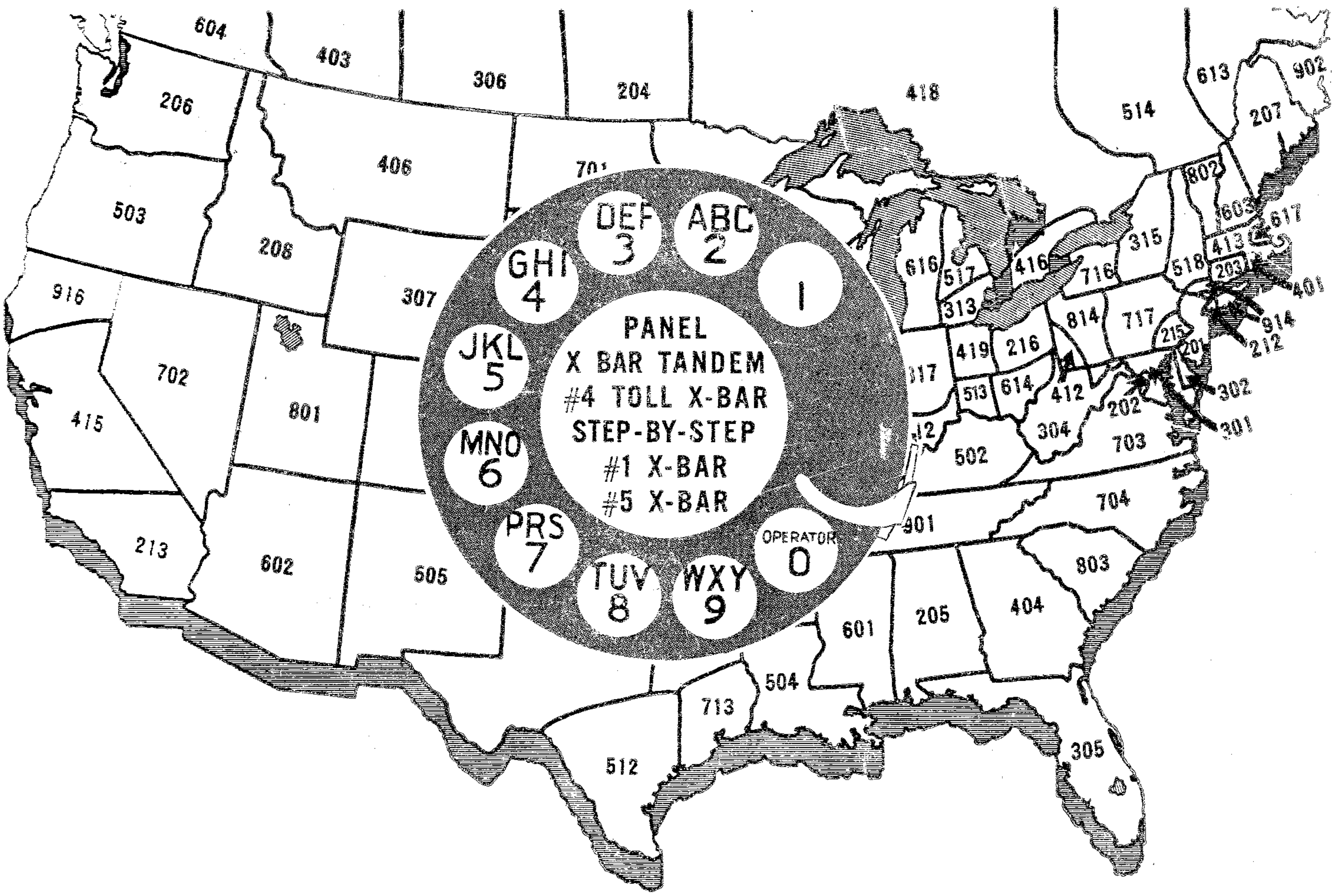
FUNDAMENTALS OF *Intertoll Dialing* AND ASSOCIATED SWITCHING SYSTEMS



AMERICAN TELEPHONE & TELEGRAPH COMPANY
DEPARTMENT OF OPERATION AND ENGINEERING

AUGUST, 1948

FUNDAMENTALS OF
INTERTOLL DIALING
AND
ASSOCIATED SWITCHING SYSTEMS

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AMERICAN TELEPHONE AND TELEGRAPH COMPANY
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FOREWORD

Along with the rapid conversion from manual to dial switching for local calls there is a growing trend toward dial switching for toll calls. While the present systems are intended primarily to permit an operator at the calling end to do all the necessary dialing, the facilities and systems are so planned that direct dialing by the subscriber may be readily added to whatever extent future conditions should warrant. Installations are being made as rapidly as development and manufacturing will permit and the network will expand quickly. Charts 1 and 2 indicate the extent of the growth of the network during 1948 and 1949 in circuits actually in service. Installations to be started during 1949 will increase the network appreciably.

The introduction of intertoll dialing presents many new problems, one of which is the training of maintenance personnel in a new technique. As the control of the overall call is under the direct supervision of one operator, so the control of overall circuit testing becomes the responsibility of the Toll Testboardman at the originating office. Since the call is extended automatically through switches to the terminating telephone and the circuit becomes, effectively, a unit, sectionalization of a trouble requires a good working knowledge of all the facilities used in the call. In his operations therefore, the testboardman must be able to identify and relate to their sources the various circuit conditions set up by different signaling and switching units as they perform their cycles. He must further be able to talk on equal terms with maintenance men at all types of offices in the necessary interchange of information and ideas.

The local switchman similarly must be equipped to recognize toll circuit conditions which control and affect the local equipment and he must be able to exchange information equally as proficiently as the toll man. In the final analysis, while each man will be a specialist in his own field, the operations are so interlocked that he must have a knowledge of the overall system to enable him to do his own job intelligently.

A considerable amount of information is available on all of the units which will make up the intertoll dialing network. Magazine articles, pamphlets, maintenance instructions, training material, drawings and specifications all contribute useful information. For the purposes indicated in the foregoing however, this material is either too detailed, requiring considerable time for simplification, or it is too specialized, failing to include the overall picture. Further, even without these shortcomings, it is too widely spread and voluminous.

