The XY Toll Ticketing System

H. L. FOOTE
ASSOCIATE MEMBER AIEE

IN RECENT years independent telephone companies have become acutely aware of steadily decreasing net profits on short-distance toll-call operation. The recording, for billing purposes, of certain information concerning the toll call has required the assistance of an operator. For this reason, manual toll switching has been retained in spite of the fact that mechanical systems for performing the actual switching functions have been available for many years. Fixed toll charges and rising labor costs have combined to make it extremely difficult for the operating companies to realize a profit on this phase of their business.

One solution to this problem is the granting of free service on these loss-producing toll lines. While this would prevent further losses, resulting increased traffic would create a demand for additional expensive plant equipment and personnel which in turn would produce no revenue.

A second solution is the reduction of the number of people involved in producing the toll billing records known as "toll tickets," by the installation of automatic toll switching equipment incorporating automatic ticketing means. Several attempts have been made to provide such equipment and two basic types have emerged.

One, the verifying type, requires the calling subscriber to dial his own directory number before dialing the number of the desired station. The other, considerably more complex and expensive, is the identifying type wherein the calling station number is automatically found and recorded without effort on the part of the subscriber.[1] The system described herein is of the verifying type.

Any toll ticketing system, manual or automatic, must accomplish the following three things:

1. The information concerning the toll call must be recorded in some manner.
2. The recorded information must be translated and interpreted for use by the ticketing device.
3. The information must finally be presented in a readily usable form.

Recording the Information

Since the primary objective of any toll ticketing system is the reduction of manual labor in producing the toll tickets, the most desirable system would be the one which would reduce the labor factor to zero. In order to achieve such a goal, the designer is confronted with the need for an inexhaustible medium on which to store temporarily the billing information until that information is printed as a toll ticket. Several such storage devices are available, only one of which is economically sound.

The Recorder

The unique magnetic tape recorder shown in Figure 1 forms the heart of the XY toll ticketing system as the intermediate storage device. The tape in the magazine can record information concerning 100 average toll calls before it requires automatic interpreting equipment to print the tickets, simultaneously preparing itself for reuse. One recorder is permanently associated with each toll trunk, operating completely unattended in all of its functions. The recorder records the calling and called subscribers' directory numbers, the duration of the call (elapsed time), the time of day, and the date.

Figure 2 shows the XY switch manufactured by Stromberg-Carlson Company. This is a universal switch for use in any circuit in a step-by-step dial telephone system. Comparison with Figure 1 will show the similarity between the recorder and the switch. Great savings in tooling and manufacturing costs were achieved by using as many identical parts as possible in the two devices. Both are built on the same plate, use two of the same magnets, mount in the same way, and are jacked into the associated trunk relay equipment by means of identical cord and plug assemblies. Thus, the entire design of the XY toll ticketing equipment can be harmonious with standard XY switching equipment.

Paper 53-184, recommended by the AIEE Communication Switching Systems Committee and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Southern District Meeting, Louisville, Ky., April 22–24, 1953. Manuscript submitted January 21, 1953; made available for printing March 11, 1953.

H. L. Foote is with the Stromberg-Carlson Company, Rochester, N. Y.

The author wishes to acknowledge the contributions of F. A. Morris, J. D. Confeld, and H. S. Gleason who should be credited with the major portion of the circuit and mechanical design of the XY toll ticketing system.

