CHAPTER 14

AUTOMATIC MESSAGE ACCOUNTING

14.1 INTRODUCTION

The Bell System serves upwards of 87 million telephones and completes over five billion long distance conversations a year. In dealing with quantities such as these, it does not take much imagination to appreciate that the accounting and billing problems are great. To carry on such a business the collection of earned revenue becomes most essential, and before this revenue can be collected bills must be prepared and presented to the customer. It is in the preparation of the data that is to be presented on the bills that Automatic Message Accounting (AMA) concerns itself.

Telephone Companies have unique problems in preparing bills. They sell tailor-made service items to millions of customers. Each service item consists of putting temporarily at the customer's disposal, an impressive physical plant, and a skilled human organization to enable him to communicate at will with his family, friends or business associates, whether they be just around the corner or thousands of miles away. A very large proportion of these service items are of truly low price. Although the Bell System is a multibillion dollar concern, much of its revenue is derived from service items, a great many of which cost only 30, 25, 20 cents or even less. There are, of course, toll calls that cost several dollars, but even these fall in a group which can be classified as low price service items. What runs up the system's total annual revenue into hundreds of millions of dollars is the enormous volume of these low priced service items. Therein lie the problems of recording, accounting for, and billing the customer.

14.2 AUTOMATIC MESSAGE ACCOUNTING (AMA)

A. BACKGROUND

Within the past few years, most of the lines within the Bell System have been integrated into the AMA system. This system records all the data required to charge for subscriber-dialed toll and many subscriber-dialed local message rate telephone calls and to mechanically process the records in accounting centers. Both the recording and processing arrangements employ many novel circuit and apparatus components. The use of the system permits

the wide expansion of direct subscriber dialing to nearby and more remote points, with resultant increased speed, and convenience to telephone customers. Although AMA is the first system to carry out automatically both recording and accounting for toll calls, it is not the first step in this direction, but is rather the culmination of a long line of developments.

During the early years of the telephone, subscribers were charged exclusively on a flat monthly or yearly basis; but since the end of the last century, message rate service has been available in many of the cities. Initially, the record of such calls was in the form of tickets prepared by operators. This method was later supplemented by the use of a small electromagnetic counter, called a message register, associated with each message rate line and operated once for each call made. As the metropolitan areas grew larger and subscribers began to call regularly beyond their local areas, zone registration was adopted. It provides circuits that, on each call beyond the local area, operate the message register the proper number of times to represent the cost of the call. Thus, if the charge on a call is 20 cents and each message register operation represents a charge of five cents, the register would be operated four times for this particular call.

Although zone registration is an economical method of charging for short calls, it does not leave any record of the details of the various calls. For calls requiring more than five message register operations, it has generally been felt desirable to have a record not only of the point to which the call was placed but of the day and time it was made. To secure such a record, and at the same time to obtain the economies and increased speed possible from automatic operation, automatic ticketing arrangements were developed. With this system a ticket is automatically printed for each chargeable call, and thus all essential information pertaining to the call is permanently available.

The printing of a toll ticket is only part of the work of charging for calls. Before subscribers can be billed for their calls, the tickets must be brought together and sorted out for each subscriber, computed, and totaled; from this data the bill is prepared. This work is extremely laborious and represents an appreciable item of expense.

It was recognized that the entire process of recording calls and preparing the customer's bills could be done mechanically but considerable development was required to make possible an economical automatic message accounting system.

B. GENERAL OPERATION

In the AMA system, the information pertaining to all calls requiring a charge is perforated, in code, on an oil-impregnated paper tape three inches wide. A specimen of the section of the tape after perforation is shown in Figure 14-3. There is space for twenty-eight holes across the tape, which is used for recording six digits in coded form, each representing a single item of information. Adjacent rows are about one-tenth inch apart, and either four, six, or seven rows of information are required per call. The items of perforated information are automatically read and interpreted at the accounting center at a rate of 150 digits (25 reader cycles) per second.

The perforating machines, see Figure 14-1, are installed in cabinets. They are associated with the outgoing trunks in the No. 5 Crossbar and No. 1 Step-by-Step systems, with the district junctors in the No. 1 Crossbar system, or with the incoming trunks of tandem and toll switching systems. One recorder serves 100 trunks or district junctors. Together with their associated equipment, they are installed in the individual telephone central offices. Each day at about 3 a.m. the tapes in all the recorders are automatically prepared for cutting by perforating a readily recognized pattern to indicate the section where the tape is to be manually cut. After cutting they are transported to the accounting center for processing. This accounting center may handle the tapes from many central offices and may be remote from any of them.

Since each tape from a recorder includes the information for all calls handled by a group of 100 trucks or district junctors, calls from a particular subscriber may be distributed over a number of tapes, and the information for any one particular call will usually not be on adjacent lines of the tape. Some of the information is recorded as the call is dialed or shortly thereafter, but the time the called subscriber answers, which is the beginning of the charge period, is somewhat later; in the meantime information relating to other calls may have been recorded on the same tape. The time the conversation is

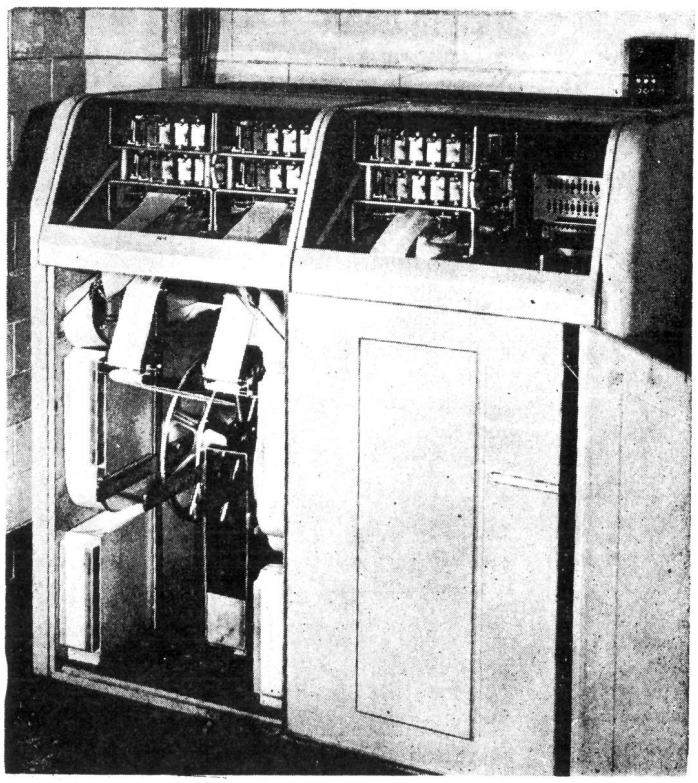


Figure 14-1 Two Tape Perforators

completed will, in general, be considerably later, and thus there will be information pertaining to any calls between the beginning and the ending of any particular call. Each tape, moreover, will include information on calls that are charged for in entirely different ways. For calls that are billed in bulk (message unit basis) it is not necessary to record the office and number of the called subscriber, since the duration of the call and other billing information provided in the call record is sufficient to determine the charge. This type of call requires only four lines on the tape, while six or seven lines are required when information pertaining to the called subscriber must be recorded.

At the accounting centers, all information pertaining to each call is gathered, conversation time is computed and the type of call, (toll, message unit, bulk billed, special) is noted. A printed or punched card with this information is then produced for each subscriber.

C. AMA TAPE FEATURES

In the central offices, recorders perforate, on paper tape, the records of calls routed over trunks arranged for AMA operation. Central office circuits are arranged to provide these recorders with the information required for determining the proper charges for each message. In order to control the processing of this information at the accounting center, the recorders are assigned in recorder groups. A section of tape produced by a central office recorder and its interpretation is shown in Figure 14-3.

It should be noted in Figure 14-3 that a "line" of information actually consists of the alternate holes of each of two adjacent rows. This arrangement permits a greater compactness of perforator equipment than would otherwise be possible. Figure 14-2 shows the staggered arrangement of the plungers for perforating the paper tape. However, the type of diagram representing the information as being on a straight line shown in Figures 14-5, 14-6 and 14-7, is used to simplify the discussion.

The "2 out of 5" code used to represent the call information on the tape is explained in Figure 14-4, the lower box illustrating a typical line of information.

The information for each message is recorded in three main parts on the paper tape in the following manner.

1. Initial Entry

After a subscriber completes dialing a call an initial entry is recorded on the paper tape. (See Figures 14-5, 14-6 and 14-7.) This entry consists of a series of consecutive lines containing information about the calling subscriber, and if needed, similar information about the called subscriber. The last line of an initial entry contains, in addition to other information, a 2-digit code known as the call identity index which identifies the trunk used for this call, and may be any number from 00 to 99. This index, which will be the same for each of the three recorded elements of a message, is used later in the accounting center to associate these elements to compute chargeable time.

2. Answer Entry

When the called subscriber answers, a second entry, called the answer entry, is made by the same recorder on the same tape. (See Figures 14-5 and 14-6.) This entry consists of a single line and contains the tens, units, and tenths of minutes of the hour in which the call was answered, and the call identity index. An Hour entry is recorded on the tape at the beginning of each hour and applies to all subsequent calls until a new hour entry is recorded. Day entries, in like manner, are recorded once a day. The day entry is made at 3 a.m. with the splice entry.

3. Disconnect Entry

When the call is terminated, a third entry, called the disconnect entry, is perforated on the tape. (See Figures 14-5 and 14-6.) This entry is also a single-line entry and contains the tens, units, and tenths of minutes of the hour in which the message was terminated, and the call identity index.

A central office equipment arrangement is available whereby on single message unit (SMU) non-overtime calls, only the initial and answer entries are recorded.

4. Other Entries

In order to insure, as far as possible, smooth and correct accounting center processing of the charge information recorded on the tape, there are numerous other entries perforated on the tape, when required. Information that is common to all messages from a particular central office is perforated only at the beginning and end of the central office tape. Typical of these are the entries denoting the month, day, and recorder number. An hour entry is perforated every hour on the hour, and later aids in correctly timing and associating the correct hour with each message. Cancel entries are perforated, when necessary, which later instruct the accounting center machines how to proceed when certain irregularities are encountered.