It is the purpose of this text, therefore, to gather all of this information under one cover and in such form that it will serve as a textbook of fundamentals. No assumption of previous knowledge has been made in the preparation of the material so that, to a man who has become proficient in his own field the approach will seem elementary. However, to the student who is coming into contact with a system for the first time, and who will not be directly concerned in its maintenance, it will give an adequate foundation of the general operating functions and concepts.

It is expected that this book will be used as a complete textbook for appreciation training in intertoll dialing or as the textbook for the introductory phase of any training course on the systems which make up the intertoll dialing network. It will be useful in the following situations:

1. To give a functional, correlated concept of the overall system to the personnel who require such knowledge.

2. To assist engineering personnel in relating their requirements on detailed jobs to the overall system.

3. To provide maintenance men with the necessary understanding of the overall system.

4. To provide a text of general information.

For the most part no original material is included in this text. It is rather, a compilation of material from some of the numerous sources previously mentioned, edited as necessary to meet requirements. It should be noted that the text has been prepared during the period of transition from manual to dial operation and while development work is still going on. Even at the time of issue therefore, the material may discuss operations which have already become obsolete or been modified or it may anticipate developments which have not progressed to the point of actual practice. In all of the discussions of dial operating it is assumed that the equipment is available to do the job as it is intended it finally will be done. This is a large assumption and requires overlooking many cases where manual and dial operation will overlap for some time.

As the text is used therefore it should be kept in mind that it is intended to establish general concepts only and that none of the material is applicable as a source of maintainance or engineering information.

SECTION I

NATIONWIDE OPERATOR TOLL DIALING

1.0 <u>THE PRESENT GENERAL TOLL SWITCHING PLAN</u>

1.01 Before considering the projected plans for nationwide operator toll dialing, it must be appreciated that any plan which is adopted will be an evolution from the present General Toll Switching Plan which has been in use for manual ring-down operation since the 1920's. It may be well therefore to review the more important features of the present plan and use it as a basis for further discussion.

1.02 Under the present General Toll Switching Plan about 2500 cities throughout the United States and Eastern Canada are designated as "Toll Centers" (TC). Connected to the toll centers by various types of trunks are the tributary offices for which they handle the toll traffic, preparing the tickets, timing the calls and performing the other operations incident to toll operating.

1.03 The toll centers in turn are grouped into approximately 150 networks based upon "Primary Outlets" (PO), each toll center having direct circuits to its primary outlet. The primary outlets also serve as toll centers for their locality. In turn each primary outlet has direct circuits to one or more of the "Regional Centers" (RC) which, at present are New York, Atlanta, Chicago, St. Louis, Dallas, Denver, Los Angeles and San Francisco. Figure 1-1 shows the distribution of regional centers and primary outlets.

1.04 The distribution of direct circuits is not necessarily limited to these points. Where the volume of traffic warrants it, direct circuits are provided between primary outlets and between toll centers in the same region and may be provided to toll centers in other regions. Therefore, while basically a call between toll centers would involve a switch at a primary outlet and calls between primary outlets would require a switch at a regional center, this may not always be necessary.

1.05 The circuits which connect together the toll centers, primary outlets, and regional centers are known as inter-toll trunks and the traffic handled over them is generally indicated when reference is made to "toll traffic". However, strictly toll traffic is any traffic wherein the called station is outside the local service area of the calling station, the local service area being as defined in the local telephone directory. Calls of this nature, usually handled by local "A" operators, may be completed on a dial basis but they will not be considered further in this discussion. The fundamental principles may, however, be readily applied to them.

Fig. 1-1 - Locations of Primary Outlets and Regional Centers

2.0 MANUAL OPERATION UNDER THE GENERAL TOLL SWITCHING PLAN

2.01 For purposes of discussion let us assume a call from Portsmouth, N.H. to Vinland, Kan. The routing of such a call is shown in Figure 1-2 which conforms to the fundamental pattern of the General Toll Switching Plan.

2.02 The subscriber at Portsmouth is connected to the toll operator and passes the details of the call. This operator determines the route and selects an idle circuit to Boston. Upon reaching Boston she requests a circuit to New York and is transferred to the RX or through operator. The request is again repeated and Boston RX selects an idle New York trunk and rings on it. The same procedure is repeated when New York answers and again at St. Louis and at Kansas City. When the Vineland operator answers, the called number is passed to her whereupon she selects a trunk and rings the customer.

3.0 NATIONWIDE NUMBERING PLAN

3.01 In order to effectuate nationwide dialing, every telephone in the dialing network must be assigned a distinctive code which will differentiate it from every other telephone. Further, with operator toll dialing, it is proposed not to increase the number of digits a customer must dial on a local call because of the introduction of toll dialing. It is also desirable to limit the number of digits an operator must dial in order to complete a toll call to any point. The Nationwide Numbering Plan which is described in the following paragraphs meets these objectives by utilizing existing local numbers wherever possible and by providing for the selection of any telephone with a maximum of 11 digits (10 in most cases).

3.02 Under this plan, an operator will dial seven digits to reach a number in her own state or numbering-plan area,

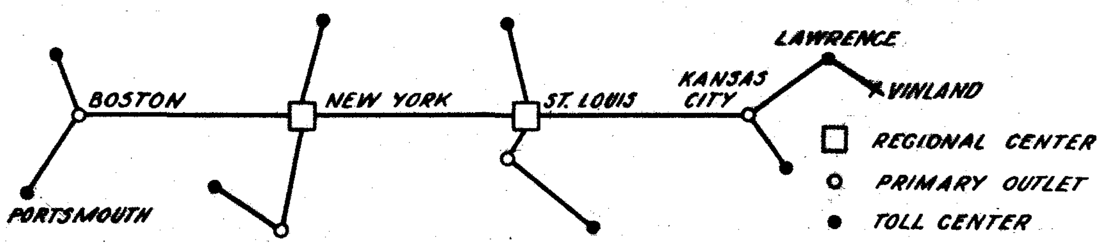

Fig. 1-2 - Routing of a Manual Toll Call

2.03 In order to establish this call, it should be noted, the originating operator must know every switching point along the route and must supervise the connection at each point. This requires that she consult her directory to obtain the necessary information.