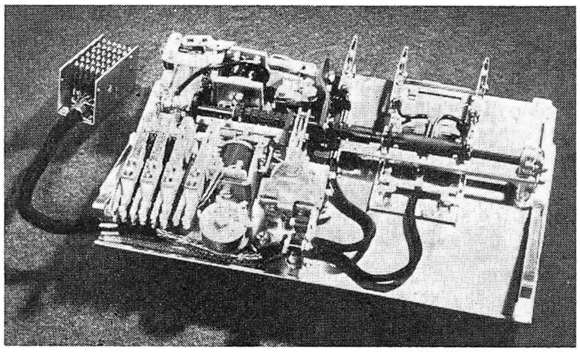


Figure 1 (left). Trunk recorder-reproducer used in the XY toll ticketing system

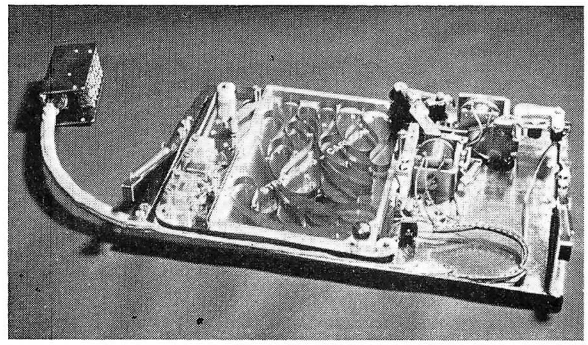


Figure 2 (right). The Stromberg-Carlson XY switch

The recording is made on standard 1/4 inch magnetic tape. Approximately 30 feet of tape are contained in the magazine in the form of an endless loop. The tape is transported by a capstan which can be driven by either of two methods. For recording, the tape is advanced step by step in 0.057-inch increments by means of a ratchet drive. For playback, a clutch connects the capstan to a common motor shaft and the tape is driven at a constant rate of about 3 inches per second. The tape passes over a twin-track recording head and a double-width erase head. Felt-faced pads apply the necessary pressure to assure proper contact between the tape and the heads. Three contact springs, sensing two conductive areas applied to the back side of the tape, control the cycling of the recording and playback process.

The Tape Heads

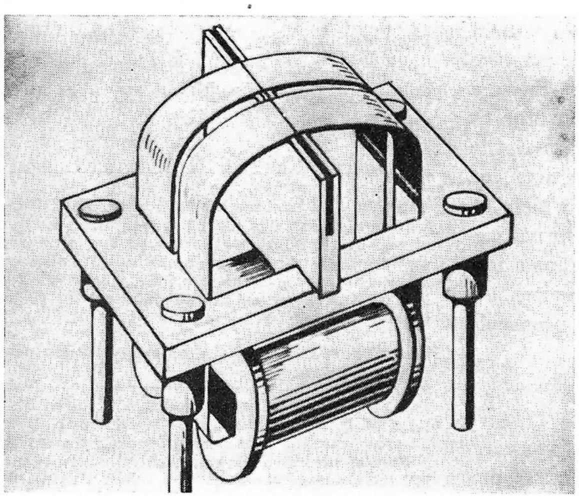
Figure 3 shows the twin-track record-playback head before and after it has been cast in resin. Each head consists of a single 0.112-inch wide lamination of molybdenum permalloy with a 1-mil gap spacer. The coils are 2,700 turns of no. 46 wire wound on a bobbin. The various parts are mutually supporting and interlocking. The erase head is built on the same principle, the lamination being 0.270 inch wide, and its coil is 50 turns of no. 27 wire.

The upper half of the twin-track head is energized by each dial impulse and makes a magnetic impression 0.002-inch wide on the upper half of the tape. The lower half of the head is energized upon release of the interdigit relay in the trunk circuit which also affects the advance of the tape by a single step. These interdigit pulses serve to separate the several groups of pulses derived from the dialed digits. The two series of pulses are known as "mark" and "space" pulses respectively. To indicate the end of a call, mark and space pulses are recorded simultaneously when the trunk is released.

Block Diagram

Figure 4 shows a block diagram of the XY toll ticketing system, while Figure 5 shows the equipment itself, except for the trunk circuit. The digits of the subscriber's own number are used for two purposes. They are recorded in order to bill the call and they also set up a connection to verify the accuracy of the number dialed. If the call is verified, the verifying circuits are dropped off, and subsequent pulses (of the called number) are passed over the trunk to establish the connection to the distant subscriber. As soon as the called subscriber answers (answering supervision), the trunk transfers the recorder input to a common time impulse circuit, the minute pulser, transmitting one impulse per minute to the recorder during the conversation. When the calling subscriber hangs up (on-hook supervision), the trunk drops the linkage and transfers the input of the recorder to a common clock-calendar. Digital representation of the time of day and date is automatically pulsed into the recorder. Upon completion of this operation, the trunk releases and causes an end-of-call signal to be recorded. The trunk and its associated recorder are then free to accept another call.

If the calling subscriber dials other than his own number the call will not be verified and subsequent pulses are neither recorded nor repeated to the distant office. This condition is indicated to the subscriber by means of a suitable tone. Upon receiving on-hook supervision the trunk will merely enter an end-of-call signal and release. Similarly, in the case of "don't answer" and busy line calls, the trunk will enter an end-of-call signal—omitting the time and date information—and release. The presence of the date and time of day information is the criterion for the playback equipment to print a valid ticket. Abnormal calls are thus ignored by the printing equipment.