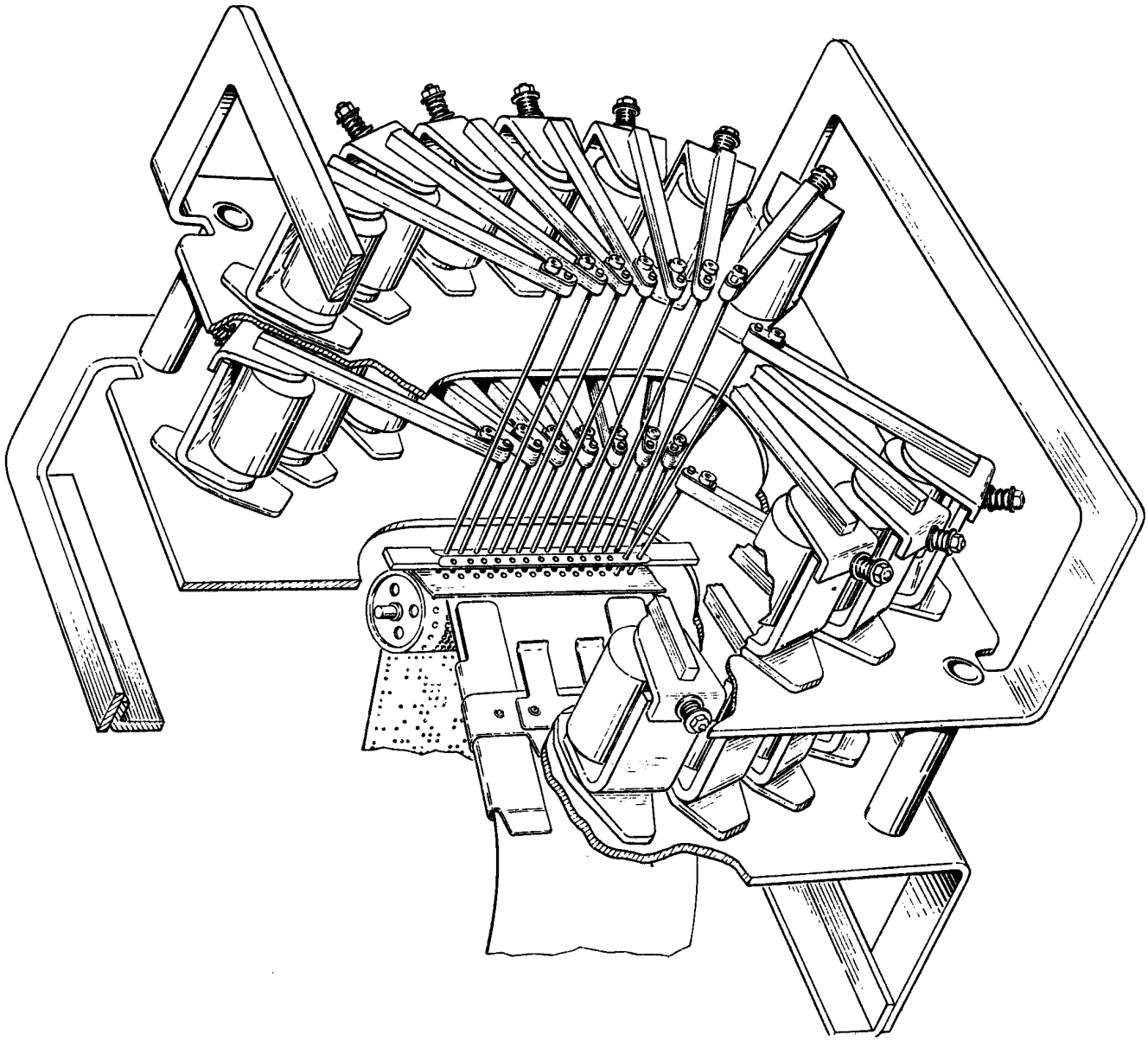


Figure 14-2 Broken Away Perspective View of the Perforator

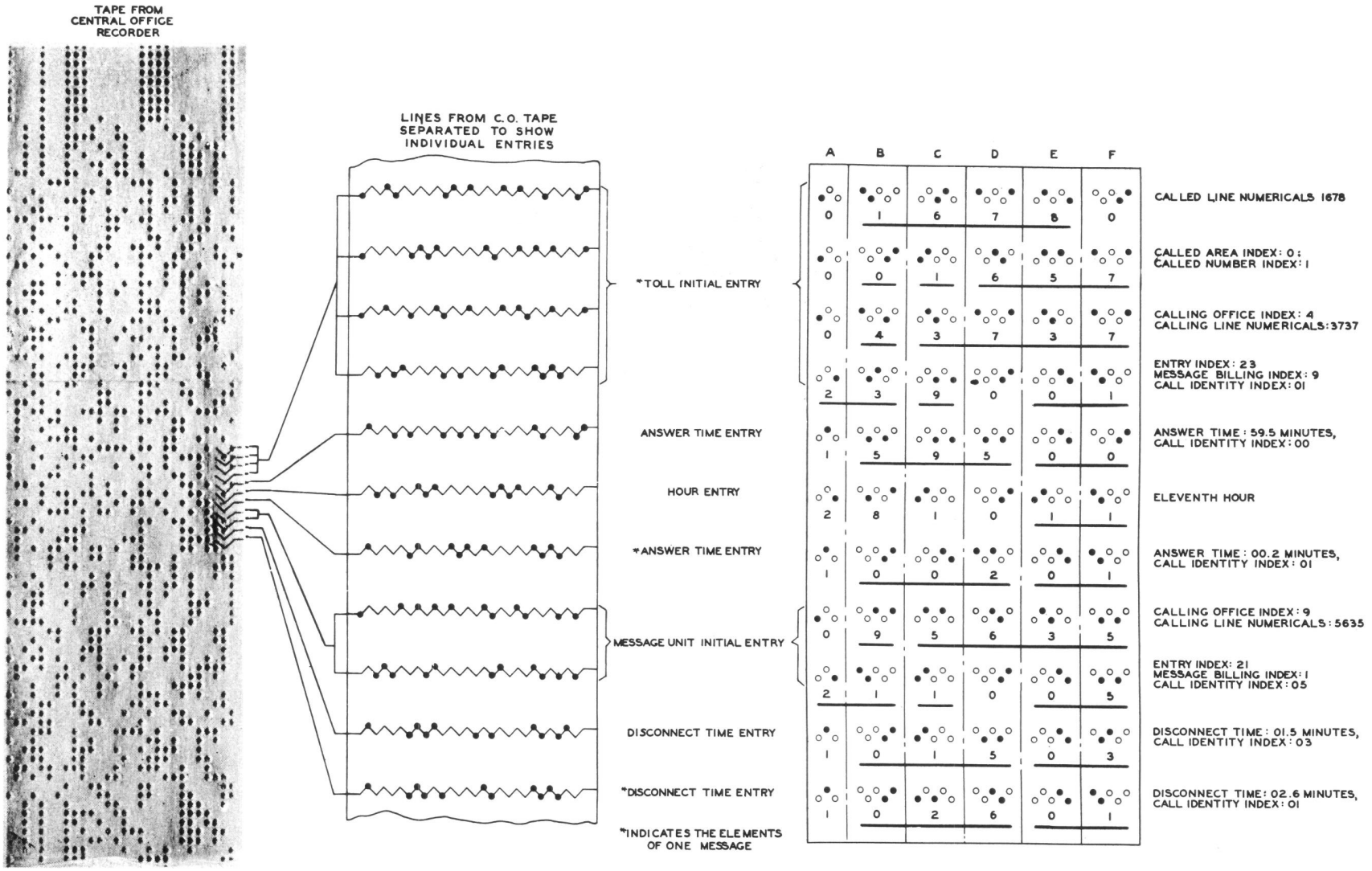


Figure 14-3 AMA Central Office Recorder Tape

A DIGIT CODE

NUMBER RECORDED ON TAPE	HOLE POSITION PERFORATED	APPEARANCE OF A DIGIT		
		0	1	2
0	0	●	○	○
1	1	○	●	○
2	2	○	○	●
3	0, 1 AND 2	●	●	●

B TO F DIGIT CODE

NUMBER RECORDED ON TAPE	HOLE POSITIONS PERFORATED	APPEARANCE OF B,C,D,E AND F DIGITS				
		0	1	2	4	7
0	4,7	○	○	○	●	●
1	0,1	●	●	○	○	○
2	0,2	●	○	●	○	○
3	1,2	○	●	●	○	○
4	0,4	●	○	○	●	○
5	1,4	○	●	○	●	○
6	2,4	○	○	●	●	○
7	0,7	●	○	○	○	●
8	1,7	○	●	○	○	●
9	2,7	○	○	●	○	●

TYPICAL ENTRY LINE REPRESENTING 239041

DIGIT DESIGNATION	A	B	C	D	E	F
LOCATION OF PERFORATION	0 1 2 ○ ○ ●	0 1 2 4 7 ○ ● ● ○ ○	0 1 2 4 7 ○ ○ ● ○ ●	0 1 2 4 7 ○ ○ ○ ● ●	0 1 2 4 7 ● ○ ○ ● ○	0 1 2 4 7 ● ● ○ ○ ○
NUMBER REPRESENTED	2	3	9	0	4	1

Figure 14-4 Codes Used to Represent Numerals in AMA Recording

D. CALL IDENTITY INDEX

A group of recorders may have a maximum of 10 or 20 recorders depending on the type of switching equipment employed at the recording office. Each recorder can serve up to 100 separate trunks, with each trunk having a different call identity index assigned to it. After a message is terminated, the trunk over which the message was routed, together with its call identity index is then available to serve another call. While the entries for a particular message will be in time order on the tape, the recording technique may result in the entries for a number of calls being interleaved. It is through the use of the call identity index that the accounting center equipment is able to separate and properly associate the respective elements of each message.

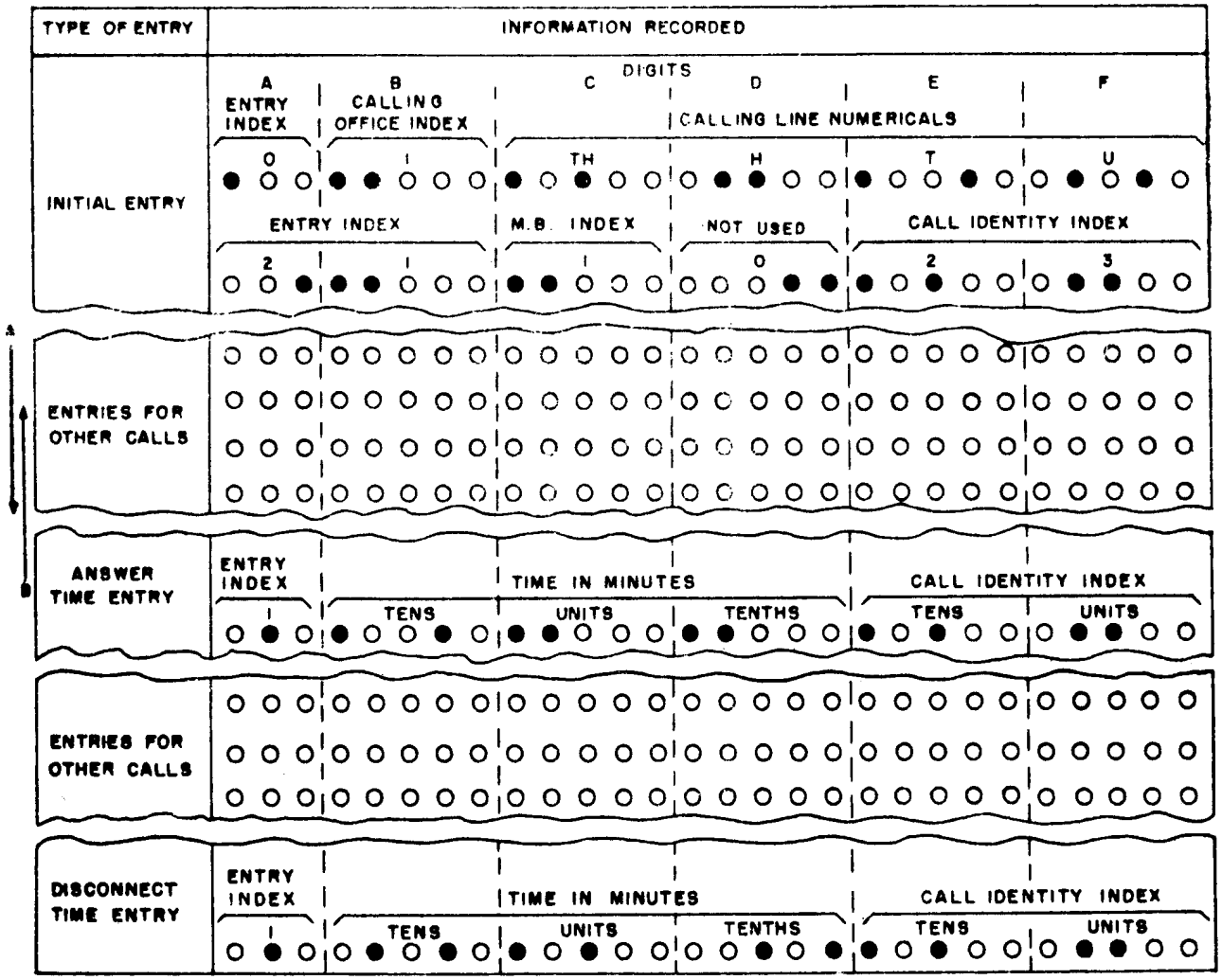
At the end of each day, or several days if a weekend is involved, the tapes from all recorders in a recorder group are cut and forwarded to the accounting center, see Figure 14-16. Collectively, these tapes provide all the information required for the billing of AMA recorded customer dialed, chargeable messages (completed calls).

E. TYPES OF AMA MESSAGES

AMA recorded messages presented to the accounting center fall into two main categories; one type of message is charged on the basis of message units and ultimately bulk-billed to the customer, and the other type is itemized individually on the subscriber's toll statement and referred to as detail-billed messages. These two types of messages are considered separately in the following paragraphs.

1. Bulk Billed Messages

Message unit messages which are bulk-billed to the customer are charged for in terms of message units. These are usually calls made to a point within the local service area of the calling station. Consequently, the accounting center equipment must convert chargeable time to the equivalent number of message units. These machines accomplish this through the use of (1) the message billing index recorded with each message and (2) the chargeable time in minutes for the message, as derived by the computer or



NOTES:

1. ENTRY INDEX 21 SHOWS THAT THIS IS AN INITIAL ENTRY OF 2 LINES.
2. MESSAGE BILLING INDEX 1 SHOWS THAT THIS IS A MESSAGE UNIT CALL.
3. CALL IDENTITY INDEX OF THIS CALL IS 23.
4. CALLING LINE NUMERICALS ARE 2345.
5. CALLING OFFICE IS DESIGNATED AS OFFICE INDEX 1 OF THE RECORDER GROUP.
6. ENTRY INDEX 1 INDICATES THE TIMING ENTRIES OF THE CALL.
7. SINCE DISCONNECT TIME IS 52.9
   AND ANSWER TIME IS 41.1
   ELAPSED TIME IS 11.8 MIN.