2.04 82 per cent of toll calls are completed over direct circuits and 16 per cent involve only one switch. In these cases no directory work is required but the operator does refer to a bulletin on the switchboard which contains a list of all direct circuit groups and as many others as can be usefully included. Alternate routes are specified in some instances, but the use made of alternate routing is quite limited under ringdown operation as compared with the use that will be made under dial operation. A simple bulletin also shows the route to all Class One toll centers, that is, toll centers located along strategic circuit routes. While all this aids in expediting toll traffic, further improvement is desirable and can be obtained under the nationwide numbering plan.

or ten digits to reach a number in another state or numbering-plan area. An individual designation, called a routing code must therefore be created, by the selection of a three-digit number, for each Central Office, for both Bell System and independent companies, in the United States and other adjacent countries included in the operator dialing plans. It is this three-digit code which a calling operator will dial in order to reach a given central office.

3.03 At the present time local numbers vary by places from three digits in the smaller towns to seven digits in the larger cities. In many cases, some numbers are four digits and others are five in the same place, and in other places there are five and six-digit numbers. In some mixed five and six-digit places, the numbers consist of all numerical digits, while in others they consist of one letter and four or five numerals. Mixed six and seven-digit places may have two letters and four or five numerals in the number. Seven-digit cities may have three letters and four digits in the local number or two letters and five digits.

3.04 All of these arrangements are appropriate for the places in which they exist, but a long distance operator in a distant city might well be uncertain what to dial in many cases unless rules are given for her guidance.

3.05 From this description of the present numbering arrangements it will be seen that there is a problem of choosing central-office routing codes for operator toll dialing which must be superimposed on the present numbering arrangements.

3.06 That problem will be met in this way: The United States and Canada will be divided into about 85 numbering-plan areas and, where practical, these areas will include an entire state or province. Each area will include up to approximately 500 central offices, and each office will be assigned a three-digit routing code which does not conflict with any other routing code in its area. Each numbering plan area will itself be reached by means of a three-digit code that does not conflict with any other area code or with any central office routing code.

3.07 Thus, each central office in this country and in Canada will be designated by six digits which will distinguish it from every other central office in the two countries. A maximum of ten digits dialed by the originating operator will reach any telephone: three digits for the area code, three digits for the central office code, and four digits for the called line number. The few exceptions to this ten-digit standard include principally party-line designations, numbers over 9999 used in manual offices, dial local numbers consisting of six numericals (e.g. 52-7456), and calls to TX operators designated by three digits. In the following, reference will be made to 10 digits only. The exceptions should be kept in mind.

3.08 In the Bell System, and in many of the independent telephone companies "0" (zero) is reserved as a special code by which a customer reaches the operator. "Zero" therefore is not available as the first digit of a routing code. The figure "1" (one) is avoided as a first digit of a code because some of our equipment

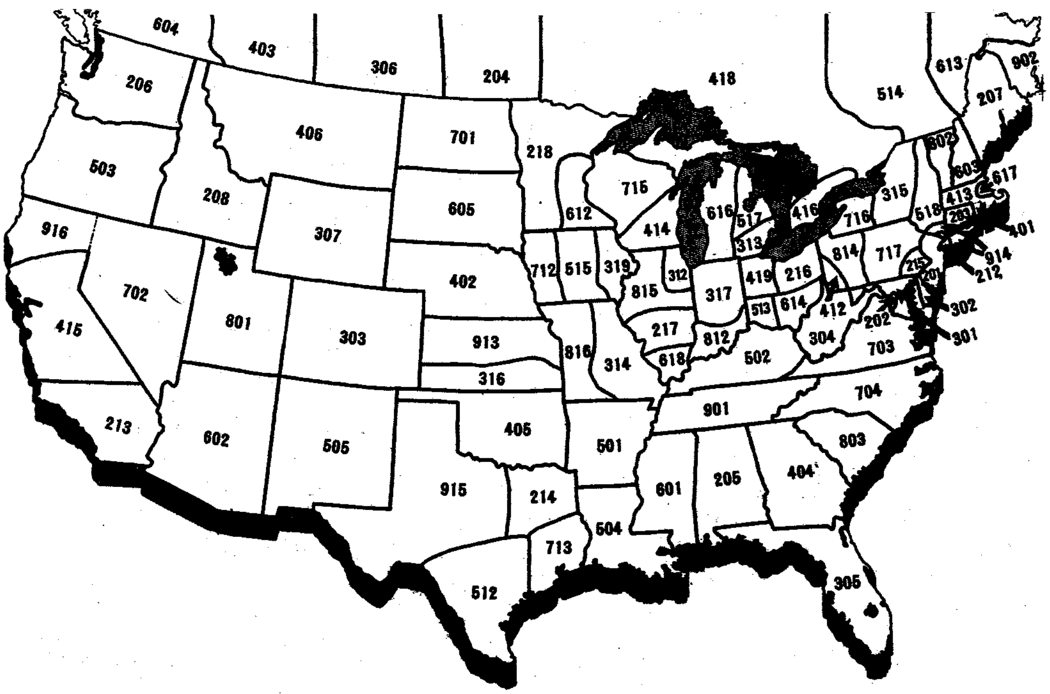

Fig 1-3 - A Nationwide Toll Numbering Plan is arranged so that an initial pulse of "1" is ineffective. These figures, "0" and "1" are not used in central office names and there are no letters on the dials in the "0" and "1" positions. (You may have noticed that in some places the dial number plate has the letter "Z" in the "0" position, but it is not used as part of a central office name.)

