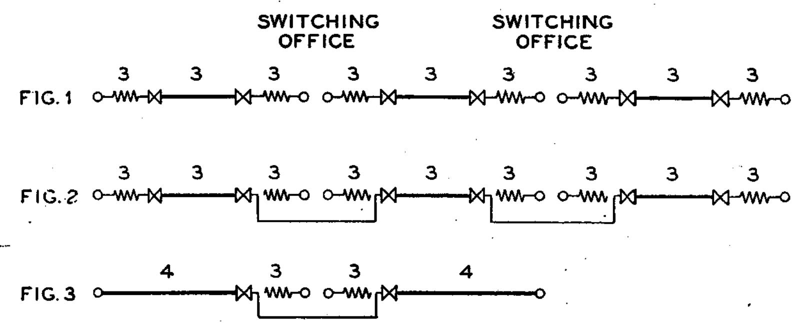

Fig. 10—Illustration of typical transmission data of terminal repeater—switching pad method of operation. Fig. 1—Circuits between switching pad offices in terminal condition. Fig. 2—Circuits of Fig. 1 interconnected at switching pad offices. Fig. 3—Connection between non-pad offices switched at pad office.

hand, the end links will contribute a total of 8 db, whereas their design values equate to only 6 db. The 2 db marginal deficiency in the intermediate links is compensated for by the 2 db marginal surplus in the end links. When intermediate links are used as end links in built-up connections, the switching pads at the terminating ends restore the necessary positive margins.

The design of the very long intermediate circuits, such as some of those connecting two regional centers, requires special consideration and treatment to meet the transmission requirements specified. By making use of a fundamental feature of four-wire circuits equipped with echo suppressors and by employing circuits with the highest velocities of propagation for this purpose, these circuits may be designed in practically all cases to contribute not more than the desired operating equivalent for an intermediate link. Four-wire circuits equipped with echo suppressors are unique in that at the longer circuit lengths the increase in minimum net equivalent with further increase in length becomes very slight.

Two general arrangements for removing the switching pads from and restoring them to the toll line circuits are available depending upon the type of switchboard facilities involved. Either arrangement

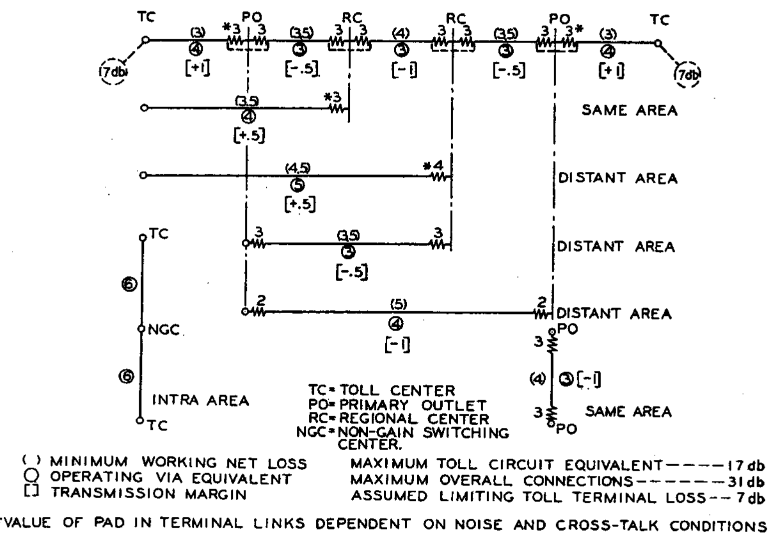

Fig. 11—Diagrammatic representation of transmission data for handling switched toll traffic under general toll switching plan.

requires the modification of both the toll line circuit and the switchboard circuits. One method controls the switching pad by a marginal relay in the sleeve of the toll line circuit. In the other arrangement, the pad is under the control of relays operated by battery supplied from a simplex bridge in the connecting circuits.

With the general toll switching plan the number of places in which switching gain is required is greatly limited, being, as pointed out above, a total of about 150 out of 2,500 toll centers. This number will be somewhat increased by secondary switching points in which it is found economical to insert switching gain in order to save the back-haul involved in following the routing provided by the plan. However, the net result is that under the toll switching plan the number of points at which switching gain is provided will be materially limited, with corresponding economies.

Programming the Establishment of the General Toll Switching Plan

The full application of the general toll switching plan involves a large number of individual rearrangements of plant layout, the establishment of certain new circuit groups and the rerouting of a considerable amount of switched business, the conversion of the switching offices to the terminal repeater arrangement, and the modification of the transmission requirements of certain of the circuits. The date at which these rearrangements will be completed is naturally different for different sections of the country and is determined by the regular program of plant additions and rearrangements to take care of increasing business and of needed service improvement. The existence of a comprehensive plan of this sort insures that the program of rearrangements as carried out will be along the lines of greatest economy and maximum improvement in service. The present plans of the telephone companies in the United States and Canada indicate that the plan as now established will be very closely approximated by the actual plant in the course of about five years.

Future View

Such a plan as has just been discussed is naturally not a static thing but is subject to continual modification to bring it into correspondence with changed conditions. In connection with such changes it is of interest to consider briefly the probable long time trend of the development of the plan.

One possible ultimate development would be the increasing connection of primary outlets to a single regional center so that ultimately only one regional center would be necessary. If this were to take place, the regional center would undoubtedly be Chicago. Fig. 12 is interesting as showing the extent to which the primary outlets already are connected directly with Chicago, over one half of them having such direct connection.