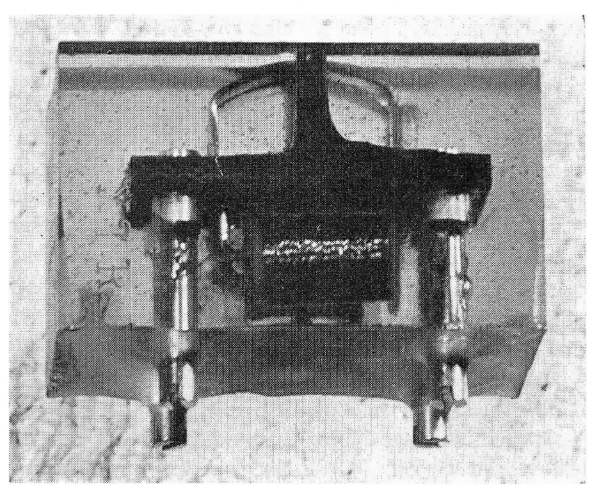


Figure 3. Record - playback head used in the XY toll ticketing system—before (left) and after (right) being molded in resin

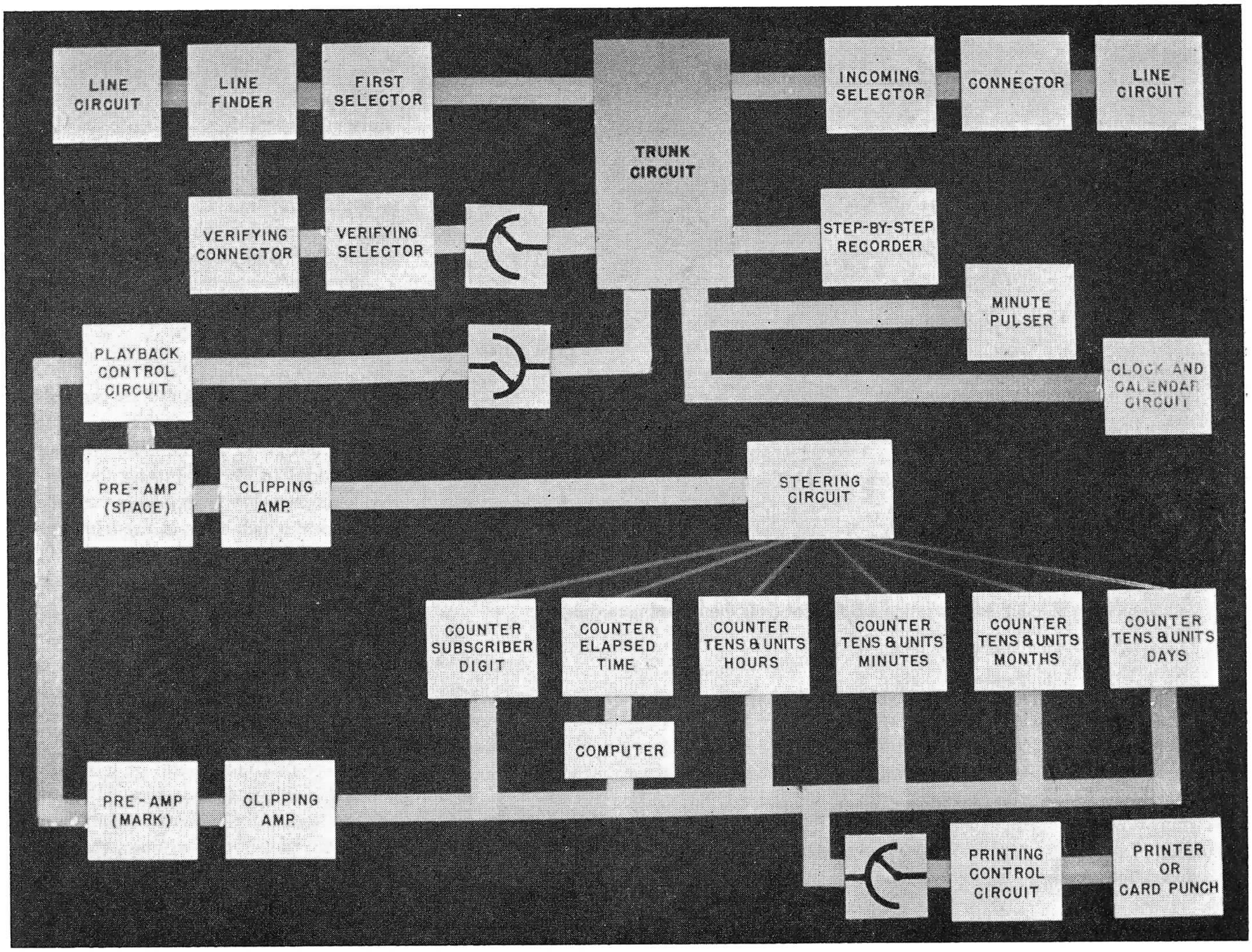


Figure 4. Block diagram of the XY toll ticketing system

Interpretation and Presentation

Common playback equipment attaches itself to each trunk recorder according to a prearranged schedule to permit common interpreting equipment to analyze the information recorded on the magnetic tape recorder. The interpreting equipment operates a ticket printer, common to all recorders, which prints a standard size toll ticket and automatically stacks these tickets, printing up to 10,000 per day. If complete automatic billing is desired, the information can be directed into a card-punching machine instead of the printer. In this case, 15,000 calls can be ticketed per day, since the card punch will operate somewhat faster than the printer.

Playback Control Circuit

Due to the large storage capacity of the trunk recorders, it is necessary and desirable to interpret the stored information only periodically, the period being determined by the toll traffic. Presumably, this would be once a day during a time of light traffic. The common clock-calendar unit is so wired that it will start playback at a predetermined time. The playback control circuit consists of a rotary switch and relays which function on a common equipment basis to augment the trunk during the playback cycle. The rotary switch acts as a trunk finder, stepping until the first idle trunk is found and associating the common control equipment upon seizing the trunk.

In the event that unusually heavy traffic conditions should cause a tape to become completely filled before the normal playback period, the normal schedule is ignored and the services of the playback control circuit requested at once. The rotary switch will advance directly to the full trunk and begin ticketing the calls from the recorder.

The "full" tape condition is sensed by the two conductive areas (foils) on the back of the tape. Should a subscriber seize the trunk and recorder just before the first foil is sensed, the recording of the data concerning the call will carry the tape past this point. Upon receiving on-hook supervision, the trunk immediately busies itself out and calls for playback as described previously. A "safety zone" has been provided to take care of long conversations in this area. Should the subscriber pass the first foil and the conversation continue for 99 minutes, the second foil will be sensed—indicating an absolute "deadline." However, a super-safety area has been provided so that when the second foil gives a forced disconnect, there still remains sufficient tape on which to record the date and time of day. If desired, the call can be continued by a manual operator rather than forcing disconnect.

Printing Control Circuit

The clutch of the recorder of the seized trunk is energized to move the tape to its "home" position. This is determined by the foil on the back of the tape. Control of the clutch is then transferred to the printing control circuit and the outputs of the twin record-playback head are con-