3.09 Just because they cannot be used to start a central office code, however, does not mean they cannot be used in the numbering plan area codes. With "0" and "1" in the area code, this code is distinguished from all central office routing codes. Area codes with a "0" in the middle will be assigned to numbering plan areas in states which have more than one numbering plan area.

do not

3.10 In the central office, the operator will have a bulletin at her position which shows the numbering plan area codes for all of the single area states and for the larger cities in each numbering plan area of the multi-area states. If she is handling a call to a distant city in a state in which the area code has a "0" in the middle, and the number given by the customer has more than four digits, she will know that she may proceed with the call without reference to the routing operator, since the "0" in the code indicates that it gives access to the entire state.

3.11 When she receives a call for a city listed on her bulletin and the area code for that call has a "1" in the middle, she knows that she may proceed with that call but may not go ahead with any other call to points in that state not listed in her bulletin without reference to the routing operator. On calls for which neither the state nor the city is listed on the bulletin, she must of course refer to the routing operator.

3.12 Since each call which must be referred to the routing operator is delayed by the additional seconds that must be added to the time required to establish the connection, any plan that can be followed in the assignment of routing codes that makes it unnecessary to refer to the routing operator will improve the quality of the service.

3.13 As mentioned earlier, numbering plan area boundaries will, in general, coincide with state boundaries. In each of the fourteen states which have more than five hundred central offices, including independent company offices, there will be anywhere from two to five numbering plan areas. In determining the locations of boundaries between numbering-plan areas, a few general rules were followed. All tributaries of a toll center are included in the same area as the toll center. And as much as possible, boundaries within a state are located so as to avoid cutting across heavy toll routes.

4.0 ASSIGNING ROUTING CODES TO CENTRAL OFFICES

4.01 At this point we will consider the plan followed in assigning routing codes to the central offices within a numbering plan area. The objective is to establish central office routing codes that will minimize the number of calls on which the operator must refer to a bulletin or to the routing operator to obtain the route. Also, it would be most advantageous, if possible, to assign all central office routing codes so that the operator could tell the routing code from the number given by the customer - since the customer gives the number on about 80 percent of the calls placed.

4.02 In the seven-digit cities, all central offices have names. In some cities the first two letters of the office name and a numeral for the office designation - CO (rtlandt) 7-1234 in New York City, for example. In others, the first three letters of the office name form the designation - as in Chicago's CEN (tral)-5678. Central office routing codes are made to conform with the central office designations in these cities.

4.03 In six-digit cities, which have office names, the code is made to correspond with the first three letters of the office name - HOP-1234 to reach HO (pkins)-1234 in Providence, R.I., for instance.

4.04 In cities with five digit numbers (these central offices do not have names) the first two letters of the city name and the first digit of the telephone number are used as the central office routing code. In Albany, N.Y., by way of example, this would be (AL) 3-4567.

4.05 Cities with four or less digits will be given three digit numerical codes which will be based on the first two letters of the city name, as far as this is possible without introducing code conflicts within an area. For Salem, Ore., the central office routing code would be 725, corresponding to SAL. In some states there are many cities whose names begin with a word such as "San" "Saint" or "New". This makes it impossible to follow the city name rule in many cases. It will be noted that by applying these rules, the operator can tell on a high percentage of calls what the central office routing code is from the number in the distant city given by the customer, and can proceed at once with the handling of the call without reference to bulletin or to the routing operator.

5.0 PROPOSED DIAL TOLL SWITCHING PLAN

Conditions Which Proposed Plan is Intended to Meet and Service Objectives

5.01 The condition which the proposed switching plan is designed to meet is that in which the plant is on a dial basis both for local and toll. The purpose of the plan is to enable an outward toll operator to complete a call to any dial telephone in the nation, without the intervention of operators at intermediate points, by dialing a maximum of 10 digits. Uniformly fast service between all communities, large and small, nearby or distant, is the objective.

5.02 The plan contemplates a new system of routing toll calls in which intertoll trunks will be utilized at high efficiency by means which will at the same time reduce to a very small figure the chance of a call being delayed on account of all trunks busy. The realization of this objective will involve full exploitation of the capabilities of the dial equipment to try in rapid succession a first route and several predetermined alternate routes, the purpose being to advance the call over any of several suitable routes in which an idle trunk is available. This is called alternate routing. The economy of this system lies in the opportunities which it presents for deliberately engineering most trunk groups to carry only part of the load offered, the balance of the load overflowing successively to the other groups where it is combined with similar overflows from other sources, the whole design being coordinated and regulated in such a way that a call will be almost certain to find an idle path before it has run the complete gamut of the routes available.

Alternate Routing

5.03 It is proposed to apply to toll routing the basic principles of alternate routing currently employed for plant economy and service reasons in certain large crossbar office cities for local trunking. The principle on which alternate routing is based is that in general the cheapest way to handle a traffic load between two points X and Y is to handle part of it over direct

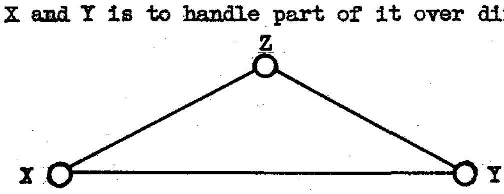

Fig. 1-4 Alternate Routing

trunks between the two points and overflow whatever calls cannot be handled on the direct XY trunks to an alternate route XZY with a switch at the intermediate office Z. See Fig. 1-4. The economic division of the load between the direct and alternate routes is related to the cost of a direct trunk between X and Y as compared with the sum of the costs of an XZ trunk, a ZY trunk and of switching a trunk's worth of load at Z. The direct routing is always cheaper on a per trunk basis since even where the geographical routings and circuit mileage are the same for the direct and alternate routes, the alternate route includes additional switching, toll terminal and signaling equipment at the intermediate switching point Z which are not required in the direct trunk.