If Chicago ultimately became the only regional center, it would reduce the maximum number of switches to three. It seems evident, however, that such a plan would have many disadvantages. It seems clear that with such an arrangement, numerous secondary regional centers would be necessary to avoid uneconomical back-haul of large amounts of traffic, and the economies of such an arrangement do not look promising. Furthermore, it would lead to a tremendous congestion of through switching at one point, this congestion going far beyond the limits of economical concentration and leading to serious operating difficulties.

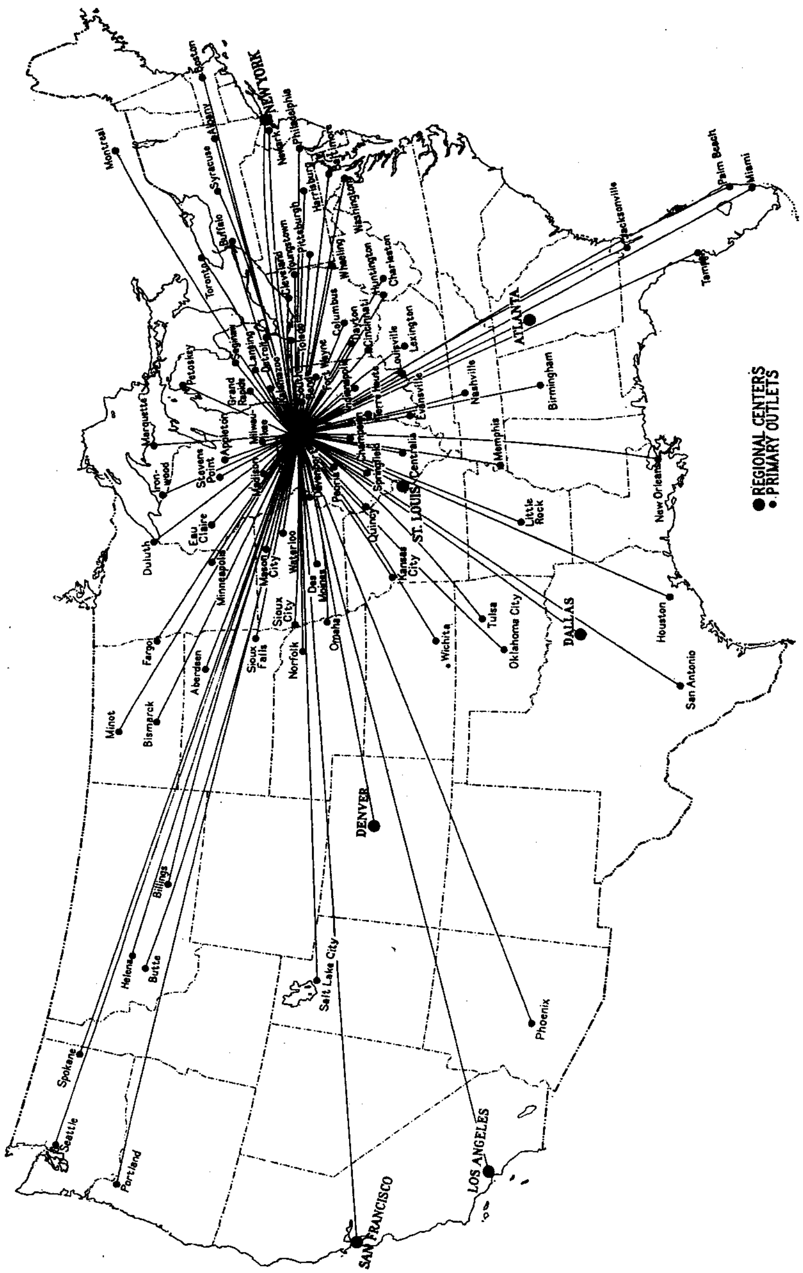

Fig. 12—General toll switching plan—number of primary outlets and regional centers having a direct circuit group to Chicago.

A second, and it is believed more promising general trend would result from the gradual increase in the number of regional centers as the continued development of business makes this economical. With this growth would come also a continued increase in the number of toll centers connected directly to a regional center. By this process there would be a continued growth in the number of toll centers which can be interconnected with a maximum of two intermediate switches, and it is possible that ultimately the primary outlets can drop out of the picture completely, giving a maximum of two intermediate switches for the entire country. While any such outcome is evidently many years away, it seems probable that it is along these lines the growth in development of the plan should be directed.

Although this direction of development avoids the congestion which would be brought about by the single regional center plan, even under this plan the rapidly growing amount of toll switching to be done in large metropolitan centers offers a very important problem for the future. Toll switching at these points is rapidly outgrowing the capacity of a single manual switchboard, as the switching of local calls did long ago. Equipment changes are being made which increase this capacity, but they can be but a temporary relief. Looking to the future, an increasing amount of the outgoing traffic will be handled by operators in the local central offices, reaching the toll line over toll tandem trunks. It is evident, however, that the ultimate solution of the problem will involve the use of machine methods for the selection of the toll line by the operators, as is now done in certain segregated toll tandem systems.

The entire trend of recent years is thus to decrease the differences between the handling of exchange messages and of toll messages. At the present time more than 95 per cent of the toll messages are completed while the subscriber remains at the telephone, with speeds of completion only slightly slower than those of exchange messages. Transmission standards, while naturally somewhat better for the shorter distances involved in exchange messages, are, nevertheless, rapidly becoming very comparable. The present view of trends for the future is for continuation of this process, perhaps even to the use of similar types of machine equipment at central offices for switching the various classes of messages.

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