The Lenkurt® Demodulator

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### *Importance of Carrier in*

# NATIONWIDE TOLL-DIALING

*The achievement of nationwide toll-dialing will require the careful planning and close co-operation of all segments of the telephone industry for the next several years. The new concepts in toll routing and design and the increased importance of carrier are significant aspects of the over-all plan.*

*This article discusses the basic plan as it exists today and describes the important role that carrier will play in its achievement.*

The ultimate objective of the nationwide toll-dialing plan is a system of communications throughout the United States and Canada which will enable any telephone customer to call any other customer merely by dialing his number. The accomplishment of the plan involves some new techniques and equipment. These in turn demand a high standard of transmission performance which will depend to a large extent on the use of carrier and microwave radio.

The basic structure of the plan has been set and the philosophy underlying it has been accepted by the major segments of the communications industry. However, telephony cannot afford the luxury of being a static art. As new developments occur, minor details of the plan may require revision; but the trend of any changes will remain directed toward an improved and more economical telephone service.

## The Plan

The general plan is based on a principle called automatic alternate routing. By means of alternate routing, a call between any two points in the United States-Canada network may have many possible paths to its destination. These paths may vary in complexity from a direct connection to a connection containing as many as seven or eight intertoll links in tandem.

A call will be offered first to paths made up of the most direct routes between its two end points. These will be tried in logical order until either a

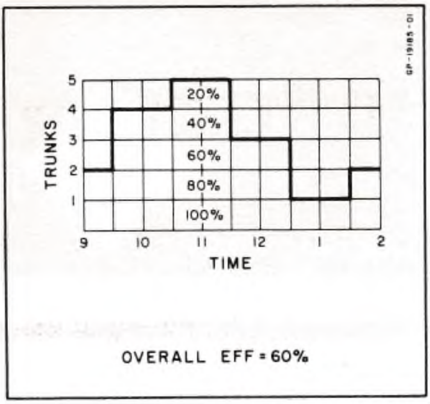


*FIG. 1. Typical traffic distribution and trunk efficiencies over a period of several daytime hours.*

through route is found or until it is determined that all trunks on these direct routes are busy. Since they are always the first choice, the trunks on such a route carry a heavy average traffic load and comprise what is termed a *high-usage group.*

If all high-usage groups are busy, the call will then be offered to a final group. A *final group* consists of trunks which have no alternate route. Such groups will have low-usage and be capable of handling the overflow of many high-usage groups with a small probability of lost calls.

The advantages of alternate routing stem from two fundamental facts associated with long-distance traffic: irregularity of flow, and diminished returns from additional trunks. Both of these are illustrated in Fig. 1 which shows a typical average variation of daytime traffic for a number of trunks between two points.

The curve consists of a peak of heavy traffic and valleys of light traffic. If this traffic is handled by directing the flow so that the trunks are used in ascending numerical order, the efficiency decreases with each succeeding trunk. At one extreme, trunk 1 is used to capacity throughout the entire time and operates at 100 per cent efficiency. At the other extreme, trunk 5 is idle most of the time and operates at only 20 per cent efficiency.

The over-all efficiency could be considerably improved by eliminating one or two trunks. However, this would mean that the calls represented by the top of the peak would be "lost" or at least delayed.

Long-distance traffic destined to one point in the country will differ in the positions of peaks and valleys due to time zone differences at the points of origin and for other reasons. If the peak traffic for several direct routes is allowed to overflow to a combined alternate route, the trunks on this alternate route may be operated at high efficiency as the peaks and valleys will tend to counteract each other and the curve will level out somewhat.

The trunks handling this peak traffic can then be eliminated from the direct routes. The net result is fewer trunks required and a higher operating efficiency for all trunks involved.

A hypothetical situation with and without alternate routing is shown in Figs. 2 and 3. Figure 2 shows the trunk requirements and traffic distribution between B and A and between C and A without alternate routing. Figure 3 shows how the same volume of traffic is handled by allowing the shaded portions of traffic to overflow to an alternate route between D and A.