A. DIRECTION OF TAPE MOVEMENT DURING READING OPERATIONS AT THE AMA CENTER.

B. DIRECTION OF TAPE MOVEMENT DURING PERFORATING OPERATIONS AT THE CENTRAL OFFICE.

Figure 14-5 Message Unit Call Entries on Central Office Tape

assembler-computer. The initial entries of these messages consist of two consecutive lines of information on the central office tape, except service observed (OBS) and message unit entries shown at the top of Figure 14-5.

2. Detail-Billed Messages

Toll messages, as defined for AMA purposes, are usually detail-billed to the customer and are calls made to points beyond the locally prescribed message unit area. More information is required to be recorded on these than on message unit messages, resulting in a 4- or 5-line initial entry, as shown at the top of Figure 14-6 and in Figure 14-7. In addition to recording information about the calling subscriber, toll messages require the recording of the called office and called number. Also recorded is the called area index and the called number structure. The accounting center computer or assembler-computer calculates the elapsed time to the nearest tenth of a minute after the application of the appropriate timing allowance. The elapsed time is then rounded off to the next highest full minute to give chargeable time. Charges are later calculated by punched card methods and are then individually itemized on the subscriber's toll statement.

When the customer makes certain direct distance dialed (DDD) calls, a 5-line initial entry is required in order to provide for the recording of the 3-digit national area code. An example of such a 5-line entry is shown in Figure 14-7. However, by means of "code compression," calls to nine selected, frequently called foreign areas may be recorded within the standard 4-line initial entry required for a toll call. With "code compression," the 3-digit foreign area code is compressed to a single digit which can be included in the standard 4-line initial entry without resorting to the perforation of a fifth line.

In order to permit correlation of AMA data with service observing results, means are provided for recording all calls that are service observed on a separate perforator in the assembler-computer

or computer. Entries are made on this tape on all service observed calls regardless of whether they are completed or not. All service observed entries are in the detailed form.

An infrequently used feature in AMA provides for recording and processing the details of message unit calls. To do this requires central office entries similar to those for toll calls (4-line entry), and a separate perforator in the accounting center or assembler-computer for message unit detail output. The actual customer billing is on a bulk-billed basis. This arrangement is not expected to be used except in special temporary cases where local conditions appear to demand it.

F. AMA EQUIPMENT

1. Perforators

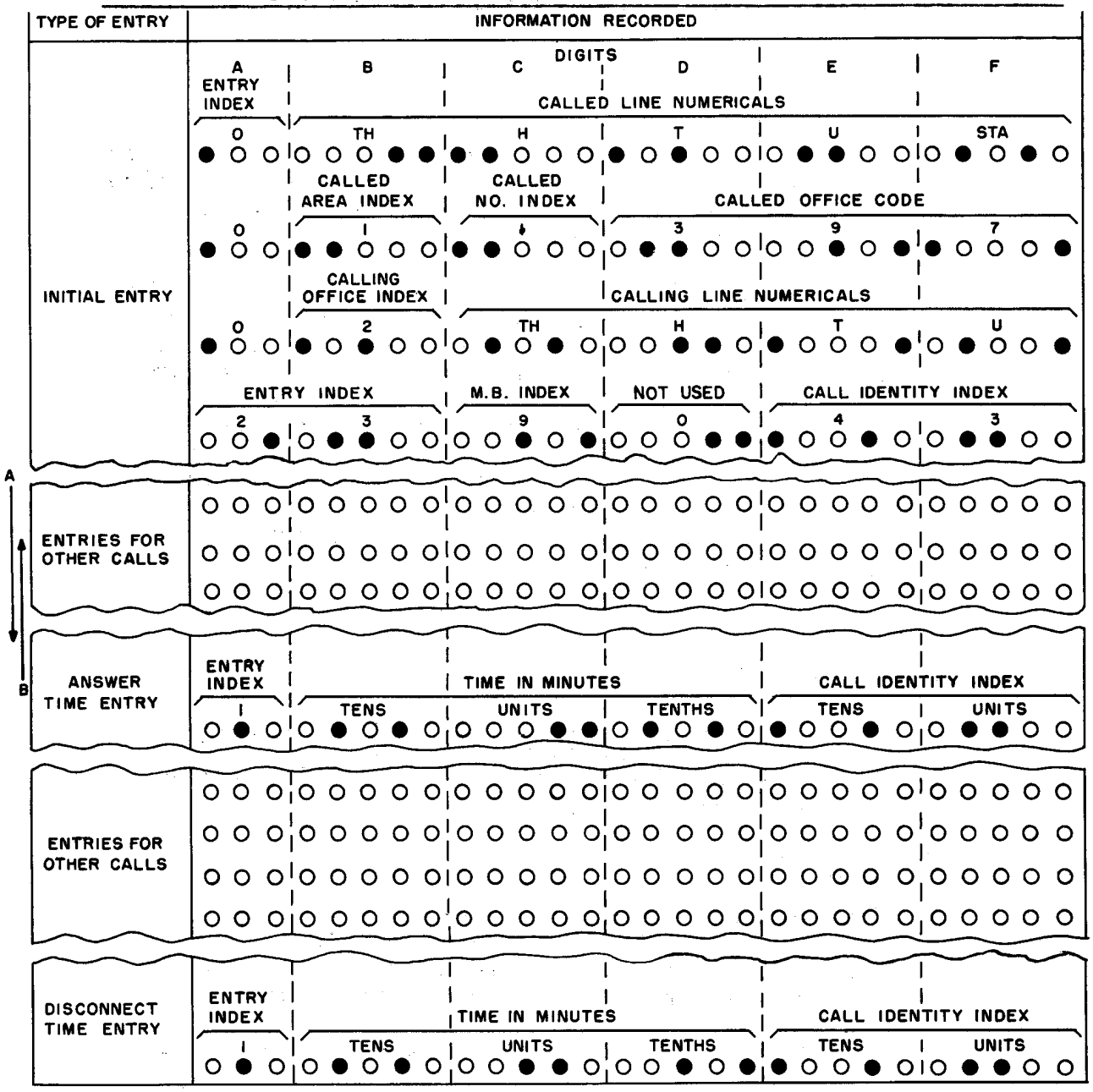
The perforator performs the mechanical job of punching the paper tape for each entry. It is furnished on the basis of one per 100 outgoing trunks or district junctors.

2. Recorders

The recorder controls the perforator in making the record on the paper tape. While the functions of the perforators are very closely associated with the recorders, they are furnished as separate units due to their different physical locations within the office building.

3. Call Identity Indexer

The call identity indexer identifies the one trunk or district junctor out of the group of 100 with which each tape entry is associated. The call identity indexer, the recorder and the perforator form a group to serve the associated 100 trunks or district junctors. These groups are furnished as required to serve the trunks and junctors.

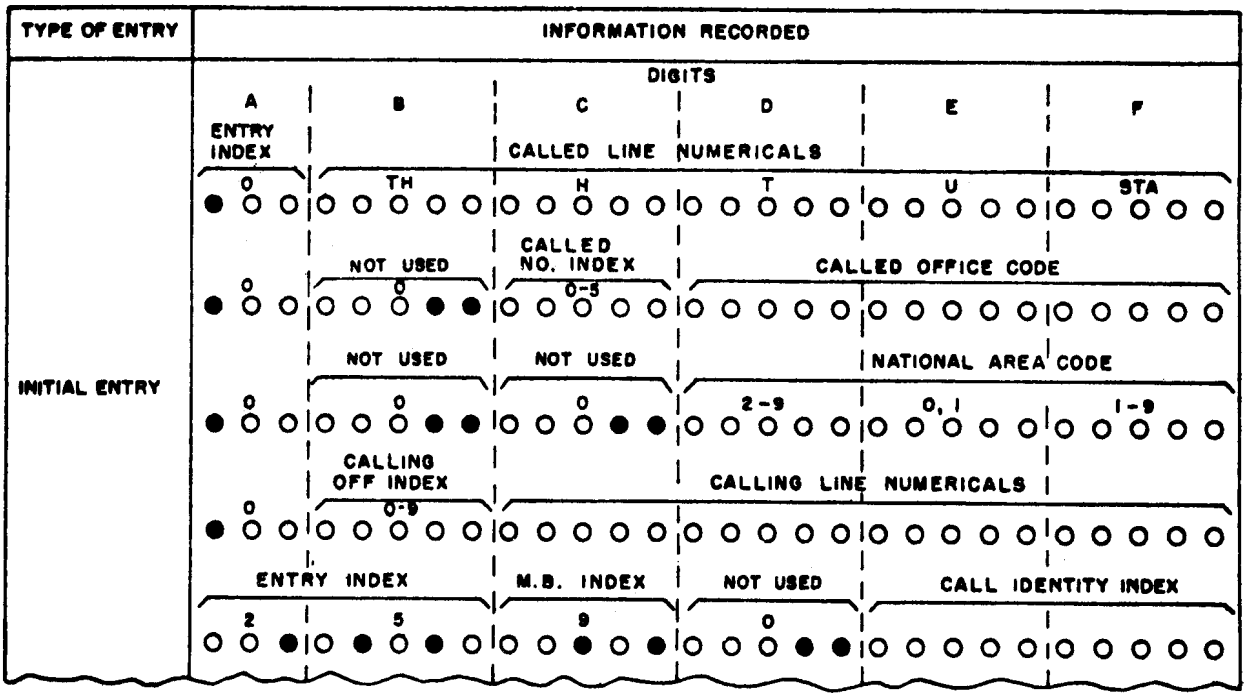


NOTES:

1. ENTRY INDEX 23 SHOWS THAT THIS IS AN INITIAL ENTRY OF 4 LINES
2. MESSAGE BILLING INDEX 9 SHOWS THAT IT IS TO BE BILLED AS A TOLL CALL.
3. CALL IDENTITY INDEX OF THIS CALL IS 43.
4. CALLING LINE NUMERICALS ARE 5678.
5. CALLING OFFICE IS DESIGNATED AS OFFICE INDEX 2 OF THE RECORDER GROUP.
6. CALLED AREA INDEX IS 1.
7. CALLED NUMBER INDEX IS 1 (INDICATES FOUR NUMERICALS AND PARTY LETTER).
8. CALLED LINE NUMERICALS ARE 0123. PARTY LETTER IS J.
9. CALLED OFFICE CODE IS 397.
10. ENTRY INDEX 1 INDICATES THE TIMING ENTRIES OF THE CALL.
11. SINCE DISCONNECT TIME IS 56.9
    AND ANSWER TIME IS 50.5
    ELAPSED TIME IS 6.4 MIN.

A - DIRECTION OF TAPE MOVEMENT DURING READING OPERATIONS AT THE AMA CENTER.
B - DIRECTION OF TAPE MOVEMENT DURING PERFORATING OPERATIONS AT THE CENTRAL OFFICE.

Figure 14-6 Toll Call Entries on Central Office Tape



NOTES:
1. ENTRY INDEX 25 SHOWS THAT THIS IS AN INITIAL ENTRY OF 5 LINES.
2. NATIONAL AREA CODE SHOWS AREA TO WHICH CALL IS DIRECTED.
3. MESSAGE BILLING INDEX 9 SHOWS THAT CALL IS TO BE BILLED AS A TOLL CALL.

Figure 14-7 5-Line (DDD) Initial Entry
On Central Office Tape

4. Master Timer

The Master Timer furnishes information for the timing portion of the entries. It keeps track of the time in six second intervals (tenths of a minute) minutes, hours, days and months. The one master timer frame mounts two timing circuits (odd and even) with either circuit being used to control the time entries. Every minute the two timers check each other and the recorders to see that the timing selectors are in synchronization; any indication of the lack of synchronization will sound an alarm.

5. Trouble Recorder

The trouble recorder performs a maintenance function in that as a trouble condition occurs, a punched card record is made of the equipment involved and the circuit condition within the equipment. With this arrangement the AMA equipment can be freed to serve other calls and the maintenance personnel will have a record of the trouble condition.

6. Translator

The translator's functions are essentially the reverse of the number group or block relay frames in that it translates the equipment location of the calling subscriber into his office indication and directory number. This type of translation is required by the AMA equipment so the initial tape entry can identify the subscriber to be billed. The capacity of the translator is either 1000 or 2000 tip or ring subscriber line locations; the capacity varying according to system and vintage. Translation is obtained by using the "ring" translation technique. A lead for each line location is threaded through a series of coils. When an electrical signal is pulsed through the wire, a voltage is induced in each coil that the wire passes through. This voltage is detected by the electronic circuits, one for each coil. The coils represent the units, tens, hundreds, thousands and office of the calling number.