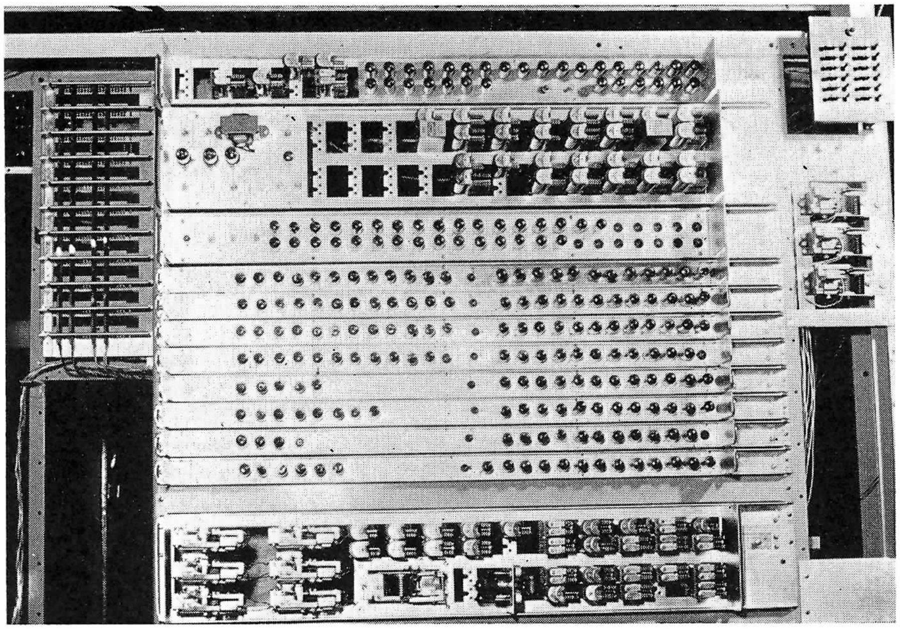


Figure 5. XY toll ticketing equipment (less trunks and recorders)

nected to the mark and space preamplifiers. The recorder remains under the control of the printing control circuit until the tape has been completely played back and erased, whereupon the playback control circuit takes over once again. Before the trunk is released, a single reset signal is recorded for purposes to be discussed later.

Upon releasing the trunk, the rotary switch advances and associates the playback control circuit with the next idle trunk to repeat the playback process. After completing a search through all of the trunks, the rotary switch will reach home and the playback control circuit will normally become inactive until the next scheduled start. After being amplified in the preamplifiers, the mark and space pulses are fed to the clipping amplifiers which further amplify the signals to a level suitable for driving the counting chains. The clipping amplifiers also act as marginal devices and will not transmit low-level signals resulting from interference. The signal pulses are shaped and brought to a uniform size by these amplifiers which have a very large range. Pulses having as little as 30 per cent of "standard" amplitude are transmitted and restored to full amplitude. The cutoff below that point is very rapid so that pulses only slightly less are completely eliminated. Pulses may be many times larger than standard and may still be restored.

Steering Control Circuit

The function of the steering control circuit is to energize the proper circuits to count and store the recorded digits. When the steering control circuit is primed, it enables the first counter to count and store the first digit. Upon receiving a space pulse, the steering chain will be advanced to the next step, enabling the second counter to count and store the second digit, and so forth. The steering chain will have as many stages as there are total digits of billing information.

Counters

With a playback tape speed of about 3 inches per second, the stored pulses are read off the tape at about 52 per second. Relay counting chains for counting and storing at this rate are extremely complex and expensive. Cold-cathode counting chains, on the other hand, can count very comfortably at this rate. One counting chain is used per digit of billing information, but the several chains vary somewhat in number of counting stages depending upon the maximum number of pulses expected. Those used for subscriber digits must count to ten, whereas those counting tens days, for instance, need count only to three. Where a large number of pulses must be converted into a 2-digit decimal number (for example, the elapsed time can have as many as 99 pulses) there is no single symbol for the quantity 99 and it must be represented as two 9's. This is accomplished by connecting the ends of a counting chain together to form a "ring." This ring will represent the units digit of elapsed time. It will continue to count around, repeating as many times as necessary. However, for every time the units ring returns to zero, one pulse will be fed into an associated chain to represent the tens digit of the elapsed time. Thus, if 45 pulses, representing 45 minutes of elapsed time, are fed into the counter, the units ring will return to zero four times, thus stepping the tens chain to four and will stop on the fifth tube in the ring representing units digit five. This automatically converts a continuous series of pulses into two decimal digits.