Of course, the shaded portion of curve B-A must find available trunks between B and D and the shaded portion of curve C-A must find available trunks between C and D. These are provided either by direct high-usage groups or by final groups which are alternate routes for the combined traffic from several other points destined for D. Considerations of cost and existing traffic will determine the routing designation to preserve the efficiency and economy described for the initial situation above.

The example cited is a simple one involving one intertoll switching point (at D). Under the present general toll switching plan, as many as seven or eight intertoll links may be connected in tandem on some calls. The increased switching requirements are being handled by machines which automatically determine the destination of a call, search for an idle trunk, and build up a through circuit in the proper direction.

A large body of traffic theory and mathematical analysis underlies the techniques used in automatic switching. The final result, however, is simply that calls can be switched so quickly and so economically that switching is not a limiting factor in the achievement of the over-all plan.

## Transmission Requirements

Alternate routing means that the path which any particular call may take will depend on the trunks available at the time. Thus successive calls between the same two points may vary widely in the number and types of links which make up the total path. For this reason it becomes important that the losses of each link be kept as low as practicable in order to prevent large differences in transmission levels among calls between the same two points.

Differences in transmission levels could be entirely eliminated if all links could be operated at zero loss. However, there is a practical limit to the minimum loss at which a circuit can be operated. This limit is a value of loss below which the factors of echo, singing, noise and crosstalk become objectionable. Of these factors, echo is usually the most critical and, in most cases, a circuit designed to hold echo within tolerance will meet the trans-

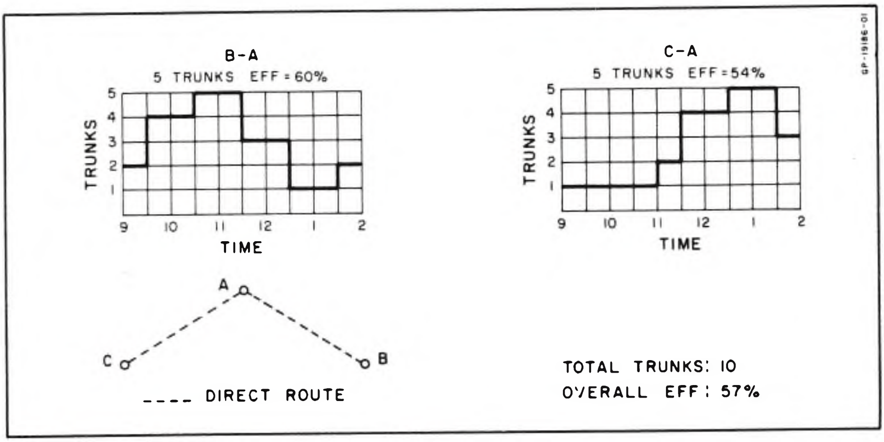


*FIG. 2. Traffic distribution and trunk facilities required for a situation without alternate routing.*

mission requirements for singing, noise and crosstalk.

The minimum loss of a circuit depends on the type of facility and the makeup of the total connection of which the circuit is a link. Since the makeup of the connection may vary from call to call, the minimum loss for a link will also vary. To maintain this minimum loss for each link for each possible makeup is far too cumbersome to be practicable. Therefore, a compromise is adopted which, with some approximation, gives a much simpler method of determining the lowest practicable loss for any link.

This method uses a figure called Via Net Loss (VNL) to define the loss which a particular circuit must maintain when it is used as an intermediate link, regardless of the total number of links in the connection. When the circuit is used as a terminal link rather than as an intermediate link, additional loss must be inserted. In either case, however, the VNL determines the lowest practicable loss at which a trunk can be operated without incurring objectionable effects of echo, singing, noise and crosstalk.

The VNL of a circuit is obtained by multiplying the circuit length by a value called Via Net Loss Factor (VNLF) and then adding 0.4 db to allow for individual variations. The VNLF is computed from the transmission characteristics of the circuit and a statistical analysis of customers' tolerance to echo. The relationship of tolerance to echo and VNLF is such that decreasing the objectionable nature of echo decreases the VNLF.

Tolerance to echo depends on the loudness of the echo and the time required for the talker's voice to make the round trip of the circuit and return to him. If this time delay is short, the effect of a given amount of echo is not too objectionable. As the time delay increases, however, the effect of the same amount of echo becomes more and more objectionable.