5.04 If the entire X to Y load is offered to one XY trunk, and any XY calls which this single trunk is not free to handle immediately are overflowed manually or automatically to the XZY route, the XY trunk will operate at a high efficiency perhaps 80 per cent, or more if the load is substantial. That is, the XY trunk will be busy a large part of the time during the busy period. If a second XY trunk is added it will carry less load, and its efficiency will be less than the first. The third will be still less efficient, etc. Thus the cost per unit of load carried on the direct XY route increases as trunks are added on this route, and there is, therefore, a point at which it is cheaper to overflow part of the load to the alternate XZY route than to provide additional direct trunks to carry it. On the alternate route a nucleus of trunks is required for XZ and ZY traffic whether or not there is any overflow to this route so that the added loads due to overflow can be carried at a relatively high efficiency per added trunk on the alternate route. Non-coincidence of busy hours as between the direct and alternate routes is also an element which can be exploited in many cases to realize further economy. For any given set of conditions a determination can readily be made of the number of direct trunks that ought to be provided for the most economical layout and of the amount of overflow to the alternate route. In some cases, particularly where the XY load is small, the most economical arrangement will be to switch the entire load, that is no direct trunks would be provided.

5.05 Under this plan as proposed herein a call in general would have several available routes over high-usage groups. These would be tested in a predetermined order and the call advanced over the first route in which an idle trunk was available at the moment of testing.

5.06 The small residue of calls not disposed of on the high-usage network are passed with practically no delay to a final group where they are almost certain to find an idle path available. The effect is to keep all trunks busy a larger part of the time, while at the same time the percentage of calls encountering all trunks busy is reduced to a very small figure.

Basic Difference Between Dial and Ringdown

5.07 Before embarking on a further discussion of the principles of the proposed routing system, the features of which are outlined above, it will be profitable to take a broad look at those fundamental features and capabilities of dial operation which make it practicable and desirable to modify present toll routing practice. Table I lists six basic items and compares the conditions under dial and ringdown operation.

Physical Features of Proposed Plan

5.08 The physical features of the proposed plan as now envisioned are as follows:

1. The proposed general toll switching plan is an evolution of the present plan, the principal features of which are retained.

2. The proposed plan envisions two broad classes of toll centers: ordinary TC's and CSP's (control switching points).

3. The CSP's are to be the intermediate switching points for multi-switch calls corresponding in a general way to the present primary outlets and regional centers. Three classes of CSP's are postulated:

   Regional Centers (RC's) - Each serves a large area as at present. Each is

TABLE I

	Item	Ringdown Operation	Dial Operation
a.	Supervision on intertoll trunks	Non-through (1 lamp). Outward operator supervises call by means of lamp associated with calling line, by listening for start of conversation and by ringing signals from forward operators.	Through (2 lamp). Outward operator supervises call by means of two lamps, one associated with calling line and other with called line. By these lamps she is apprized of all events connected with the call.
b.	Cost per Switch..	High	Low
c.	Effect on service of switching.	Slows service and causes errors.	Negligible delay (about 1.5 sec. per switch) and little chance of error.
d.	Type of Switching equipment.	2-wire	2 or 4-wire as required.
e.	Routing control	It is necessary for operators to know (from bulletins on route guides) every intermediate point on the route and to build up connection point-by-point.	Called number contains all information needed for routing. Routing is entirely automatic after call dialed into the equipment at a CSP. The equipment at each intermediate CSP will be capable of translating the digits of the called number into the information needed to select the first and alternate routes in predetermined order and of passing on to the next point the digits necessary to advance the call beyond that point. Except where the first leg is selected in the multiple the operator need not know what circuits or routes are used in handling the call.
f.	Alternate routing	Limited because done by operators.	Less limited because done by dial equipment.

connected to every other regional center by a liberally engineered "final" trunk group. Four-wire switching required.

Sectional Centers (SC's) - This is a new classification. It serves an intermediate role between the regional center and primary outlet. Each SC where established would serve an area comprising part of a regional area. It would embrace the area served by several primary outlets. Each SC would be connected to a home RC by means of a liberally engineered "final" trunk group. Four-wire switching required.

Primary Outlets (PO's) - Each serves a part of a sectional or regional area. Each is connected to its home SC or RC by means of a liberally engineered "final" trunk group. Two or four-wire switching applicable.

4. All toll centers not designated as CSP's (including present primary and secondary outlets and secondary switching points that are not made CSP's) will become ordinary toll centers limited to single switch traffic. Each TC will be connected to its home PO (or SC or RC) by means of a liberally engineered "final" trunk group. Two-wire switching and step-by-step, crossbar or other types of equipment applicable. Gain arrangements may be provided if desired for use on single switch connections through the TC.

5. CSP's must be provided with sender features as well as gain control features. Crossbar equipment will generally be used to provide these features.

6. In addition to the basic network of liberally engineered "final" trunk groups referred to above (i.e., RC to RC, SC to home RC, PO to home SC or RC, TC to home PO, SC or RC), "high usage" groups (i.e., groups engineered to operate on the basis of high loading) will be provided between pairs of points in all categories to the extent justified by traffic. The number of high usage groups will greatly exceed the number of "final" groups.

7. It is believed that there will be about 200 CSP's. Some present gain centers are expected to become ordinary TC's and some places that are now TC's are expected to become CSP's. Very broadly, the selection of CSP's involves balancing the added cost of providing CSP features against the savings in trunking costs, the purpose being to select a combination of CSP's which results in the lowest over-all cost.

"Home" CSP's and Final Trunks

Basic Concept

5.09 A toll center may have high-usage groups to other TC's and to several CSP's. In addition to these high-usage groups, it is contemplated under the proposed plan that each toll center will have a final group to one particular CSP. This is its "home" CSP and may be a primary outlet, sectional center or regional center. The home CSP serves as the final routing point for the toll center for both incoming and outgoing traffic. Similarly each primary outlet has its "home" sectional center (or regional center) and each sectional center its "home" regional center.

"Final" Trunk Group Layout

5.10 The "final" trunk groups are those connecting the ordinary toll center with its "home" primary outlet (or SC or RC); the primary outlet with its "home" sectional center (or RC); the sectional center with its "home" regional center; and the groups which completely interconnect the regional centers. The "final" groups are the "final" routes and collectively comprise the backbone network of paths required to furnish a connection from any toll center to any other toll center. These final groups would be engineered on a liberal basis; that is, enough trunks will be provided in a final group so that the probability of a call encountering NC is small.