7. Transverter

The transverter can be described as the marker of the AMA system, in that it controls the other equipment on the initial entry. The transverter receives information from the sender, as covered previously. This information along with the calling line number from the translator permits the transverter to instruct and control the recorder in making the entry.

8. Transverter Connector

The Transverter Connector interconnects the sender and the transverter, for the transfer of information. Each connector has access to all transverters and in No. 1 Crossbar offices serves 10 senders; while in No. 5 Crossbar offices, the connector serves five senders.

14.3 LOCAL AUTOMATIC MESSAGE ACCOUNTING (LAMA)

A. GENERAL

Local Automatic Message Accounting, LAMA, is a system in which recording equipment is located within the local office and serves only subscribers assigned to that office or group of offices.

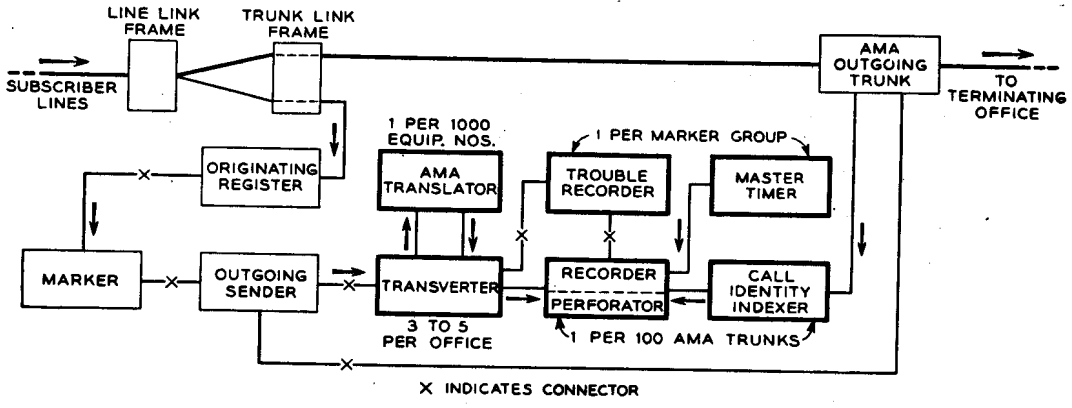
The logic circuits of the central office switching system recognize, on each call, whether the subscriber placing the call has flat-rate or message rate service; they also recognize whether the destination called is to be billed on a local (message unit) or toll basis.

Block schematics of the AMA equipment for use in No. 1 and No. 5 type of Crossbar offices are shown in Figure 14-8. Inspection of these two schematics show considerable similarity between the two systems: the difference being in the switching equipment itself.

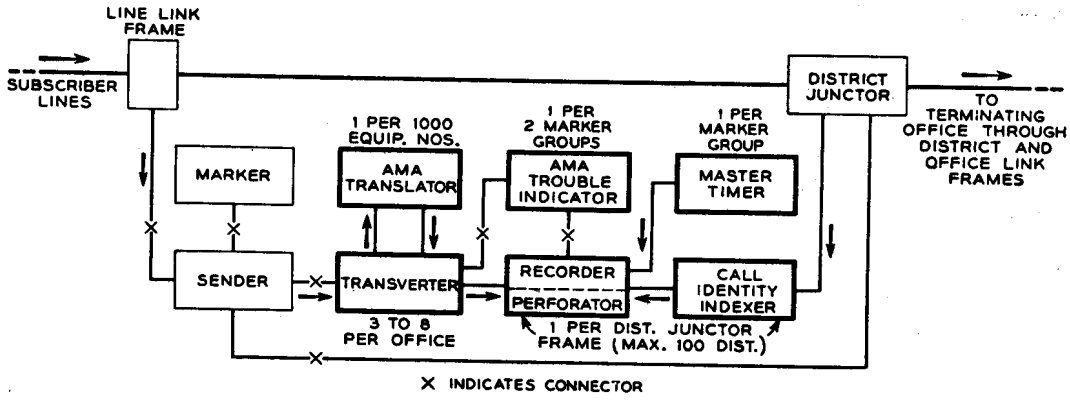
B. TYPICAL OPERATION

1. Common Control Equipment Functions

In No. 1 Crossbar offices the digits dialed by the subscriber are temporarily stored in the subscriber sender. When the originating marker performs the route relay operation, it determines from the class of service of the calling subscriber and the called office code, what charge, if any is to be made for the call. It is capable of recognizing eight different charging rates for message unit charging, message billing index 1-8. All calls for which the charging rate is in excess of these eight message unit rates are grouped into the toll call category, message billing index 9.



No. 5 Crossbar Office



No. 1 Crossbar Office

Figure 14-8 Block Diagrams of the LAMA Circuits Associated With Crossbar Offices

After the marker has informed the sender that the call requires an AMA record and as soon as the subscriber has completed dialing, the sender seizes the AMA transverter. The sender tells the transverter the message billing index, the type of entry required, the number dialed, the recorder number, as well as the line location and party identification of the calling subscriber.

The message billing index and the type of entry is obtained from the marker. The recorder number is represented by the district link number, which is needed to complete the call, since the 100 junctors of one district group are assigned to one recorder. The line location is obtained from the line link controller at the time of sender seizure. Party identification is part of the sender's function.

The No. 1 Crossbar system was designed and installed previous to the development of AMA. Therefore, circuit changes were required in order to obtain and convey the AMA information. Part of these changes could not be incorporated into the existing frames and units. Consequently auxiliary equipment is furnished to transmit the line location from the line link frame to the LAMA equipment. This equipment takes the form of a district group connector frame, a sender group connector unit, and a calling line register frame. A block schematic of this equipment is shown in Figure 14-9. This equipment is furnished as follows: one district group connector per sixteen line link frames, one sender group connector per district group, and one calling line register frame per 30 senders.

In No. 5 Crossbar offices the originating register functions as a temporary storage unit for the calling line location and class of service, in addition to its main functions of counting digits and making party identification. When dialing is completed, all of this information is transferred to the marker. The marker from its route relay operation recognizes an AMA call and determines the message billing index, type of entry required and the number of the recorder that the outgoing trunk is associated with.

When the marker selects an outgoing sender, it gives it the AMA information: message billing index, type of entry, dialed number, recorder number, calling line location, party identification, as well as all of the information needed for outpulsing. If the call is intraoffice, an outgoing sender is selected to permit the AMA record to be made even though the sender performs no outpulsing functions.

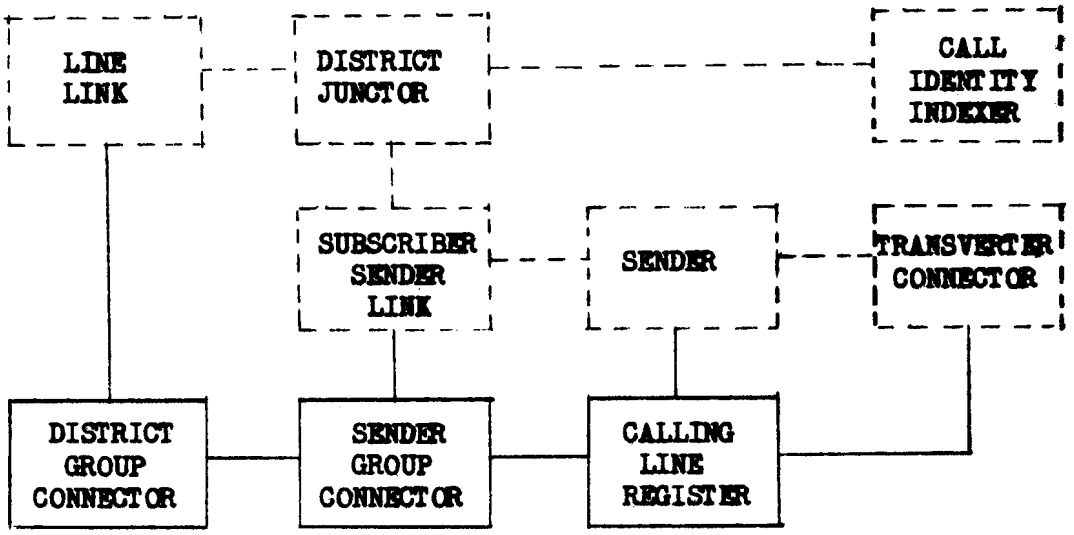


Figure 14-9 Auxiliary Equipment in a No. 1 Crossbar Office for Transmission of the Line Location

2. AMA Equipment Functions

The action of the AMA equipment is essentially the same for both crossbar systems; therefore, the following explanation will apply to either system.

As soon as the sender has stored in its memory circuits all of the AMA information and the call has progressed to the stage where the AMA entry is to be made, the sender sends a start signal to the transverter connector. The connector seizes an idle transverter and connects 120 or 150 leads, depending upon the system, from the sender to the transverter. Information that has been stored in the sender is transferred to the transverter over these leads.

The transverter by using the calling subscriber's line location and party identification, seizes the proper translator frame, signaling to it the identity of the line placing the call. The translator translates the line location into directory number information and sends this information back to the transverter. The transverter then seizes the recorder that the trunk or junctor is assigned to, and instructs it as to what is to be recorded on a 2-line, 4-line or 5-line initial entry. During the recording process, a signal for the trunk or junctor to identify itself is sent via the sender. The call identity indexer recognizes the trunk or junctor requesting identification and gives the 2-digit identity index to the recorder for entry on the tape.

The sender does not outpulse all of the digit information until the transverter informs it that the initial entry is completed. Should trouble be encountered in the AMA equipment preventing a successful entry, the call can still be blocked by the sender. In practice, local calls are permitted to be completed without charge in case of failure in the AMA equipment while toll calls are blocked.

When the recorder completes its recording job, it signals the transverter; the transverter then releases the recorder. The transverter signals the sender that a record has been made and releases itself from the connector, making itself available for other calls.

There will be a time lapse before the called party answers. During this time the recorder and perforator can be used for entries involving any of the other 99 trunks or junctors. At the time the called subscriber answers, the off-hook signal is recognized by the trunk or junctor; whereupon it signals the call identity indexer. At this time if the recorder is idle or as soon as it becomes idle, a 1-line answer entry is recorded. The 1-line entry is a time entry showing the time in minutes, tenths of a minute and the identity index of the trunk as covered previously.

At completion of the call, the trunk or junctor will recognize the on-hook condition of the subscriber's line and again signal the call identity indexer for disconnect entry. The disconnect entry is a 1-line time entry, the same as the answer entry except for recorded time. Therefore, each completed call will have three entries, initial and two time entries; while "don't answers" will have only two entries, initial and one time entry, which will be discarded by the accounting center.

14.4 CENTRALIZED AUTOMATIC MESSAGE ACCOUNTING (CAMA)

Extended customer dialing, as provided for by the original AMA equipment, had certain limitations. For instance, there are many offices in areas where the dialable traffic to charge points is relatively light and the installation of AMA equipment would not be economical. Also, in offices actually equipped with AMA, the equipment for the automatic identification of the calling customer for charge purposes recognizes only individual and two-party customers; therefore, other multi-party customers must place their charge calls through an operator. In the existing dial offices of the panel type, the design of LAMA equipment would prove rather costly and, even if available, might well be prohibited by the lack of floor space in the existing office. Centralized Automatic Message Accounting (CAMA) was developed to care for these subscribers that could not be served by LAMA. This system locates the recording equipment in a central location which serves a number of central offices.

CAMA arrangements were initially available in crossbar tandem offices on a PCI basis only. PCI pulsing was available from Panel, No. 1 and No. 5 Crossbar offices; thus, the maximum number of lines was served by this type of pulsing.

Dial Pulsing and Multifrequency pulsing is now available for the tandem offices. The CAMA technique has been expanded to other systems, No. 4 (type) Crossbar, No. 5 Crossbar, and intertoll SXS offices. Also, any type of local mechanical office can be handled by a CAMA system.

In addition to the work functions of LAMA, CAMA has other problems to solve. In LAMA the equipment must be able to identify a maximum of ten calling office designations. CAMA has the additional problem of identifying one of a possible 20 recorder groups with a maximum of 200 originating

offices. These offices may have widely differing rate treatments even though the actual charge on a particular call is one of 13 message billing indexes. Two central offices, for example, may have identical rates on calls to 25 other offices but different rates on calls to the 26th, and the CAMA equipment must provide for the various combinations. Identification of the calling customer, of course, is necessary for proper billing. There are two techniques used to identify the calling subscriber. The first method used is operator identification. The second method is automatic and is covered under the heading, Automatic Number Identification.