The primary transmission requirement of the toll-dialing plan—minimum loss on each intertoll link—becomes therefore a matter of achieving minimum VNLF for each link. This, in turn, means reducing the amount of echo in the circuit, the time delay of the echo, or both.

The computations of VNL and VNLF are based on the performance of four-wire circuits. For two-wire circuits, no simple solution exists and minimum loss must be determined from evaluations based in part on past experience.

## Role of Carrier

Carrier has long since proved its worth over long-distance circuits by reason of the economies it affords. In addition, the inherent low noise level and high stability of carrier systems have continued to provide the quality of transmission required for toll use. As the nationwide toll-dialing plan progresses toward its goal, these contributions will be enhanced by other transmission characteristics necessary to the plan. Among these are low tendency to echo and high velocity of propagation.

The major share of echo stems from impedance mismatches at the hybrid junctions which must be used whenever a circuit is converted from two-wire to

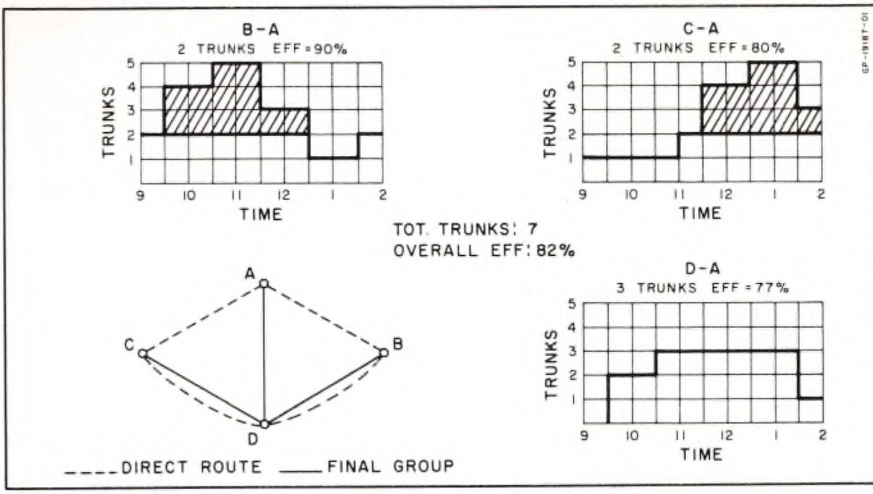


*FIG. 3. Traffic distribution and trunk facilities required for same situation as in Fig. 2, but with alternate routing through D.*

four-wire or from four-wire to two-wire. In two-wire circuits, these points of mismatch will occur at intermediate repeaters, terminal repeaters and switching connections.

Four-wire circuits with four-wire switching have much less tendency to echo since these points of impedance mismatch exist only at the terminal drops. In this respect, carrier circuits, which are electrically equivalent to four-wire circuits, serve the over-all plan by eliminating intermediate sources of echo and allowing circuits to be operated at low losses.

The high velocity of propagation of carrier circuits, on the other hand, acts to bring echo within tolerable limits by reducing the objectionable effect of whatever echo is present in the circuit. A higher velocity means a shorter time delay as the signals will require less time to make the round trip of the circuit.

Carrier and microwave circuits have a velocity above 100,000 miles per second. This assures a short time delay over even the longest intertoll circuits. Thus a higher echo level can be tolerated, or, in terms of transmission requirements, the circuit can be operated at a lower loss than it could if the delay were longer.

The transmission advantages of carrier and microwave are universally accepted throughout the industry. The vast majority of toll routes existing today make use of carrier and microwave circuits and as the plan progresses, more and more will be called into play. Also of importance, however, are the advantages carrier offers in providing some of the new short- to medium-haul facilities the intertoll-dialing plan will require.

One such application will come about when many small manual tributary offices are converted to automatic with the consequent transfer of operators to a toll center serving the area. Functions such as directory, information, complaints, and other services will require additional circuits. Since only a few extra channels are required and the distances are usually short, a carrier system such as the Lenkurt Type 33A or 45C, providing up to four channels and designed to prove-in over short distances, may result in greater savings than the alternate method of stringing extra wires or constructing extra facilities of other types.

