# A Subscriber Toll Dialing Tape Reader

W. H. BLASHFIELD
MEMBER AIEE

**Synopsis:** Low cost machine scans punched tape produced by customer-dialed long-distance calls and prints a ticket or punches a card for each call. Process includes automatic rate selection and charge computation.

TO IMPROVE service and avoid the unprofitable manual handling of short-haul toll calls, systems have been developed which enable the telephone user to dial numbers in nearby towns. In one such system, intended for small independent offices and described in an earlier paper,[1] the call record is a punched tape as illustrated in Figure 1. Because the tape is not easy to read by eye, an automatic "reader" is needed to present the information in a form more suitable for the telephone company's billing department.

Several factors are involved in choosing the type of presentation. For the small company, simple and inexpensive equipment is the first consideration. For larger companies, a record permitting efficient handling of a large volume of business is important. In any company, the presence of operator-written toll tickets makes it desirable that the tape-reader record be capable of being handled in the same manner as the written tickets.

The availability of an inexpensive printer resulted in the development of a reader producing printed tickets. The tickets are the same size as standard toll

---

Paper 53-112, recommended by the AIEE Communication Switching Systems Committee and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 19–23, 1953. Manuscript submitted November 5, 1952; made available for printing December 5, 1952.

W. H. BLASHFIELD is with the North Electric Manufacturing Company, Galion, Ohio.

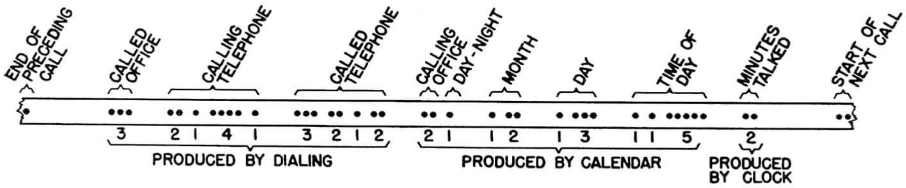


**Figure 1. Punched tape. Called office and day-night entries are sometimes omitted**

tickets, permitting them to be sorted and handled together with operator-written tickets. Furthermore, the electrical operation of the printer is similar to that of business-machine card punches, so that a standard card punch can be substituted for the printer if a company's volume of business is sufficient to warrant punched-card accounting.

The reader is shown in Figure 2, and a printed ticket in Figure 3. The punched black paper tape is received from the recording equipment on 8-millimeter movie reels, and is run through the reader backwards to avoid rereeling. A motor drives the tape past a phototube scanning unit which operates relay circuits that analyze the information and actuate the printer. Approximately 45 minutes are required to print tickets for one reel of tape carrying about 300 telephone calls.

The reader not only prints the information found on the tape but also computes and prints the charge for each call. If toll dialing is provided between two towns only, all calls take the same rate and computation is relatively simple. If a number of towns are involved in a dialing network, however, calls among several offices may appear on the same tape, requiring the reader to recognize the offices, choose the appropriate rate, and compute the charge based on that rate.

Because of the differences in scope of computation, two types of readers are made, one for the simple single-rate situation, and the other arranged for automatic rate selection. The simpler type contains about 10 tubes and 50 relays, the more elaborate version requires twice as many relays. The latter type will be described here.

## Tape Information

To place an interexchange call, the subscriber dials an office code for the town he wishes to reach, then dials his own telephone number, and then dials the desired telephone in the distant office.

Office codes may be one or two digits, depending on the number of offices and arrangement of trunks in the network. With a 2-digit code, the first digit selects a tape recorder, and the second digit selects the desired office and also is punched on the tape to record the identity of that office. For example, if the subscriber dials office code *83*, the *3* is the first information on the tape, as illustrated in Figure 1.

The tape recorder consists of a punch magnet driven directly by dial impulses and a step magnet to step the tape each time it is punched. The step magnet can also be operated independently to provide separation between digits and numbers.

After the office code, the dialing of the subscriber's own number is recorded, followed by the dialing of the called number. (The customer is requested to dial his own number in order to avoid the complex and costly equipment that would be required to locate and record that number automatically. A simple circuit compares the number dialed with the calling line to insure that the calling number is dialed correctly.)

When the call is answered, the recorder engages a calendar, which punched a digit identifying the originating office, followed by a day-night digit indicating weekday or night-Sunday-holiday. Then comes the month, day, and time of day. (Time of day is in hour and tenth; thus *115* is 11:30 A.M.) Following the calendar information, a clock punches the tape once a minute to record the duration of conversation.