The charging rate (billing index) is obtained from the billing indexer frame. In this frame the originating point of the call is compared with the destination of the call, as well as the rate treatment of the calling subscriber, to determine the message billing index number (0-12). While the function of the billing indexer is closely related to the transverter circuitry, the physical size and cost of the billing indexer exceeds the transverter. Since the operating time of the billing indexer functions is a fraction of the transverter operating time, fewer billing indexer circuits can be furnished by separating them from the transverters. Twelve transverters, which is the maximum size of a transverter group, can be served with three billing indexers.

The identification of the calling subscriber as it was done initially, and still is in many offices, was accomplished by the CAMA office setting up a connection to an operator before seizing the transverter. The operator requests the number of the calling subscriber's telephone from the party originating the call. This number is keyed into the sender for transfer to the transverter. Considerable operator effort is saved since she does not make out a ticket, obtain routing, select a trunk, time or supervise answer and disconnect of the call.

In order for each sender to have access to a CAMA operator for obtaining the calling number, position link circuits are furnished. Each position link frame has capacity for 40 senders and 100 positions. If more than one frame is required for sender capacity, each frame has access to the same positions. The links through the position link frame are established on crossbar switches by the controller. Provision is made so that during a light load period one operator does not receive the majority of the calls while others are idle.

A. CROSSBAR TANDEM CAMA

The block schematic for the CAMA portion of the crossbar tandem office is shown in Figure 14-10. The call is received and routed through the office in the normal manner. Near the end of the incoming pulses the sender sends a signal to the position link requesting connection to an operator position. This signal is started so the operator position is seized by the end of pulsing. A lamp indication informs the operator that she has a call connected to her position. After the operator has asked for and received the calling subscriber's number, she key-pulses this number into the sender.

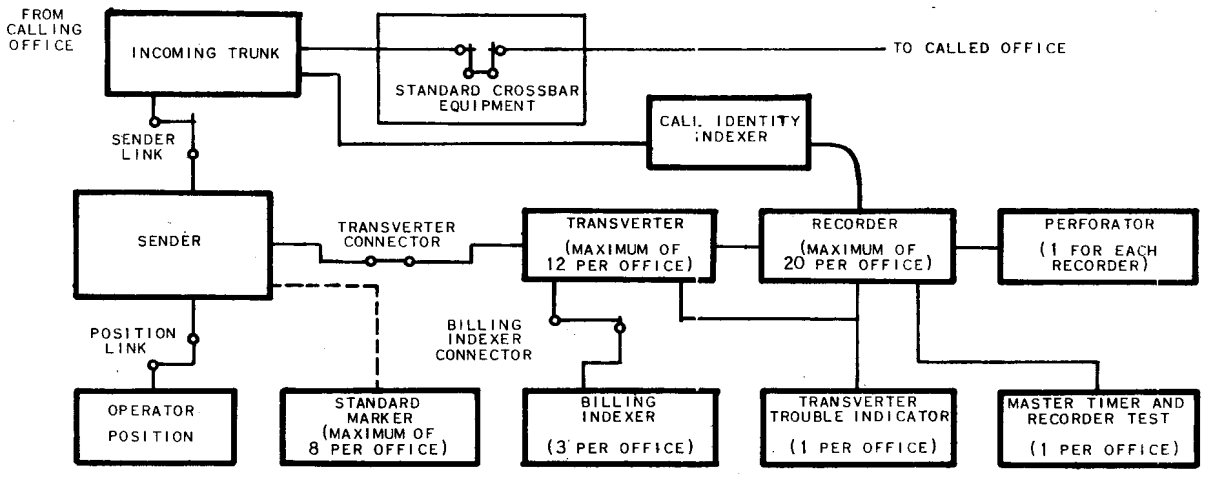


Figure 14-10 Block Diagram Illustrating the Operation of CAMA Equipment in a Crossbar Tandem Office

The sender has now been connected to a transverter. The transverter compares the calling and called number. If they are the same, a reorder signal (flashing lamp) is returned to the operator. Since this indicates that the customer has mistakenly given the called number, the operator again requests the calling number and keys this number into the sender. If the transverter had found that

the two sets of numbers it receives are different, as they should be, it will instruct the sender to release the connection to the operator and proceed to make the initial entry.

The transverter seizes a billing indexer in order to obtain the billing index and type of entry. The remaining operations are the same as in a local office; in that the transverter seizes a recorder for recording the initial entry and causes the call identity indexer to identify the trunk.

Operation with local step-by-step offices, without common control, differs in the method of receiving pulses; however, the AMA operation remains the same. When the tandem office is receiving pulses from a common control type of office, the transmission of pulses is not started until the tandem sender is connected to the incoming trunk. When the tandem office receives pulses from direct control offices, the sender must be attached during the interdigital timing interval, unless the subscriber has been instructed to wait for second dial tone. This connection may require a longer period of time than the interdigital time of the calling subscriber's dial pulses and could cause the sender to miss some of the digits, in all, or in part.

Incoming registers are used on trunks incoming from these local step-by-step offices. By-link paths are established between the trunk and register to avoid missing any of the dial pulses. When the regular link path is established, it parallels the by-link path, which was established very quickly after trunk seizure. The by-link path is now released. The first three digits are stored in the incoming register. By the time the incoming register has recorded the third digit a connection has been established from the trunk to a DP sender. The first three digits are transferred from the register to the sender and the call will now proceed the same as other CAMA calls. A partial block schematic for this portion of a call is shown in Figure 14-11.

B. #4 TYPE CROSSBAR CAMA

Figure 14-12 is a partial block schematic showing the CAMA circuits in a #4A Crossbar office. Inspection of this figure will show the same equipment, by name, is used in the #4A office as is used in the tandem CAMA office, except for the addition of the trunk class translator.

In crossbar tandem the class of the trunk and the recorder number are obtained from the trunk and given to the sender for temporary storage. In #4A Crossbar the trunk class translator makes this translation and gives the class information to the decoder and translator at the time it is required, relieving the sender of this storage function.

Another difference in operation from tandem is in the incoming register and incoming sender. The CAMA sender is of the MF pulsing type. If the local office1 is capable of sending MF pulses the local office will pulse directly into the sender. If the local step-by-step office is not equipped with senders, the DP incoming register is required. This register and associated register link is of the by-link type for quick connection to the trunk. Instead of receiving only the first three digits the register receives all the digits and then when connected to a sender through the trunk, transmits the digit information to the sender by MF pulsing.

The trunk class mark, which is needed for routing as well as by the billing indexer, is obtained by decoder. The connection to the operator position and the recording on the AMA tape is done in the conventional CAMA manner.

C. Step-by-Step Intertoll CAMA

1. Equipment

CAMA features can be added to the step-by-step intertoll office by the addition of common control equipment; registers, senders, decoders, etc.

The block schematic of the step-by-step intertoll office arranged for CAMA is shown in Figure 14-13. The switching network of the office still uses trains of step-by-step switches; however, the control of the switches is under control of a sender.

The principal common control units, other than AMA units, used in step-by-step CAMA offices are:

a. Registers

The principal function of the register is to store all of the incoming dial pulses and then to transmit these digits to a sender by means of MF pulsing.

b. Senders

The senders store the called number as well as control outpulsing. The sender also provides various circuits with information about the call; this information is used for selection, switching, and charging. As a result of the various exchanges of information the sender is advised as to what type of outpulsing (MF or DP) is required and then proceeds to outpulse the called number.

c. Decoders

From information received from the sender, the decoder determines the routing of the call, including the routing through the SXS office. The primary function of the decoder may be classified as translation.

d. Trunk Class Translator

The trunk class translator circuit is only provided in larger offices. Its function is to supply additional information to the decoder about the call in the form of trunk class marks.

2. Method of Operation

A subscriber in a local step-by-step office must first dial an access code to reach a CAMA office. A typical access code is 112. When the customer dials this code he is connected at the local step-by-step office to an outgoing trunk to the CAMA office. When the incoming CAMA trunk at the step-by-step CAMA office is seized, it causes a link circuit to select an idle register (connections #1 and 1A). This connection is established during the interdigital time between

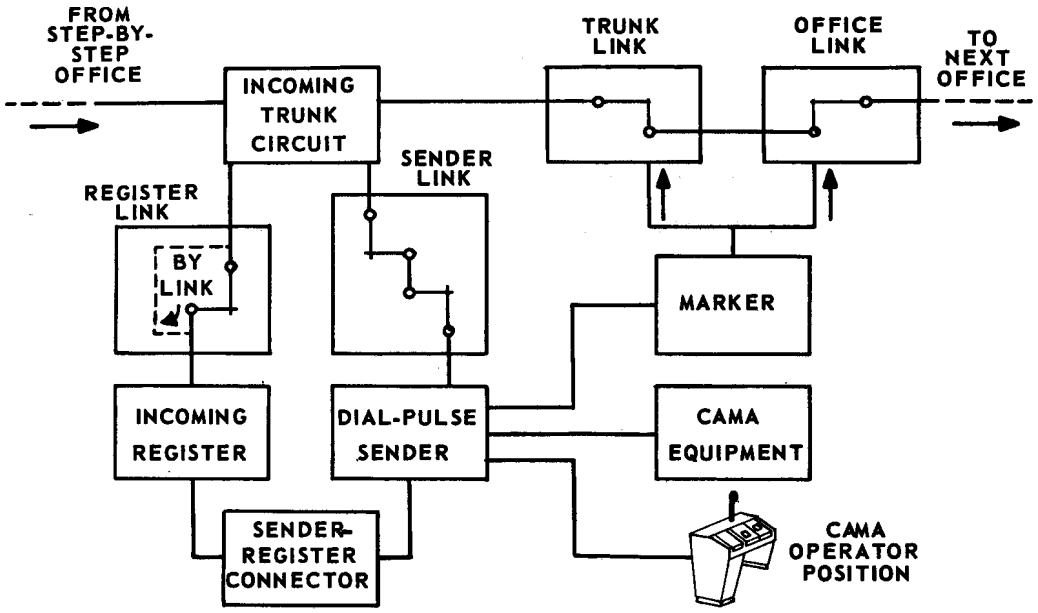


Figure 14-11 Block Diagram of the Arrangement in a Crossbar Tandem Office for CAMA to Work with Step-by-Step Offices