## Conclusion

Achievement of the nationwide toll-dialing plan will involve the careful and gradual integration of existing telephone plant into a complex long-distance network based on alternate routing and automatic toll switching. The new techniques necessary to accomplish this impose severe transmission requirements.

Probably the most important single role in the over-all transmission scheme is being played by carrier, not only in meeting these requirements but also in meeting the public's demands for more and better toll service resulting from a growing awareness of what constitutes good transmission and an increasing willingness to make use of long-distance facilities.

When the goal is reached, the plan will provide a continent-wide long-distance facility that is economical, convenient, fast, and reliable—a facility that will more than repay the effort and expense involved in its achievement.

# AUXILIARY ALARM EQUIPMENT

### *For 45-Class Carrier Systems*

An essential part of any carrier system is an effective alarm facility. The basic and familiar function of this facility is to monitor the operation of the system to provide an indication to attending personnel when trouble occurs. A good alarm facility will, in addition, incorporate several other features which contribute to the over-all efficiency of the system.

Among these additional features are fail-safe operation, provision of office alarm as well as local alarm, and a means for shutting off the alarm indicating device after an alarm has been given. All of these features are incorporated in the basic alarm circuits which are standard equipment in Lenkurt 45-class carrier systems.

When the carrier system is used in conjunction with automatic dial equipment or when rapid return to service is especially important, several functional refinements over and above the basic alarm features are provided by auxiliary alarm equipment which is optionally available with all 45-class systems. This auxiliary alarm equipment provides facilities for disconnect-make-busy (DMB), loop test, and far-end reset.

The DMB feature is an important asset to systems operated by automatic dial equipment where some means should be available to prevent the machine switching equipment from attempting to "seize" a defective circuit. After an alarm has been given, the DMB circuit of the auxiliary alarm

*FIG. 1. Type 4509A Auxiliary Alarm Unit for use with 45BN, 45BX, and 45C carrier systems. Three of these units may be plugged into a Type 4503A Auxiliary Alarm Shelf.*

accomplishes this purpose by disconnecting all called parties from the carrier system drops and causing the signaling equipment to indicate busy at both ends of the system. In effect, this function tells the dialing equipment that the circuits controlled by the alarm are busy. The dialing equipment is then free to follow its normal procedure of passing over the defective circuits to seek an available channel elsewhere.

Once the alarm has been given and the defective circuits made busy to the dialing equipment, maintenance personnel are faced with the two problems of locating the trouble and clearing it. The loop test feature of the auxiliary alarm equipment provides a means for expediting both of these procedures to reduce the out-of-service time of the system.

Loop testing is done by means of a test key, one of which is provided at each terminal of the system. When a system transmission path exists, pressing the test key at one terminal sends a test signal to the other terminal and back to the originating terminal where it lights a test lamp.

By means of the loop test, it is possible to determine immediately after an alarm is given whether the trouble is of a temporary or a sustained nature. If the trouble proves to be sustained, the loop test facilitates the troubleshooting procedure since the continuity of the circuit can be tested at any time by simply pressing the test key.

Another important advantage of the 45-class auxiliary alarm equipment is the facility it provides for resetting the system for normal operation after the trouble has been cleared. Where auxiliary alarm equipment is not provided, this resetting must be done by manually operating reset keys at each terminal of the system. This method is particularly inconvenient where one of the terminals of the system is unattended.

With the far-end reset circuit of the auxiliary alarm equipment, the entire system can be reset for normal operation from either one of the terminals. This is done by holding down the loop test key for a period of 15 seconds. This simple operation automatically returns the alarm circuit relays to their normal positions and clears the busy condition from channel signaling leads at both terminals.

The auxiliary alarm units for all Lenkurt 45-class carrier systems are consistent with the miniaturized, plug-in construction of 45-class systems themselves. Further information on these units may be obtained from Lenkurt or its distributor.

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### Cable Assembly

Lenkurt technicians are shown making up a rack wiring harness for carrier system use. Special jigs allow hundreds of feet of wire to be assembled quickly and accurately to exacting specifications.

Completed harnesses, shown in background, are being readied for final assembly.

Lenkurt ELECTRIC CO. SAN CARLOS, CALIF. VANCOUVER, B. C.

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