The day-night digit (*2* for weekday, *1* for night-Sunday-holiday) tells the reader whether day or night rates apply, night rates in telephone parlance being effective every night and also all day on Sundays and holidays. The calendar can supply day-night information to the tape rather easily, whereas it would be difficult for the reader to recognize Sundays and holidays from the date alone, although such readers have been built (Figure 2 is an example). As differentials between day and night rates usually exist only for distances greater than 40 or 50 miles, the day-night digit is omitted in many installations.

The called office digit also is absent in systems using single-digit office codes. This does not produce an ambiguous record, for in a single-digit system the recorders will be located in trunks directly connecting two offices, so that the calling office code punched by the calender is sufficient to identify both offices.

## Ticket Information

The ticket of Figure 3 corresponds to the tape of Figure 1. Ticket information differs from the tape in that

1. the charge is computed and printed;
2. an *8* (or other appropriate digit) precedes the calling and called office digits to produce the complete office codes;

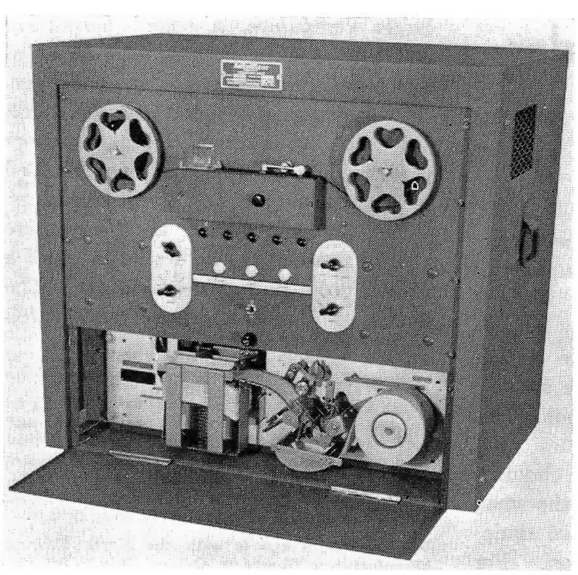

**Figure 2 (left). Front view of tape reader with hinged bottom panel open to show printer**

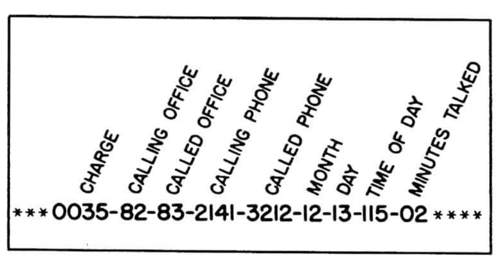


**Figure 3 (right). Printed ticket**

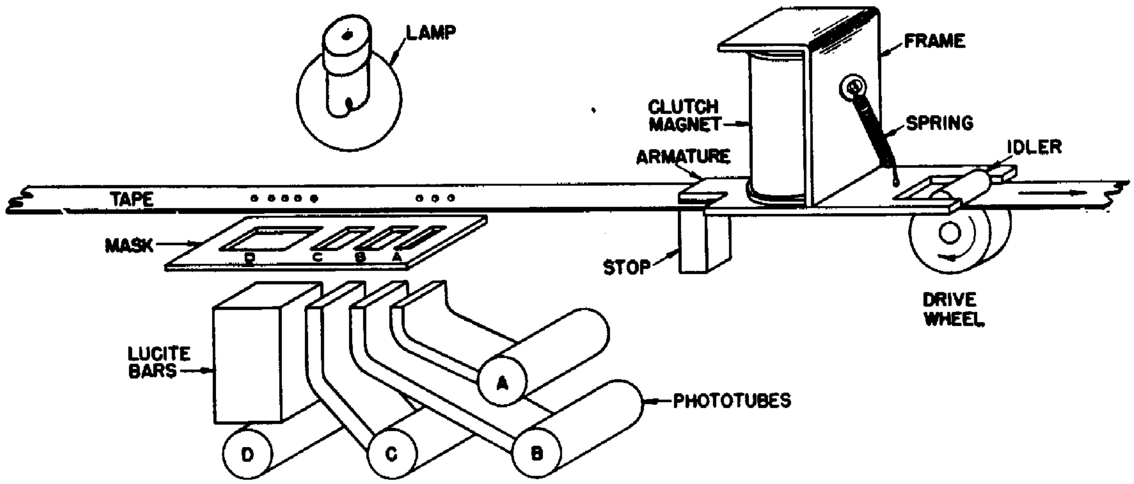


Figure 4. Scanner and tape drive principles

3. the calling office code is shifted to a position near the beginning of the ticket; and
4. the day-night digit is not printed.