5.11 A schematic of the relationship of the different classes of toll centers and the final routes interconnecting them is as follows:

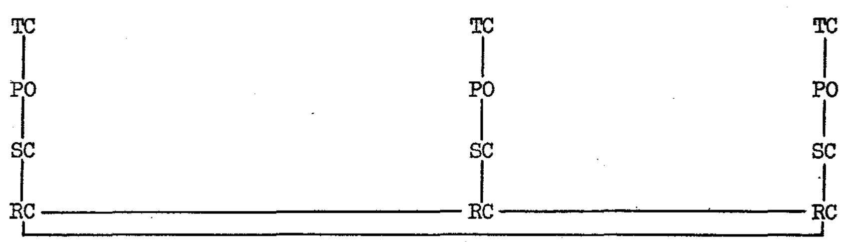

Fig. 1-5 Schematic of Final Routes

5.12 A few examples of the many possible high-usage trunk groups are as shown in Fig. 1-6. A high-usage group can be established between any two points. The number of high-usage groups is expected to be 4 or 5 times the number of final groups.

5.15 All of the possible routes are shown on Fig.1-7, but not all routes will be used in all cases. Where more than four routes exist one or more can be skipped. In many cases not all of the high-usage groups shown on the chart will be available because of insufficient traffic to justify a group.

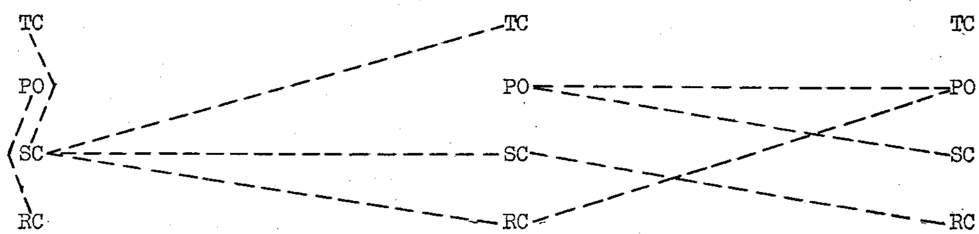

Fig. 1-6 Possible Network of High Usage Groups

Routing Pattern

5.13 Alternate routing conducted in a definite pattern at each point involved in the connection is contemplated by the proposed plan. The procedure will be that each of the appropriate high-usage trunk groups is tested in a predetermined order and if they are all busy, the call will pass over the "final" route to the next point in the chain of routings at which point a similar pattern of routings will be used to deliver the call to the called point.

5.14 The detailed routing pattern for calls between any two points can be visualized from Fig. 1-7 which is attached at the end of this section. To assist interpretation, the various points shown on Fig. 1-7 have been designated by letters as well as by distinctive codes. The Figure is divided into seven sections each of which shows all possible routes from a particular point to toll center e. Referring to section 1 of the figure, the first route between a and e would be the direct high usage trunk group if it exists. If the ae group does not exist the first route might be via an ordinary toll center i or via the CSP's f, g, h, d, c, b. Suppose that as far as the points shown are concerned the only groups from a are those to d, c, and b. In this case the first route on an ae call would be via d. If the ad high-usage group were busy the second route might be to c. If the ac high-usage groups were busy the third and final route would be to b, the home CSP of a. If the call gets to b, the routing choices in order, as shown in section 2 of the figure, are to e, f, g, h, d and c. From c the possible routes to e and the order in which they would be used are indicated in section 3, and the routings from other points to e are shown in other sections. The possible routes between any two points can be determined from the figure. Thus, from section 4 the routes from d to f are, in order, df, dg and dh.

For these reasons the actual routing pattern will be much simpler than a first look at the chart might suggest.

5.16 The routing pattern is so set up that a "final" path exists from every point to the next succeeding point in the chain of routings leading to the called point so that the call can be completed with little chance of delay due to NC regardless of how much rerouting and switching is involved.

5.17 It should be noted that a call is continuously passed to the next CSP in the routing chain. If a call encounters an all-trunks-busy condition at any point, the originating operator will receive a suitable signal and the call must then be dialed again after an appropriate interval.

5.18 It will be noted that under the proposed plan some calls may encounter six switches (TC-PO-SC-RC-RC-SC-PO-TC) as compared to the present limit of four switches (TC-PO-RC-RC-PO-TC). It has been estimated, however, that less than 3 toll board calls out of every 100,000 are likely to involve six switches and only a minute percentage will involve five switches. From the transmission standpoint the use of four wire switching equipment at sectional and regional centers tends to offset the disadvantage of the extra switches since in the rare case where six switches are required, at least four of them, would be on a four-wire basis. From the standpoint of effect on speed of service the additional switches are not considered controlling since it is expected that all the testing and switching at a CSP can be done in about 1.5 seconds.

Operating Methods

Without Sender Systems for Outward Traffic

5.19 This will be the usual condition at an ordinary TC. The operator will select toll lines in the multiple for outward traffic. All toll lines will be on a high-usage basis except for the final group to the home CSP. It is assumed that not more than three routes will be available to the operator on a given item of traffic; that is, original route, first alternate and final route. Under varying circumstances these three routes will involve the following:

1st Route - One of the following:

(a) Direct
Dial only the called number.

(b) One switch at intermediate TC having a S x S intertoll train.
Dial an arbitrary code of not more than 3 digits followed by the called number.

(c) One switch at intermediate ordinary TC having senders such as a #5 crossbar.
Dial the 7 digit national numbering plan number or an arbitrary code of not more than 3 digits followed by the called station number.

(d) Via a CSP
Dial the 7 digit national numbering plan number preceded by the 3 digit national numbering plan area code if required.

1st Alternate Route

(b) (c) or (d) under 1st route.

Final Route

Via its home CSP - proceed as under (d) above.

In some cases the variation in operating practices if 3 routes are used may make it desirable to limit the number of routes to 2, the second of which will be final route.