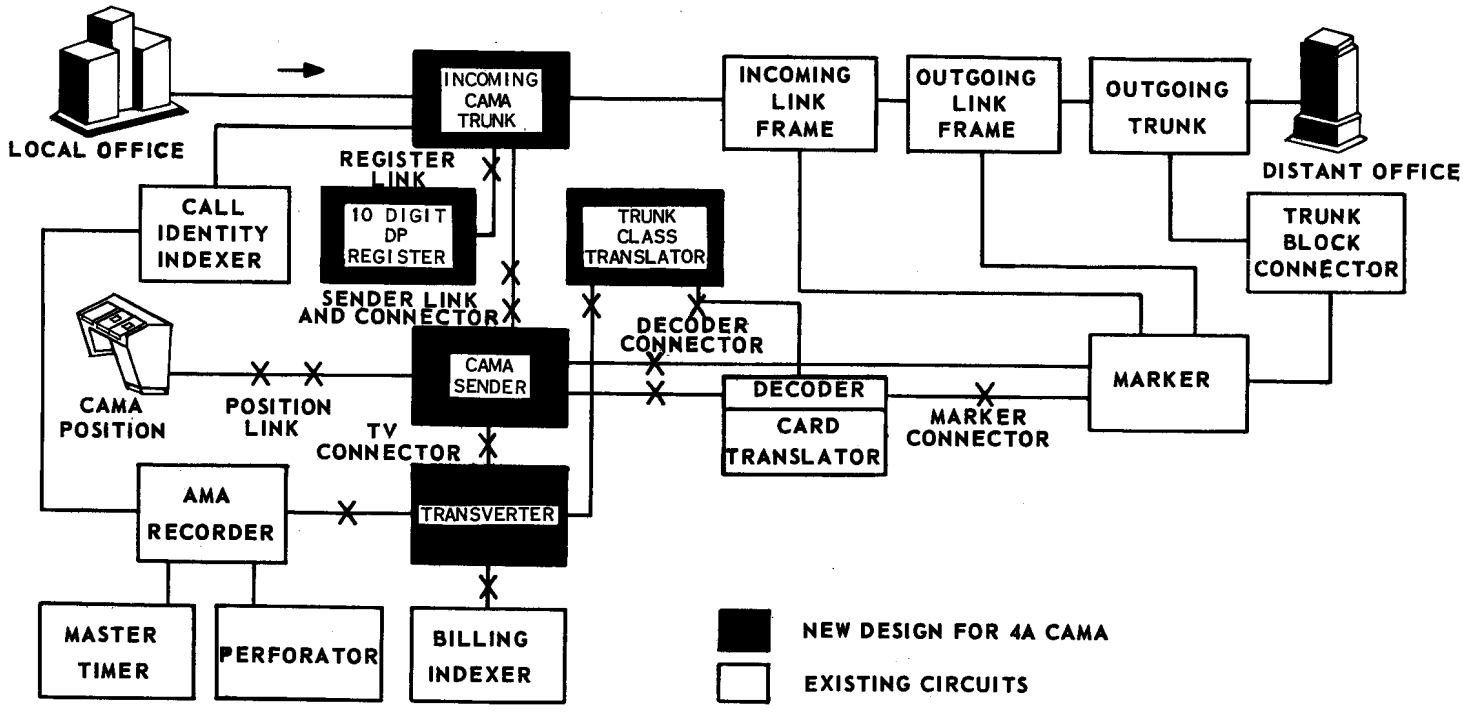


Figure 14-12 Partial Block Schematic of the New Design for 4A CAMA

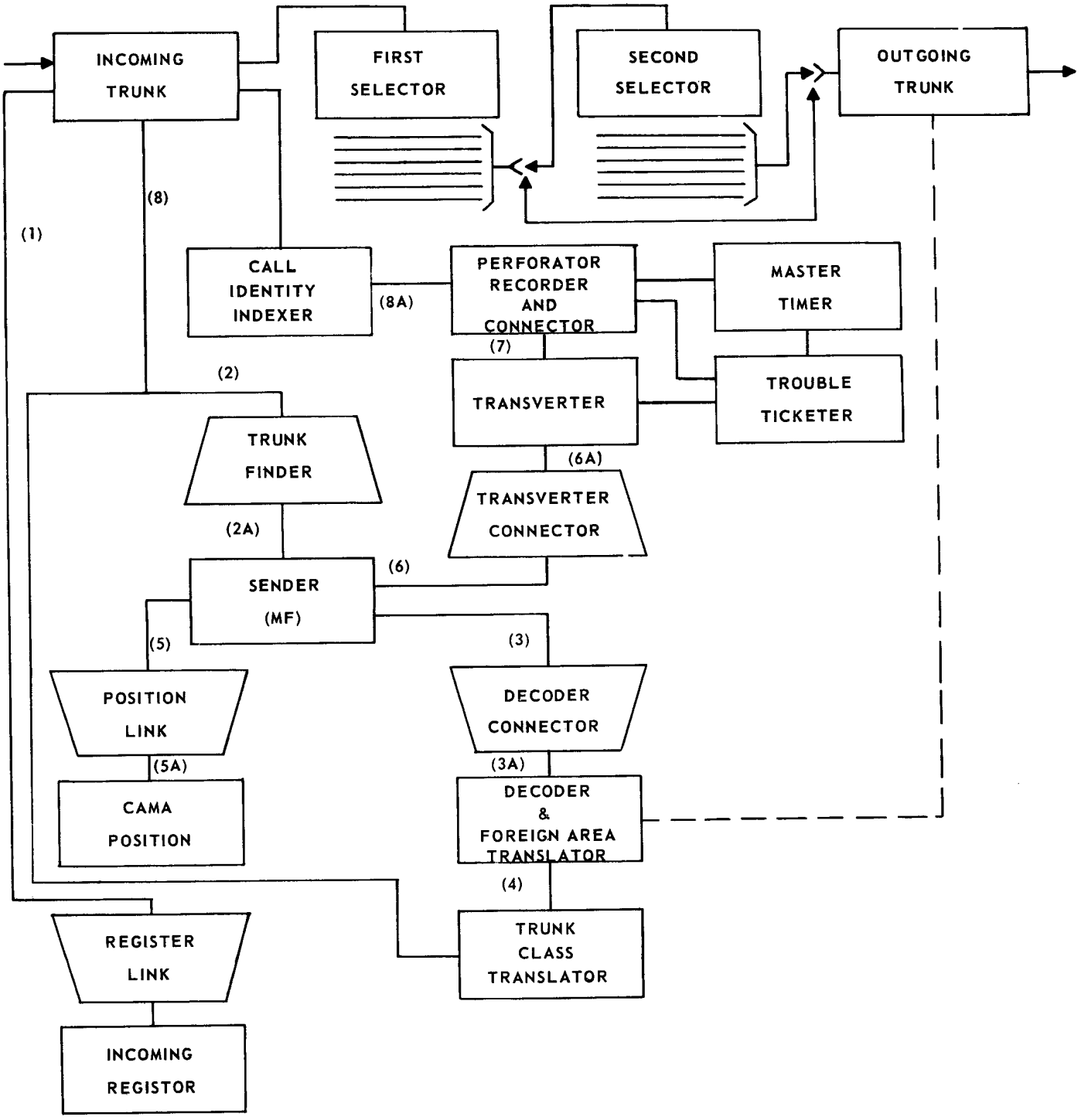


Figure 14-13 Block Schematic of Step-by-Step Intertoll Office arranged for CAMA Office

the dialing of the directing code and the dialing of the area code or the office code. No indication is returned to the customer that a register has been attached. The customer continues to dial the called number without pause. If a register is not attached in time to receive the incoming digits, the trunk is arranged to return reorder tone to the customer.

The incoming digits are registered in the register, which has a maximum capacity of 10 digits. After the sixth digit of a 7-digit call has been received or when the ninth digit of a 10-digit call starts to come in, the register causes a signal to be sent through the trunk for connection to an idle sender (Connections #2 and 2A).

The trunk secures access to the sender through the trunk finder. When the sender is attached, it signals the register that it is ready; then the register outpulses on an MF basis the digits it has registered. After outpulsing the called number, the register is released.

If the call originates from a No. 5 Crossbar office on a MF basis, a sender is attached immediately after the incoming CAMA trunk is seized. The called number is then registered directly in the sender.

When the sender has registered the sixth digit of a 7 or 10-digit call, it proceeds to call in a decoder through the decoder connector. (Connections #3 and 3A).

When the decoder is attached, the sender presents to it the first six digits it receives. The decoder uses this information (and in some cases other information) to determine the routing necessary for the call. It instructs the sender which of the received digits must be outpulsed, what digits are to be prefixed, and the type of the outpulsing that must be used. After transmitting this information, the decoder is released.

Associated with the decoder are circuits and features which may be provided on an optional basis (these circuits are shown in dotted lines on the block diagram). One of these circuits

the foreign area translator, actually functions as a part of the decoder. The foreign area translator is used to provide additional routing information when required (six digit translation).

Another optional circuit is the trunk class translator. This circuit is provided when the incoming trunks require different class marks. When this is necessary, the trunk class translator provides the class marks of the incoming CAMA trunks to the decoder (Connection #4).

A group busy feature is also provided on an optional basis. This feature permits the decoder to determine if there is an idle trunk available in a trunk group. The group busy test feature does not verify that a path through the switching network is available, but does verify that one or more trunks in the desired group is available. This feature may be used in conjunction with the alternate routing feature of the decoder.

While the decoder is engaged, the sender completes its registration of the called number. When it has registered the last digit, the sender proceeds to make a bid for a CAMA position (Connection #5 and 5A). If for some reason there is a delay in obtaining an operator, audible ringing tone is returned to the customer until the talking path is established.

When a position is attached, the operator is given order tone and a talking path is established between the operator and the customer. The operator then obtains the calling number and MF keypulses it into the sender.

On calls which route to or through common control offices, the sender begins outpulsing with the start of registration of the calling number. However, if the call does not go through a common control office, the sender will not start outpulsing until the decoder has been released. In either case the last digit is not outpulsed until the CAMA recording is completed. With this method of operation, level hunting connectors in terminating offices must be modified to wait until the units digit is received before they start hunting for an idle line.

A transverter is seized by the sender after the latter has received the units digit of the calling number (Connections #6 and 6A). The transverter receives from the sender the details necessary to make a record of the call. It translates this information into a form satisfactory for recording and the call is recorded in the conventional manner (Connections #7, 8 and 8A).

The CAMA equipment constitutes a separate train designed to handle CAMA calls. The only exception to this is for calls which have originated from and already been recorded at a No. 5 Crossbar LAMA (local AMA) office. These calls may be received on a non-CAMA MF basis. Use may be made of the CAMA senders and decoders to route through the CAMA selectors and to alternate route if desirable. This is the only non-CAMA traffic which this system is designed to serve.

14.5 AUTOMATIC NUMBER IDENTIFICATION - ANI

Automatic number identification is designed for use in offices served by various types of CAMA centers. It is a means, as the name implies, of making an automatic number identification of the calling party for recording on the AMA tape. This will eliminate the necessity for operator effort in making the identification.

The equipment for this identification is located in the local office (any mechanical type) and responds to signals from the CAMA office for transmitting the calling number. The identified number is transmitted to the CAMA office via MF pulsing.

A. STEP-BY-STEP, PANEL, #1 CROSSBAR

The general method of operation for these three systems is so similar that they have been grouped together under one description.

The block schematic of the ANI equipment is shown in Figure 14-14. Identification is made one number at a time by applying a 5800-cycle tone to the subscriber's sleeve lead and detecting this signal with electronic detectors.

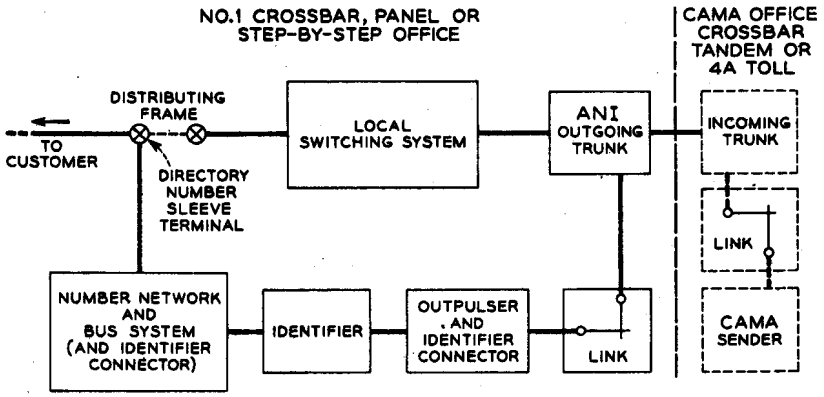


Figure 14-14 Block Diagram of Automatic Number Identification System

1. Number Network Frames

The number network frames contain a network field, which furnishes a network termination for each line, and a two-stage bus system. Each frame has a capacity of 2000 lines; five frames being required for a 10,000 number series. The network and associated bus system are passive systems in that they furnish a channel for transmitting in identification signals from the line to the detector circuits.

The bus system consists of a primary and two secondary systems for each 10,000 directory numbers. The primary buses are arranged in a 100 by 100 grid system so that each cross point represents one directory number. The two secondary bus systems are 10 by 10 grid arrangements using resistors instead of the R-C buses of the primary system. Primary buses are not scanned directly because it would require a large number of detectors. The secondary bus system converts the one-out-of-a-hundred signals of the primary system into decimal digits. The principle of the two-stage bus system is shown in Figure 14-15.

Cross connection between the primary and secondary systems provide a means of grouping directory numbers to reduce the number of detectors required.

Each cross point in the primary bus system is formed by the intersection of five buses. The vertical buses provide a tip, ring and multi-party connection for each directory number while the horizontal buses provide tip and ring connection. This arrangement produces a tip field and a ring field completely independent of each other. These independent fields are used in identifying numbers associated with two-party lines.