The position of the calling office code is changed simply to make the ticket easier to read. The day-night digit is not printed because it only supplies information to the reader and would serve no useful purpose on the ticket. The charge appears at the beginning of the ticket because that is actually the end of the printed information with the tape and printer running backwards.

## Ticket Printer

The printer is a *JP-2* Message Ticketer manufactured by the Teletype Corporation of Chicago, Ill.[2] A type wheel carrying the ten digits and dash and star is rotated continuously by a motor and friction clutch. On the same shaft is a pair of brushes rotating over a stationary commutator on which each segment corresponds to a character on the type wheel. If voltage is applied to a segment, a print magnet is energized when the brush reaches that segment, forcing the paper against the character on the type wheel. When the print magnet is released by de-energizing the commutator segment, a ratchet mechanism steps the paper ahead. The paper is on a continuous roll, and is cut into tickets by a magnetically operated knife.

Because the paper can be stepped only by operating the print magnet, dashes are printed to separate different numbers, and stars are printed to build out the ticket to standard toll-ticket length.

Printer operation consists of energizing a lead (commutator segment) corresponding to the digit to be printed; standard card punches are actuated in the same manner. For that reason, circuits designed to control the printer can also be used to produce punched cards.

## Tape Scanner

Reader operation consists basically of counting each series of holes on the tape and then energizing the printer lead corresponding to the digit counted. Series of holes are recognized by the spaces between them.

Three widths of spaces are used: (1) narrow between digits, (2) medium between numbers, (3) wide between calls. Any space signals the reader to print the digit counted: a medium space indicates that a dash is to be printed in addition to the digit, a wide space indicates the end of the call information.

The scanner and tape drive mechanism are illustrated in Figure 4. The tape rides over a mask containing four slots, lettered *A*, *B*, *C*, and *D*. Lucite bars guide the light from each slot to a corresponding phototube. Narrow slot *A* is used for hole counting, impulses from phototube *A* driving a relay counting chain. Slots *B*, *C*, and *D* are for space recognition, slot *B* being covered by a narrow space, *B* and *C* by a medium space, and slots *B*, *C*, and *D* by a wide space.

A clutch controls the tape drive. When the clutch magnet is energized, the left-hand end of the armature is lifted away from the stop against which it has been holding the tape, and the idler at the opposite end is forced against the continuously rotating drive wheel to drive the tape. After each series of holes scanned, the space covering slot *B* releases the clutch and closes a circuit to print the digit that has been counted. After printing, the counting circuit is reset and the clutch re-energized to start the tape for the next digit.

As mentioned earlier, the tape is scanned backwards to avoid the need for rereeling. Backward operation has the further advantage that incomplete calls can be recognized and ignored.

From the tape of Figure 1, it will be seen that the first information scanned is the minutes of conversation, followed by a medium space. If, however, the called number had been busy or had not answered, no calendar or clock information would have been punched in the tape; then the first thing scanned would have been the last digit of the called number, followed by a narrow space. If the reader sees a narrow space after the first digit scanned, it prints nothing, but simply lets the tape run until the next call is reached.

## Block Diagram

Referring to Figure 5, the tape scanner drives the hole counting chain which furnishes information both to the printer

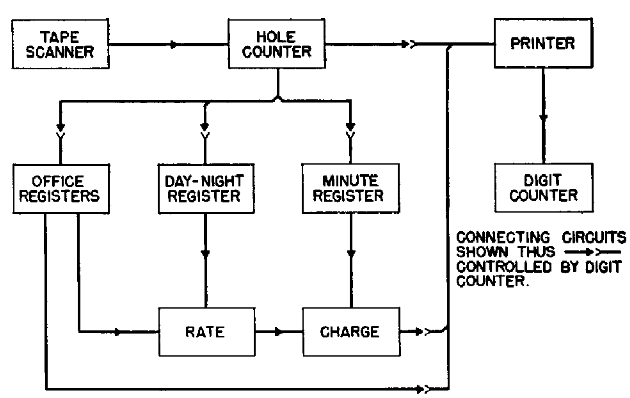


Figure 5. Block diagram of reader

and to the registers which store the figures necessary for charge computation.

The digit counting chain counts each character printed, keeping track of the location of information on the tape and ticket. This chain is driven by contacts on the print magnet and controls the connection of the various registers and printer to the hole counter, determines the number of stars to be printed to reach a standard ticket length, and controls the cut magnet that cuts off the ticket.

As a call starts through the reader, the minutes of conversation are scanned and counted first, and the digit counter energizes both the printer and the minute register. Although the minutes consist of a single series of holes, the counting circuit breaks the information into tens and units digits.