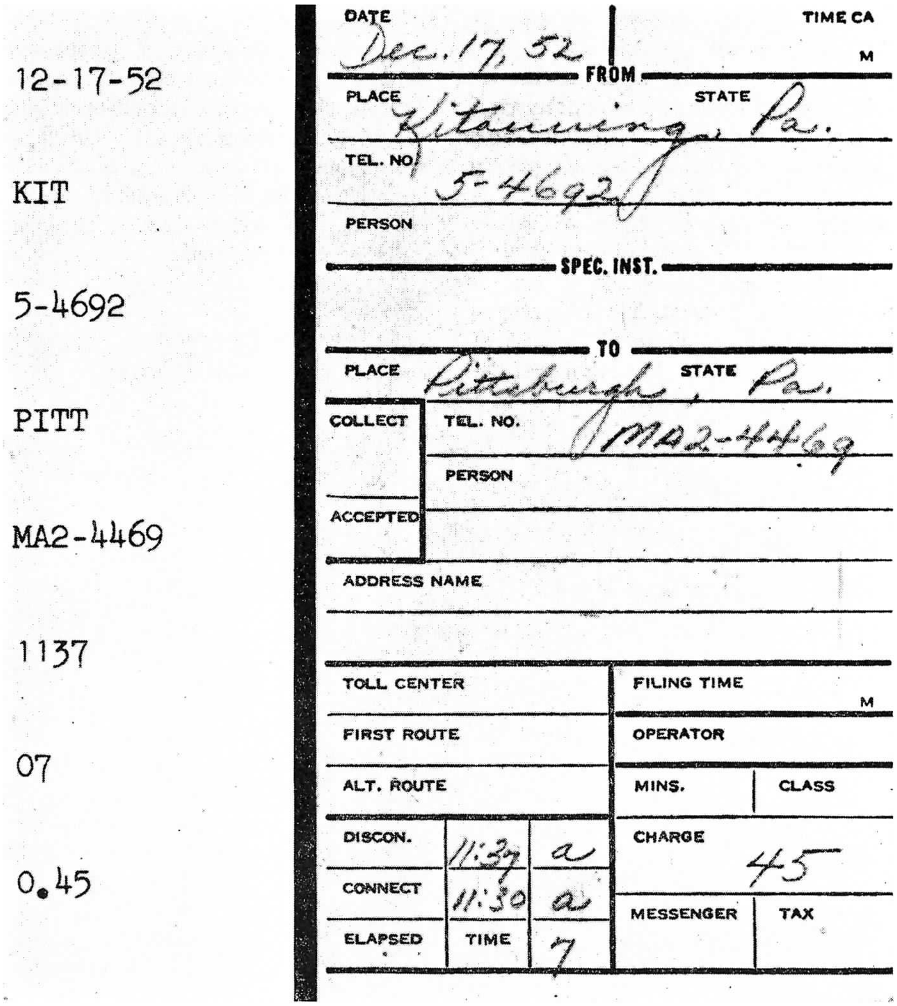
Interpretation

The information stored in the several counters must be transferred to the ticket printer a digit at a time. By connecting the anodes of the counter tubes to the banks of a rotary switch it is possible to determine which tube is fired in each of the counters. Note that the information thus stored may be read, and the ticket printed, in any order. A printed ticket is shown with a manually written ticket in Figure 5.

Due to the requirements of the ticket printer it is necessary to translate the decimal information into a permutation indicative of the numeral or letter to be printed. This translation is accomplished by a group of relays which are connected by the rotary switch to the anodes of the counter tubes. The ticket printer employs a 7-unit code so arranged that the operation of any single translating relay will result in printing a numeral. Combinations of two relays will result in printing a letter. The ticket printer and the printing control circuit are interlocked by the simple expedient of advancing the rotary switch by means of a pulse transmitted from a cam in the ticket printer.

Some of the information on the toll tickets is determined by means other than recorded data. The names of both the originating and called offices are determined by the operation of relays under the control of the playback control circuit which put the proper letter codes on the proper terminals of the rotary switch banks. Likewise, the digits representing the year are strapped on the proper bank terminals. Information needed by the printer such as carriage return, line space, ejection, etc. is strapped in.

The printing control circuit acts to correlate the functions of the playback control, steering, counters, and printing control circuit. Included in the printing control are the "destination code" relays which determine what trunk is being ticketed and thus control what office letters are printed on the ticket. These same relays are also used to adjust the


12-17-52
KIT
5-4692
PITT
MA2-4469
1137
07
0.45

DATE Dec. 17, 52 TIME CA M
FROM
PLACE Kittanning STATE Pa.
TEL. NO 5-4692
PERSON
SPEC. INST.
TO
PLACE Pittsburgh STATE Pa.
COLLECT TEL. NO. MA2-4469
PERSON
ACCEPTED
ADDRESS NAME
TOLL CENTER
FILING TIME M
FIRST ROUTE
OPERATOR
ALT. ROUTE
MINS. CLASS
DISCON. 11:37 a
CHARGE 45
CONNECT 11:30 a
MESSENGER TAX
ELAPSED TIME 7

Figure 6. A toll ticket produced by the XY system compared with a manually written toll ticket

computer for the proper base time and base rate.