5.20 The intertoll trunks available to the operator on the original and first alternate routes will be on a high-usage basis and will often be busy, particularly in the busy hour. Also, on single switched connections the trunks from the intermediate office to the terminating toll center will also be on a high-usage basis in many cases. When an operator encounters an all-trunks-busy condition on either leg of switched connections, it will be necessary to reroute. However, since it is quite likely that an idle trunk will be available in the final route, calls are not held up by this procedure.

With Senders Available for Outward Traffic

5.21 This will be the situation at all CSP's and at some ordinary TC's. In these cases some intertoll trunks may be selected manually in the multiple and others would be reached through the dial equipment using the senders at the originating point, depending upon the economies in each case. Alternate routing can be obtained through the senders on an automatic basis with a consequent simplification in operating practices. Otherwise, the conditions obtaining under 5.19 apply.

Extent of Switching Areas

5.22 The basic routing pattern is closely associated with the provision of the "final" trunk groups. Since final trunk groups are provided from all ordinary toll centers to their home primary outlets, a call originating and terminating within a primary outlet area does not go outside that area to find an idle trunk to the called point. This can be seen by reference to Fig. 1-7. Similarly final groups are provided from all primary outlets to the sectional center and a call originating and terminating in the area served by a sectional center does not go outside that area to find an idle trunk to the called point. A similar situation prevails for calls originating and terminating in the region served by a regional center. In this way routings are confined to areas of manageable size, the geographical area involved corresponding to the needs of the calls. Calls from one area to another must, of course, cross boundaries. Certain intra-area fringe items may also cross area boundaries to save backhaul.

5.23 The basic routing pattern further provides that at any given CSP the calls switched should either originate or terminate in the area for which it is the home CSP. Thus a call switched at a regional center should either originate or terminaate in that region; a call switched at a sectional center should either originate or terminate in that sectional area; and a call switched at a primary outlet should either originate or terminate in that primary area. The maximum number of possible switching points on a call between two primary outlets in different regions is thus four, the two sectional centers and the two regional centers. The bulk of the traffic that is not direct can be switched at any one of the four points as economy or service considerations or both indicate. Similarly on calls between sectional centers in two different regions, the possible switching points for traffic that is not direct are the two regional centers and either can be used as economy or service considerations indicate.

5.24 **When two sectional centers have a considerable volume of traffic between them and are some distance removed from their regional centers, it is feasible to provide final trunk groups between them and avoid having any traffic between them switched at the distant regional centers. The provision of these extra final groups involves some additional cost for trunks, but other considerations such as conditions at switching points may be controlling. In fact, final groups can be established between any two points where it is felt that the traffic, equipment, administrative or other reasons justify the cost of the extra circuits.**

Transmission

5.25 The present view is that the average transmission provided under the new plan will be substantially the same as under the present plan but that individual types of calls may be subject to small changes from the present. During the busy hour it is expected that there will be an increase in the volume of switched calls, with an attendant small effect on over-all transmission. On the other hand, it is expected that the provision of additional direct groups will improve transmission during the non-busy hours.

5.26 The increase in the maximum number of switches from 4 to 6 is not considered to be important from a transmission viewpoint because 4-wire switches will be used at 4 of the 6 switching points. The percentage of traffic encountering 5 and 6 switches will be extremely small. Further discussion of the transmission problem is contained in Section IX of this text.

6.0 EQUIPMENT FEATURES NECESSARY TO FULL TOLL DIAL OPERATION

6.01 It is expected that about 200 places in the United States and Canada will be designated as CSP's. In order to utilize the full potential of the switching plan previously described the switching equipment being designed for these places will incorporate the following significant features:

Storing and Variable Spilling of Digits

6.02 A CSP will be able to accept a number in the national numbering plan form, use it for switching to the proper outgoing trunk and pass along whatever part of it may be needed at the next point to which the call is switched. Selection of the outgoing trunk and determination of the digits to be passed along must be made from the routing digits received. In some cases they will be only the office code and in some cases both the area and office codes. The digits spilled forward may be the entire number, only the four numerical digits, the office code plus the four numerical digits or part of the office code plus the four numerical digits. This means that some device for storing digits must be provided so that they may be used for trunk selection within the office and still be preserved for use at the next office when required. The storage capacity will be eleven digits so that once it has started to receive digits it will be able to take all that may come without a pause.

The sending equipment will recognize an on-hook signal as an indication that it may spill and an off-hook signal as an indication to stop. It will be able to take one stop signal after spilling has started. After such a stop signal and the receipt of a new start indication, it will start spilling digits at the point where it had previously been stopped. This permits reaching a link type CDO (one in which the trunk from the toll office must be found by a link before dialing can proceed) or a sender office through a step-by-step TC. It also permits reaching a link type CDO through another CDO not of the link type. An off-hook condition before spilling is started is not considered a stop, but a delay dial signal. It is therefore possible to extend a call through two link type offices in series only where the first is reached by a direct trunk from the CSP.

Code Conversion

6.03 This is a term for the substitution of a different set of digits for the received code. The feature is used for handling calls to tributaries of step-by-step TC's. For example, let us assume that Redwood is a tributary of Greenfield, a step-by-step TC. The call for a Redwood subscriber would come to a CSP in the same numbering area in the form RE3-2345, the actual numericals being 733-2345. If this number were sent to Greenfield it would conflict with the Greenfield subscriber's number 7332 In order to avoid this conflict it would be necessary to send the Greenfield office code ahead of calls to Greenfield subscribers. This would require extra selectors at Greenfield.

By providing code conversion facilities at the CSP the digits 125 might be substituted for the received 733. These digits would guide the switches at Greenfield to the Redwood trunk group. There would be no conflict with Greenfield numbers because they never begin with "1".

If Redwood were in a different area from the CSP the 125 would be substituted for the area plus the office code.

Automatic Alternate Routing

6.04 The value of alternate routing for promoting efficient use of outside plant is well established and needs no extended discussion here. As was indicated in the discussion of the switching plan, extensive use of it will be made.