Next the time of day, day, and month are scanned and printed, but not registered. Then the day-night digit and the calling office digit are scanned and registered, but not printed. The digit counter controls the connection of the registers and printer at the proper points. When digits are registered without printing, the registers step the digit counter.

The called and calling telephone numbers are printed, and last comes the called office digit, followed by the wide space marking the end of the call. When that digit has been printed, the reader automatically prefixes an *8* to complete the office code. Then the printer is connected to the office register to print the calling exchange digit which had been stored earlier without printing. Here, again, an *8* or other appropriate digit is automatically prefixed.

At this point the printer is switched to the computer circuit, which delivers the charge for the call. Finally stars are printed until 40 characters are reached to give a standard length ticket.

## Computing

As indicated by the block diagram, the combination of offices and the day-night indication determine the rate; then the rate and minutes of conversation are combined to give the charge.

A typical toll rate is "35 cents for 3 minutes, 10 cents each additional minute." Four factors are involved: (1) initial charge, (2) initial period, (3) overtime rate, and (4) overtime period. Another example, differing in all four factors, is "20 cents for 5 minutes, 5 cents each additional 2 minutes."

Charge computation based on such rates involves addition, subtraction, multiplication, and division. Circuits to perform all four arithmetical operations in a universal manner would be quite elaborate, but the amount of equipment can be reduced drastically by taking advantages of limitations in the rate structure.

For example, all rates are multiples of 5 cents. An overtime rate of 20 cents per minute usually applies to distances of about 100 miles, and distances greater than 100 miles are rarely encountered in independent telephone companies. For all practical purposes, therefore, overtime rates can be considered to be 5, 10, 15, and 20 cents. Then overtime charge computation consists of multiplying one of only four numbers (rates) by a 2-digit number (minutes or pairs of minutes). When limited to this extent, multiplication requires relatively little equipment.

Rates are set in the reader by strapping between terminals. Each office combination is represented by a set of four terminals. Another group of terminals represents rates and periods. Each of the four office-combination terminals is strapped to an appropriate rate or period terminal to give the initial period, initial charge, overtime rate, and period for that office combination.

If there is a differential between day and night rates, sets of day-night terminals are interposed in the strapping between the office-combination terminals and the rate-and-period terminals to give different rates for day and night.

The strapped terminals are on a multiconductor plug which fits a permanently wired jack in the back of the reader. Different plugs can be strapped for different rates and office codes; then if a large company has several separate groups of offices, the corresponding rate plug can be inserted in the jack when running tapes from a given group of offices.

## Circuit Design

Reliability, simplicity, economy, flexibility, and speed were factors governing the reader circuit design. The importance of reliability and accuracy in a machine producing information for thousands of telephone bills is obvious. Various types of self-checking circuit principles have been employed, and choice of components and circuit values has been very conservative.

After each digit scanned, the tape is stopped until the printer prints; any print failure will leave the machine permanently stopped. Only make contacts appear on register, rate selection, and computing relays, so that failure of any relay will result in an open circuit, breaking the chain of information to the printer and thereby stopping the machine.

Besides open circuits, it is possible that short circuits, crosses, or grounds might occur accidentally. These usually result in the simultaneous energization of two or more print leads. For example, a short circuit or spurious relay operation in the minute register would look like more than one number of minutes, resulting in an attempt to compute two charges and to print two things at once. A trap circuit monitors the printer and stops the reader if two print leads are energized simultaneously.

The positions of the digit counter are compared with the medium spaces on the tape, giving a check both on correct digit counting and on proper number of digits per number on the tape.

Because the spaces on the tape are measured by physical distance (slots *B*, *C* and *D* in Figure 4) rather than by any method involving time, tape speed is unimportant. There is no lower limit on speed, for all tube circuits are direct-coupled and no slow relays are used. At the other extreme, readers are tested for satisfactory operation at 100 holes per second, or twice the normal tape speed.

Electron tubes are long life types operated conservatively, and the number of tubes and tube types has been held to a minimum. The light source is provided with efficient reflector and lens to produce intense illumination at the scanning mask, resulting in more than adequate output from the phototubes without the use of undesirably high load resistors. The black paper cuts off the light completely when spaces in the tape cover the slots.

Relays are standard telephone types of proved reliability in circuits which avoid marginal operations or close timing. Forced-sequence principles are used extensively, each step in the circuit operation depending on, and being initiated by, the completion of a preceding step. This provides maximum reliability, because a failure at any point stops the entire operation; it also gives maximum speed, because operations follow each other at their own inherent speeds rather than being assigned definite times in which to occur.