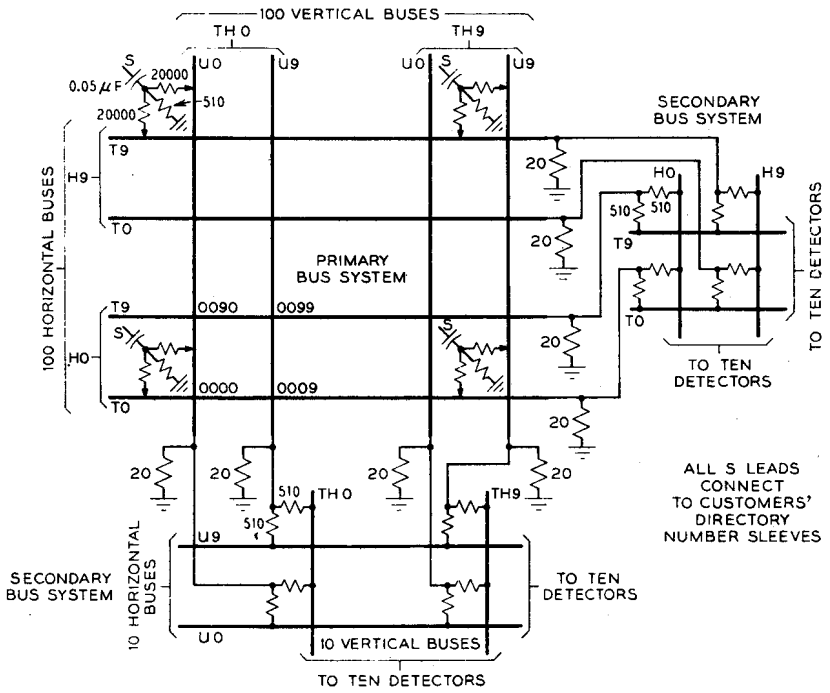


Figure 14-15 Number Network and Bus System

2. Identifier

The identifier is made up of detectors, steering circuits and translators. Ten number detectors under control of the steering circuits scan the output leads of the secondary busy systems. The signal applied to the number network and identified by the detectors is a 5800-cycle tone. The steering circuits connect the detectors to the thousands, hundreds, tens and units digits in sequence.

In addition to the number detectors, supplementary detectors are provided to identify calls from four-party and multi-party lines and calls being observed.

Only one identifier can make an identification at a time. One identifier will serve up to sixty thousand directory numbers. The average identification time is less than one third of a second, varying slightly with the number of offices to be scanned. The one identifier will care for traffic originated by most groups of six offices. Normally, however, a second identifier is provided for maintenance. If a building contains more than six offices, a second identifier group including passive network and outpulsers must be provided. Separate out trunk groups must also be provided.

3. Outpulsers

The outpulser is the equipment unit that controls the identification process. It receives party test information from outgoing trunks or obtains this information itself, when required, by making party test. It verifies that the calling customer has not disconnected before proceeding with the identification.

As the digits of the directory number are identified by the identifier, they are registered in the outpulser. The outpulser translates the office identity it receives from the identifier into the three digits of the calling office code. When all seven digits of the calling customer's directory number have been obtained, they are outpulsed, along with the appropriate information digit to the CAMA office by means of MF signaling.

The outpulser is provided with checking and timing features so that it can detect a trouble promptly. In this event, the outpulser calls in a trouble-recording medium known as the "trouble ticketer" and provides it with information for printing the trouble record. After making the trouble record, the outpulser makes a second trial identifier seizure.

Outpulsers are provided as required by the volume of Direct Distance Dialed traffic. An identifier group is arranged for a maximum of seven outpulsers to provide for traffic and maintenance usage. If more than seven outpulsers are required, a second identifier group must be established.

4. Outpulser Connector

All outgoing trunks in an identifier group have access to all outpulsers in that group. Connection of a trunk to an outpulser is established through an outpulser connector.

5. Method of Operation

When a CAMA office has advanced the call to the stage where the number of the calling subscriber is required, a signal is sent to the ANI outgoing trunk of the local office for calling number identification.

In the local office the call has been completed through the switching network in the normal manner. Upon receipt of the signal from the CAMA office, the trunk signals its outpulser connector for connection to an outpulser.

The outpulser seizes the identifier. At the same time it is connected to the identifier, it signals the trunk and the 5800-cycle oscillator to apply the 5800-cycle signal to the holding ground of the sleeve lead.

At the primary network, this signal goes through both the tip and ring networks. Only one of these primary networks is connected to the secondary network of the identifier. The tip or ring party identification of the calling

party determines which primary network is connected to the secondary network. The identifier scans the ten leads representing the thousands digits; then the leads for the hundreds, tens, and units digits; thus, reducing the number of detectors required.

The identifier group has a capacity of 60,000 subscribers; therefore, in addition to the four digits identifying the subscriber's number, office identification is also required. The identification of the office is obtained by the identifier scanning the leads representing the thousands digits of each office until a signal is detected. The identifier then informs the outpulser which group of thousands leads (office indication) the signal was found on and proceeds to identify the last four digits of the subscriber's number.

As was indicated previously there are two primary networks, one for tip party subscribers and one for ring party subscribers. The identifier must know party identification in order to make the proper connection.

The party identification is obtained in a different manner in each of the three systems; No. 1 Crossbar, Panel, and Step-by-Step. In the No. 1 Crossbar system, tip and ring party information is registered in the originating marker in the standard manner while the call is being switched. This information is forwarded to the ANI trunk while the marker is setting up the switch linkages. From the trunk, the information is passed on through the outpulser link to the outpulser and then to the identifier. In the panel system the district selector makes the party test and records party information but it is not feasible to pass the information forward to the trunk. Therefore, the ANI equipment must make a party test of its own. This is done by the outpulser, which recognizes the conventional ringer ground through the switchhook as indicating a tip party. In the Step-by-Step system, a party test is made by the ANI trunk during the interdigital time betweem the first two digits dialed

after the trunk is reached, and the result is forwarded to the outpulser, as in the case of the No. 1 Crossbar trunk.

Party identification cannot be made on lines with more than two subscribers. The ANI equipment is not capable of identifying those numbers. The fact that an identification cannot be made is recognized by the identifier.

When the information obtained by the identifier is recorded in the outpulser, the identifier releases. The outpulser transmits the recorded information to the CAMA office and then releases its connection to the outgoing trunk.

B. NO. 5 CROSSBAR

The approach used in No. 5 Crossbar offices for ANI is different than that used in the other local offices. Some of the same equipment is used for ANI as is used for LAMA and the operation of the equipment is basically the same. The equipment used is the translator, the transverter and the transverter connector.

At the completion of outpulsing the called number, the outgoing sender summons a transverter in the normal manner, giving it the calling subscriber's line location. The transverter seizes the translator for the translation of line location into directory number. At this point instead of attempting to call in the recorder, perforator and call identity indexer, which are not furnished, the transverter passes the calling number to the outgoing sender for transmission to the CAMA office. The AMA equipment then releases.

C. TRANSMISSION OF INFORMATION TO CAMA

With any of the previous methods of ANI operation, the CAMA Office sends a signal to the local office requesting the calling number. The outpulser or the outgoing sender sends the information by multifrequency pulsing.

The information is sent in the following order: KP signal, information digit, three-digit office code, four numerical digits and ST signal. The KP and ST signals

use the conventional frequencies that serve to actuate a receiver at the beginning and end of a sequence of information. The information digit serves to indicate one of four conditions:

1. Calling customer identified automatically.

2. Calling customer on a four-party or multi-party line, and therefore requires identification by the CAMA operator. No office or numerical digits are sent for these calls.

3. Calling customer is under service observation, and therefore the AMA record for his call requires a service-observing mark in addition to the usual information.

4. Calling customer could not be identified because of trouble in the automatic equipment. This condition requires identification by the CAMA operator. No office or numerical digits are sent for these calls.

When all digits have been outpulsed, the outpulser is released, or the outgoing sender releases and the trunk is closed through for the talking condition.

14.6 AUTOMATIC MESSAGE ACCOUNTING CENTER

A. GENERAL

Although the charging information for telephone calls is recorded in the central offices, all the work of telephone message pricing, billing, and bookkeeping for the Bell System is concentrated in the accounting centers (Figure 14-16), their related punched card toll units and revenue accounting offices. In addition to its magnitude, this message accounting job has, of course, very exacting requirements of accuracy and promptness. Perhaps the most challenging factor in message accounting is, however, the need for the highest efficiency, since the accounting costs must add but a negligible amount to the low price of billable telephone messages.

These basic characteristics of the message accounting job had a controlling influence on the design of the machinery for the AMA center. The original message data for

the AMA center's system is recorded in central offices as patterns of perforations on paper tapes. These tapes are then sent periodically to the accounting center where machinery performs the various data-processing tasks.

The accounting center consists mainly of machines into which the central office tapes are fed. Each machine contains a reader which recognizes the arrangement of the holes in each line of tape and provides means for (1) perforating new tapes, (2) printing of the last set, or (3) punching a card for subsequent processing, using punched card procedures. The final output of these machines provides material from which charges can be computed in the punched card accounting office.

B. PROCESSING ORDER

The machine operations involved in accounting center processing are shown in Figure 14-17. The central office tapes of a given recorder group are fed to the assembler-computer or to the assembler as shown at the top of the diagram. The assembler-computer, Figure 14-18, was developed to combine, in a more economical way, the features previously incorporated in individual assemblers and computers. It will be used in new AMA centers and for additions on replacements in existing centers.

Subsequent sorter, summarizer, and converter processing for message unit messages, and converter processing alone for toll messages, result in a punched card output which is then processed on commercial business machines.

In each of these stages, the processing consists of feeding tapes into a machine in the proper order, collecting the output, storing it when necessary, and arranging them for input to the next stage.

The operations performed in any of these stages are controlled by manually setting the control panel switches of the accounting center machine involved. The leading end of the tape contains identification information which corresponds to the setting of the control panel. The machine checks the tape identification against this setting before the operations can proceed. In transferring the output tapes from one stage of operation to the next, all tapes are tagged or stamped to indicate the processing already completed.