Facilities capable of selecting as many alternate routes as the circuit layout makes desirable will be available for Bell System CSP's.

Six-digit Translation

6.05 Facilities for translating both area code and the office code will be available. This feature will not be used where the call is destined for a point in the numbering area in which the CSP is located, since it will never receive its own area code except through an error. When it is received a reorder signal will be returned.

The value of translation of both area and office code lies in the ability it affords to make a selection of the proper route to an office in a foreign area when there are two or more routes to choose from. With translation restricted to the first three digits received it would be necessary to forward all traffic to any particular foreign area by the same route. This would result in uneconomical routings with respect to both outside plant and switching equipment, an extra switch being forced unnecessarily on many items of traffic.

For example, it is desired to reach a subscriber in Akron, Ohio from Pittsburgh which is a CSP. Akron and Cleveland are in the same numbering area, direct trunk groups to both points are amply justified by the traffic. The CSP equipment in Pittsburgh must translate both the area code and the office code for the Akron subscriber in order to be able to route the call over the direct trunk group to Akron. If six-digit translation were not provided it would be necessary to route this call through Cleveland since only one route could be chosen from the area code alone and the route selected for this purpose would be the one over which the greatest volume of traffic would flow with a choice of routes available.

Four-wire Switching and Gain Control

6.06 Among the advantages of four-wire switching are freedom from restrictions inherent in two-wire switching in planning future transmission improvements and ability to make more effective use of the transmission gain available in toll systems. Continued extension of the application of carrier facilities to a wider range of circuits will result in a toll plant made up almost entirely of high velocity circuits for intermediate links and this will in turn open the door to improvements in transmission that might be limited by the insertion of a two-wire switch at a through switching point.

For many years the toll plant will contain both high velocity four-wire circuits and several varieties of voice-frequency circuits. The most effective use can be made of this composite plant by the employment of the very flexible gain control methods possible with four-wire switching.

Speed

6.07 Provision is made for sending and receiving digits on a multi-frequency instead of a decimal basis whenever possible. This form of pulsing will be the usual means of communication between CSP's and will contribute materially to speed of operation. It offers no advantage, however, over decimal pulsing from a CSP to a step-by-step or similarly equipped TC. A further step in the direction of improved speed is provision for sending digits forward as soon as it is possible to do so, even while others are still being received.

Ease of Administration

6.08 It will be appreciated that with translating equipment provided for remote areas changes in the equipment must be rather frequent. Whenever a new office is opened up in one area translating equipment must be checked and sometimes changed in all CSP's having translators for the area.

Whenever routings are changed due to elimination or creation of a trunk group, as is frequently done for seasonal traffic, translating equipment must be changed. The Bell System CSP equipment will have the flexibility to enable these changes to be made quickly and easily.

6.09 The features demanded at ordinary toll centers, of which there will be about 2200, for operation under the nationwide dialing plan are relatively simple. They can be provided with step-by-step, crossbar or other types of equipment which will handle single switch and originating and terminating traffic. Gain arrangements may be provided for use on the single switch connections.

6.10 It should be noted that installations of No. 4 and No. A4A Toll Switching Systems do not provide all of the features required for CSP operation. These systems are being installed in a number of cities to relieve traffic congestion but will require modification for operation under the toll dial plan.

7.0 DIAL OPERATION

7.01 How the call previously described with manual operation might be handled under the proposed plan, with common control equipment provided where it is needed, is shown in Figure 1-10. The Portsmouth operator instead of being required to find out the code to be used at each switching point needs only the code for (VIN)land, i.e. 816-846. This code would be the same no matter where the call originated. She selects a trunk to Boston and keys 816 846 1234 into a sender in Boston. The sender gives the code 816 to the marker, causing it to select a toll line to New York, and then spills the complete number into a sender in New York. This process is repeated through New York and St. Louis to Kansas City. The equipment at each switching point knows that 816 is the code for eastern Kansas, and selects the best route for getting there.

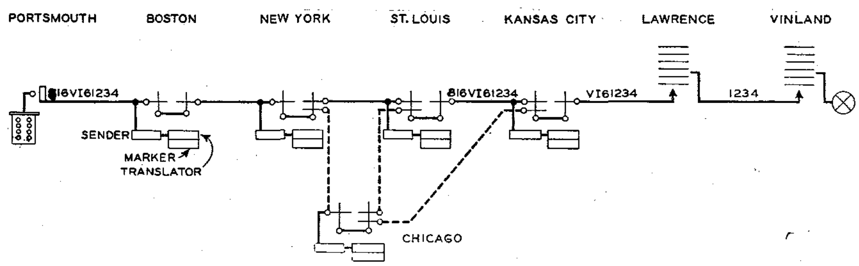

Fig. 1-10 - Codes and Routing for a Full Mechanical Toll Call

7.02 When the translator in Kansas City receives the 816 from the sender, it requires further information to enable it to select the proper route because it has direct circuits to several points in that area. It, therefore, asks the sender for the next three digits and uses them to route the call to Lawrence, telling the sender to drop the first three digits and transmit the remaining digits forward. The digits 846 drive switches in Lawrence to the selection of a Vinland trunk and the 1234 drive switches in Vinland to the subscriber's line. The symbol for step-by-step equipment is used at Lawrence and Vinland to indicate that senders are not required at those places since the digits received there do not have to be reused.

7.03 If the toll lines from New York to St. Louis are all busy, the call might be automatically routed through Chicago, where it may be routed to Kansas City directly or, if the Chicago-Kansas City toll lines are all busy, by way of St. Louis. This is possible because, as already pointed out no matter where the code 816 846 is received, it always means Vinland in eastern Kansas, just as within the New York local numbering area PE6 always means the Pennsylvania 6 office no matter which local office is the originating point.

7.04 Although in the example used the call was handled by an operator, it will readily be seen that the fundamental toll switching arrangements would be no different if the subscriber had dialed his own call into a sender in Portsmouth. It is contemplated that future toll developments will follow a pattern that will place no impediment in the way of long distance dialing by subscribers.