The printing and playback control circuits are carefully interlocked so that playback cannot proceed unless the counters are in a receptive condition nor can control by the printing control be relinquished until the information is completely interpreted. To make certain that the counters do not contain any information left over from previous ticketing or other interference the playback control transmits a reset signal each time a new trunk is seized. As an additional precaution a reset signal is also recorded at the beginning of each tape as mentioned earlier. The reset signal is simply an end-of-call recording, which, when not preceded by normal ticketing information, serves to restore all of the counting chains to the starting condition. After the two safety resets, the counters receive and store the call information, storing all information about one call before any other action takes place.

The Computer

The computer makes use of the elapsed time and destination code information to derive the charge for the call. It too uses cold-cathode counting chains to calculate the charge. Essentially, there are two chains and two rings. One chain counts off the minimum time for the particular call, the number of stages in the chain being adjusted by the destination code relays. If the call is based on a 3-minute period, for example, there will be three stages in the chain.

The first ring counts off the number of 5-cent increments (since all short-haul charges increase at the rate of 5 cents per minute), the second ring counts the ten cents, and the second chain counts the dollars.

The minimum charge is primed into these counters by means of the destination code relays. If the call is based on 15 cents minimum charge, the 5-cent tube and the number 1 tens cents tube will be primed and the charging will start at that point.

The elapsed time pulses are fed into the computer which at first counts them in the minimum-time chain. When the end of this chain is reached, the remaining pulses are diverted into the first money ring which will add 5 cents for each additional minute—the total being kept by the remaining two counters. The calculated charge is read by wiring the anodes of the counters to the rotary switch just as the numerical information in the other counters.

Ticket Printer

The basic mechanism of the ticket printer shown in Figure 6 is an electric typewriter to which the Commercial Controls Company adds what is known as a "translator" to make it respond to electrical control. Essentially, the translator is much the same as the selecting mechanism in a teletype machine.

For the XY toll ticketing system the ticket printer is further modified to the extent of adding a device for feeding roll paper into it and converting the continuous roll into individual tickets neatly stacked.

The paper rolls are sufficient for 10,000 tickets, the paper being standard toll-ticket width. It is fed to the platen through guide channels, and after passing around the platen and being printed, it passes through another guide channel to a solenoid-operated chopping knife. After being cut off, the ticket is ejected into a stacking hopper.

Power Requirements

The only power required for recording the toll-call information is the normal office battery at 48 volts d-c. For play-

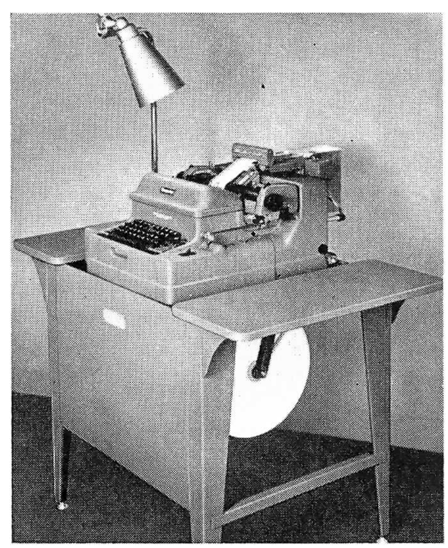


Figure 7. The ticket printer used in the XY system

ing back and ticketing, 110-volt a-c power is needed. The anode voltage for the cold-cathode tubes is derived from a simple 500-milliampere 150-volt d-c power supply.

Conclusions

The XY toll ticketing system meets the needs of the small and medium size telephone companies in their endeavor to solve the problem of decreasing profits in short-distance toll operation. By combining three basic arts—mechanical switching, magnetic recording, and electronics—the tickets for the toll calls are prepared in any desired form completely without manual attention, thus reducing to a minimum the high labor cost involved in toll billing. The 100-call capacity of the recorders and the 48-volt d-c recording operation prevent loss of revenue during a-c power failures. The use of cold-cathode tubes in the majority of the electronic circuits precludes the frequent changing of tubes since their life depends only on the number of on-off operations to which they are subjected. The *RCA-5823* tubes used have a life of approximately 40 million operations—a life equivalent to that of most of the other components of the system.

References

1. **Fundamentals of the Automatic Message Accounting System, John Meszar.** *AIEE Transactions*, vol. 69, part I, 1950, pp. 255–69.

No Discussion