Simplicity is of great importance in equipment intended for small independent telephone companies, for such companies rarely have skilled men capable of understanding and maintaining complex equipment. Unfortunately, a machine which performs all the functions of the tape reader cannot avoid a certain amount of complexity, but circuits have been kept as straightforward and understandable as possible, and the design has adhered to types of circuits and apparatus which are most apt to be familiar to the average telephone man.

The printer is rugged and quite simple mechanically, permitting adjustment or repair by a person with no unusual mechanical skill or training. The only other mechanical parts in the reader are the tape drive motor and clutch.

Relays have been used in preference to electron tubes wherever possible, because the small-company telephone man usually knows nothing about electronics but has at least a speaking acquaintance with relay circuits as the result of the extensive use of relays in dial switchboards.

Observation and testing are facilitated by test keys. The reader can be made to scan one digit and stop, print that digit and stop again, and so on, each successive operation being initiated by the manual manipulation of a key. This slow-motion principle is augmented by a switch to turn off the tape drive motor, permitting the tape to be fed very slowly by hand so that tube voltages and relay operations can be observed for each hole in the tape. With these facilities, a case of trouble can be isolated rather quickly and easily.

Low cost is facilitated in both models of readers by the use of a simple and inexpensive printer. Furthermore, the single-rate model avoids much of the relay equipment found in the automatic-rate-selection model, bringing the cost in range of the smallest telephone companies.

In the single-rate reader, the registers and rate and charge circuits of Figure 5 are eliminated, leaving only the tape scanner, printer, and hole and digit counters. With a single rate, the charge is entirely a function of the number of minutes talked; consequently the hole counting relays have contacts wired in such a manner that when minutes are counted, the corresponding charge is printed instead of the number of minutes. On the remainder of the ticket, the information is printed in exactly the same form as it is found on the tape. This elimination of all storage and separate computing circuits results in a reader with simple circuits and a minimum of equipment.

The single-rate model is not limited to systems containing only two offices, but rather to systems in which all calls on a given tape take the same rate. For example, a network might contain several towns but have the trunks and recorders arranged in such a manner that a given tape recorder handles calls between only two towns. When running tapes from that recorder, the hole counter in the reader will be wired for the corresponding rate; when running tapes from a different recorder, the hole counter wiring can be changed to a different rate by a multicontact switch or by removing and inserting different multicontact strapped plugs.

High speed of operation is desirable in readers used by larger telephone companies. This is primarily an economic factor, of course; if doubling the speed of the reader more than doubles the cost, it is cheaper to use two slow readers than one fast reader.

Rate of ticket production is determined primarily by the speed of the printer and the speed of counting holes in the tape. The optimum counting rate is about 50 to 75 holes per second; at any lower rate the printer has to wait for the counting, whereas higher counting speed does not appreciably increase ticket production because the printer is unable to go any faster.

For reliable counting at, say, 50 holes per second, the counting circuit should be capable of following 100 holes per second. This is rather fast for conventional relay circuits, yet it was desired to use relays instead of electronic countres for the sake of circuit simplicity and flexibility. If we follow the obvious procedure of operating a relay from phototube $A$, that relay operating and releasing from every hole in the tape and driving a relay counting chain, we are confronted not only by a problem of speed but by the problem of mechanical wear and contact erosion on the rapidly operating driving relay.

These problems were solved by eliminating the driving relay and developing a relay counting chain driven directly by an electronic circuit. This circuit is essentially a gas tube "flip-flop" controlled by phototube $A$, with the relay chain advanced one step by each reversal of the flip-flop. This scheme, besides eliminating the speed and wear problems of a driving relay, inherently doubles the speed at which the chain can count and actually increases the speed still further by eliminating problems of pulse ratio, thereby permitting counting at a speed of 100 per second with conventional telephone relays.

The reader normally drives the tape at 50 holes per second, at which speed 350 to 400 tickets per hour are printed, or about 3,000 tickets per 8-hour day. This is adequate for the toll traffic of small- and medium-sized independent telephone companies, and the low cost of the machine permits using two or more readers in companies with larger volumes of business.

### References

1. Simplified Subscriber Toll Dialing for Low-Rate Low-Density Toll Circuits Between Community Dial Offices, **Eric Brooke, J. M. Blackhall, W. H. Blashfield.** *AIEE Transactions*, volume 69, part II, 1950, pages 1417–20.

2. Automatic Ticketing, **O. A. Friend.** *Bell Laboratories Record* (New York, N. Y.), volume 22, July 1944, pages 445–50.

## No Discussion