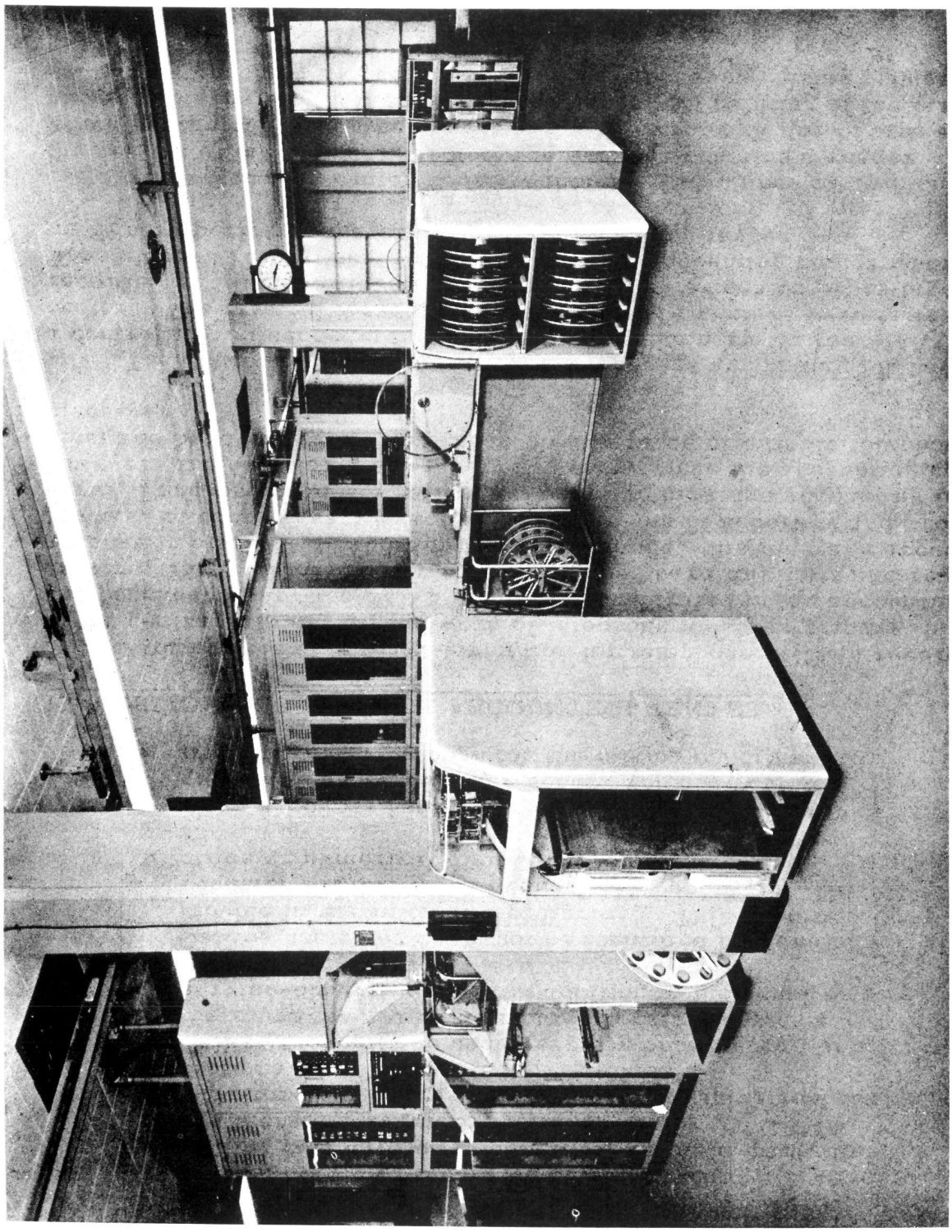
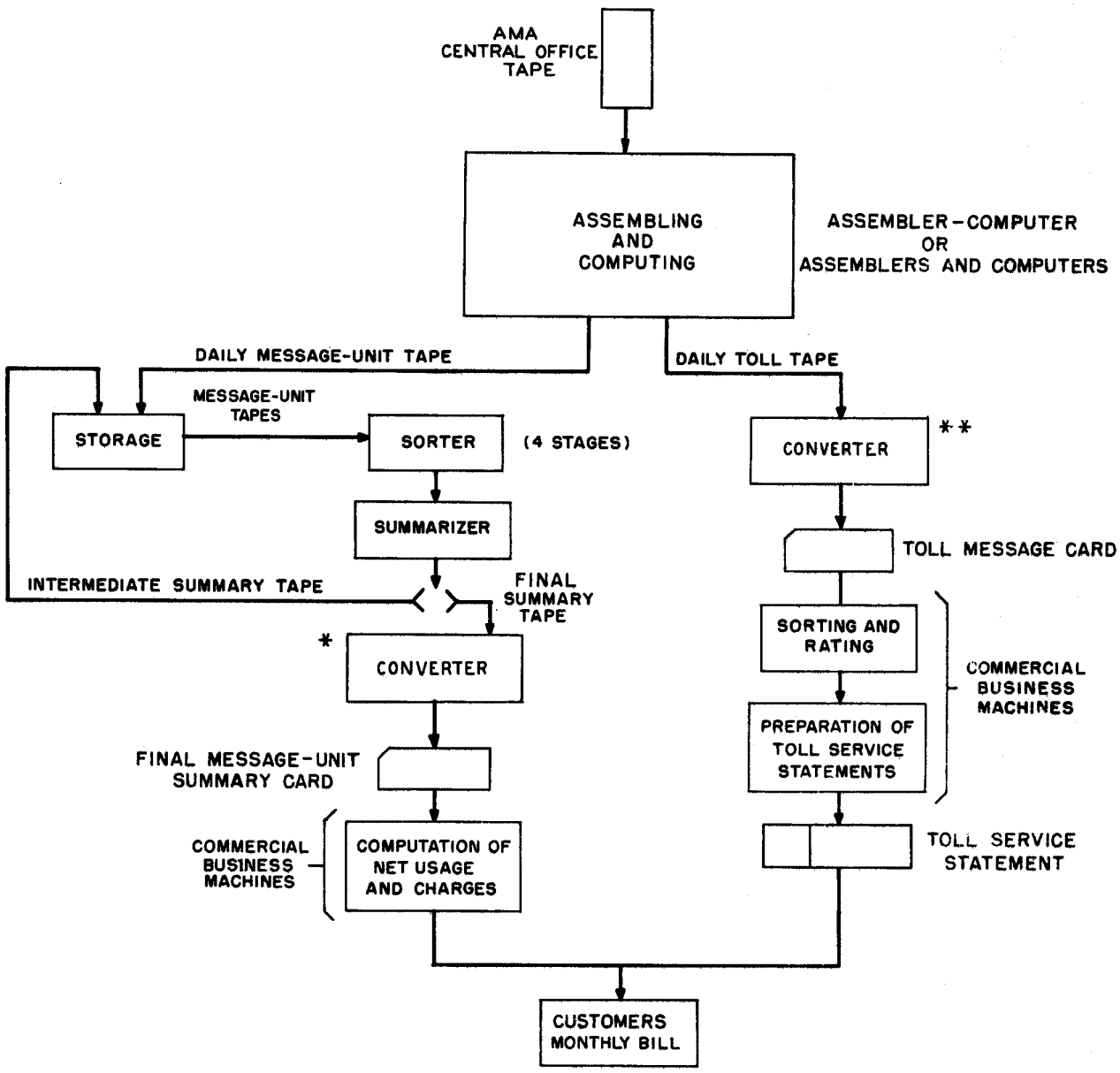


Figure 14-16 Accounting Center



NOTES:

* THE AMA PRINTER-COMPARER-SCANNER OR PRINTER IS USED TO PRINT INTERMEDIATE MESSAGE UNIT SUMMARIES AND MAY ALSO BE USED TO PRINT FINAL MESSAGE UNIT SUMMARIES.

** THE AMA PRINTER MAY ALSO BE USED TO PROCESS DAILY TOLL TAPES, IN WHICH CASE THE OUTPUT IS IN THE FORM OF PRINTED TOLL SLIPS.

Figure 14-17 Processing of Central Office Tapes

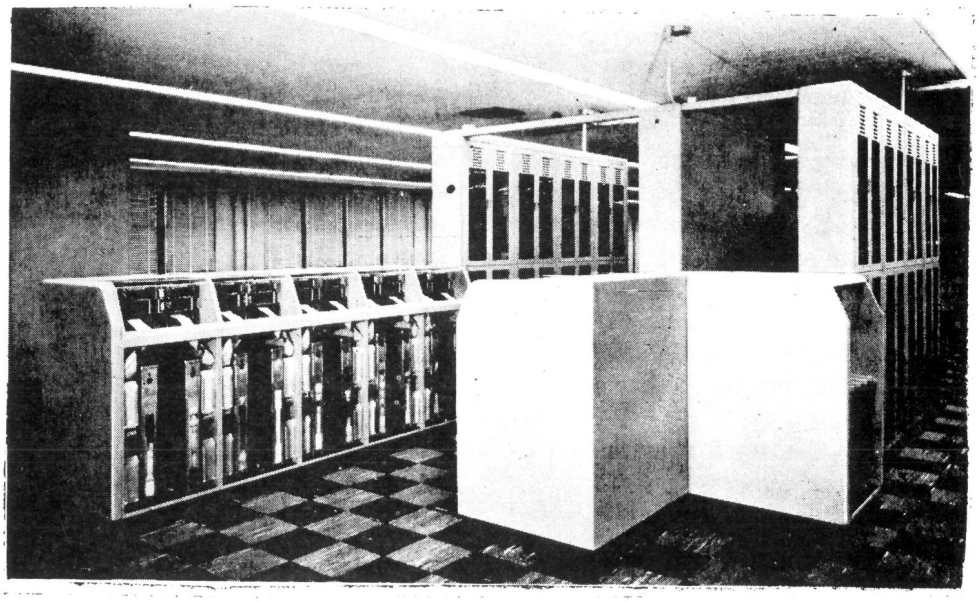


Figure 14-18 Assembler-Computer

In one assembler-computer stage or a combination of two assembler stages and one computer stage, the initial, answer, and disconnect entries of each call are brought together. Unanswered calls are eliminated and the chargeable time of completed messages is computed. For message unit messages, the chargeable time is converted to message units. Chargeable time for each toll message is derived and the complete call record is preserved. Message unit messages are separated from the toll messages during the assembler-computer or computer processing. In the four sorter stages, all the message unit messages dialed by a customer during a processing round are brought together on the output tape in line number order. In the summarizer stage, the message units of a processing round for each customer are totaled and added to the summary tape record of the previous round, except for the first processing round of the billing month.

Intermediate message unit summary tapes from the AMA summarizer are printed by the AMA printer-comparer-scanner, Figure 14-19, or the AMA printer to permit ready access to an individual customer usage to date, should a need for it arise.

Final message unit summary tapes from the AMA summarizer are fed to the converter, Figure 14-20, which provides a single punched card for each summary entry.

Toll output tapes from the AMA assembler-computer or the AMA computer are fed to the converter which produces a card containing the complete record of each toll message.

14.7 AMA FOR NO. 1 ESS

A. GENERAL

Taking full advantage of the data processing capabilities of No. 1 ESS, Bell Laboratories has programmed the AMA operation for the electronic system. The only special central-office equipment required for the ESS-AMA function is a magnetic tape unit. Besides holding considerable data the tape is stored and transported easily and it is compatible with the electronic computers already in service at most Bell System accounting centers.

In No. 1 and No. 5 Crossbar switching offices, AMA systems require control equipment and added features in trunk circuits in order to record call data as perforations on paper tape. Since there is no memory associated with the tape perforating equipment, all the data for each call cannot be punched together in sequence on the tape. Separate tape reading and computing equipment is required at accounting centers for sorting and assembling, as well as computing the charges for each call.

The AMA system in the No. 1 ESS is simpler in its operation. All its actions are contained in two programs, a data accumulating program and a data transfer program. The first records the charge details of all calls classified as billable, then encodes the data and transfers it to a memory buffer block. When this buffer block is full, the second AMA control program takes over and transfers the buffer block data to the AMA magnetic tape. All the while, the transfer program continually checks the tape unit and data-transfer circuitry for errors. The final output of both programs is a reel of magnetic tape containing all billing entries for a specific period of time.

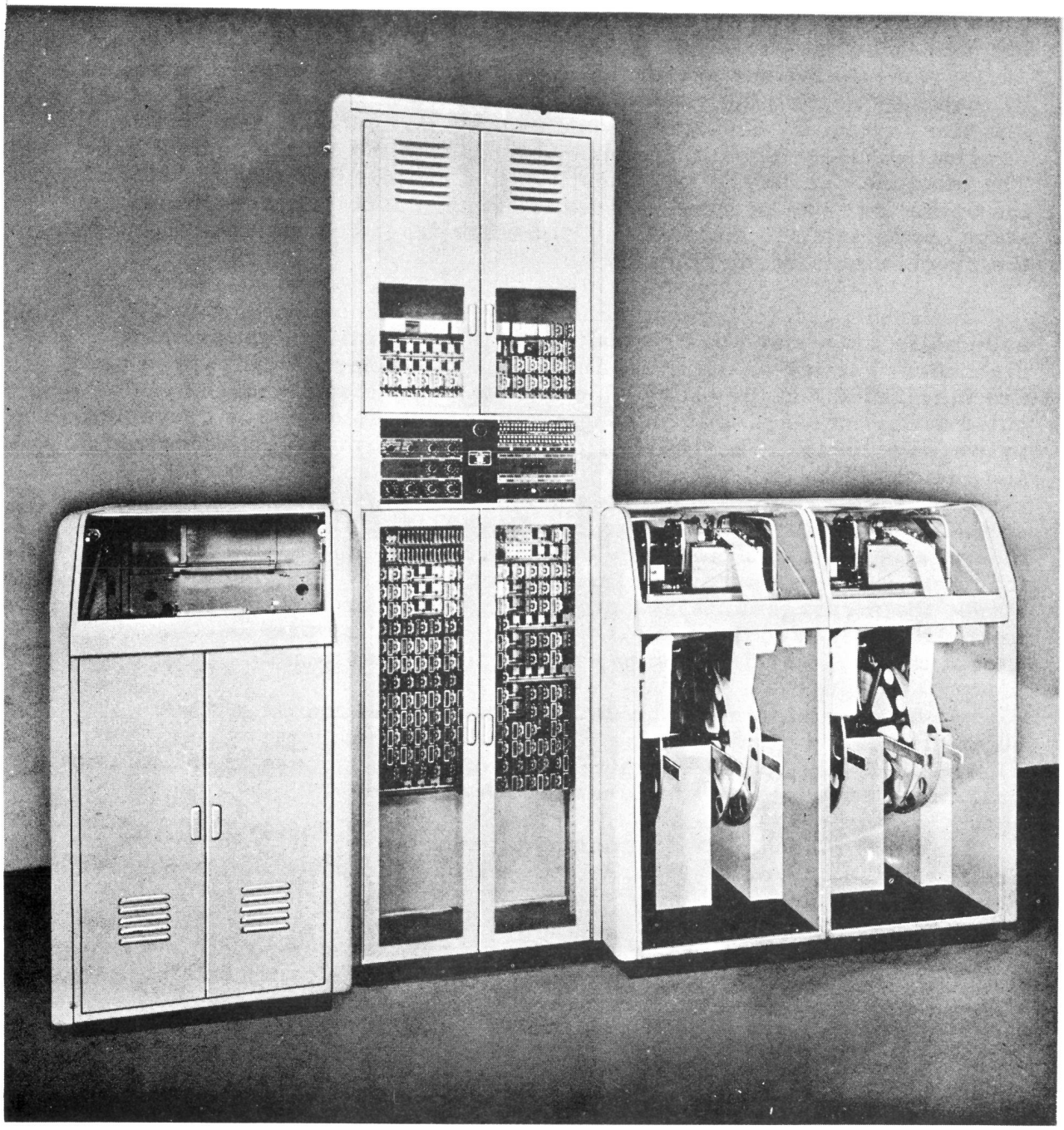


Figure 14-19 Printer-Comparer-Scanner

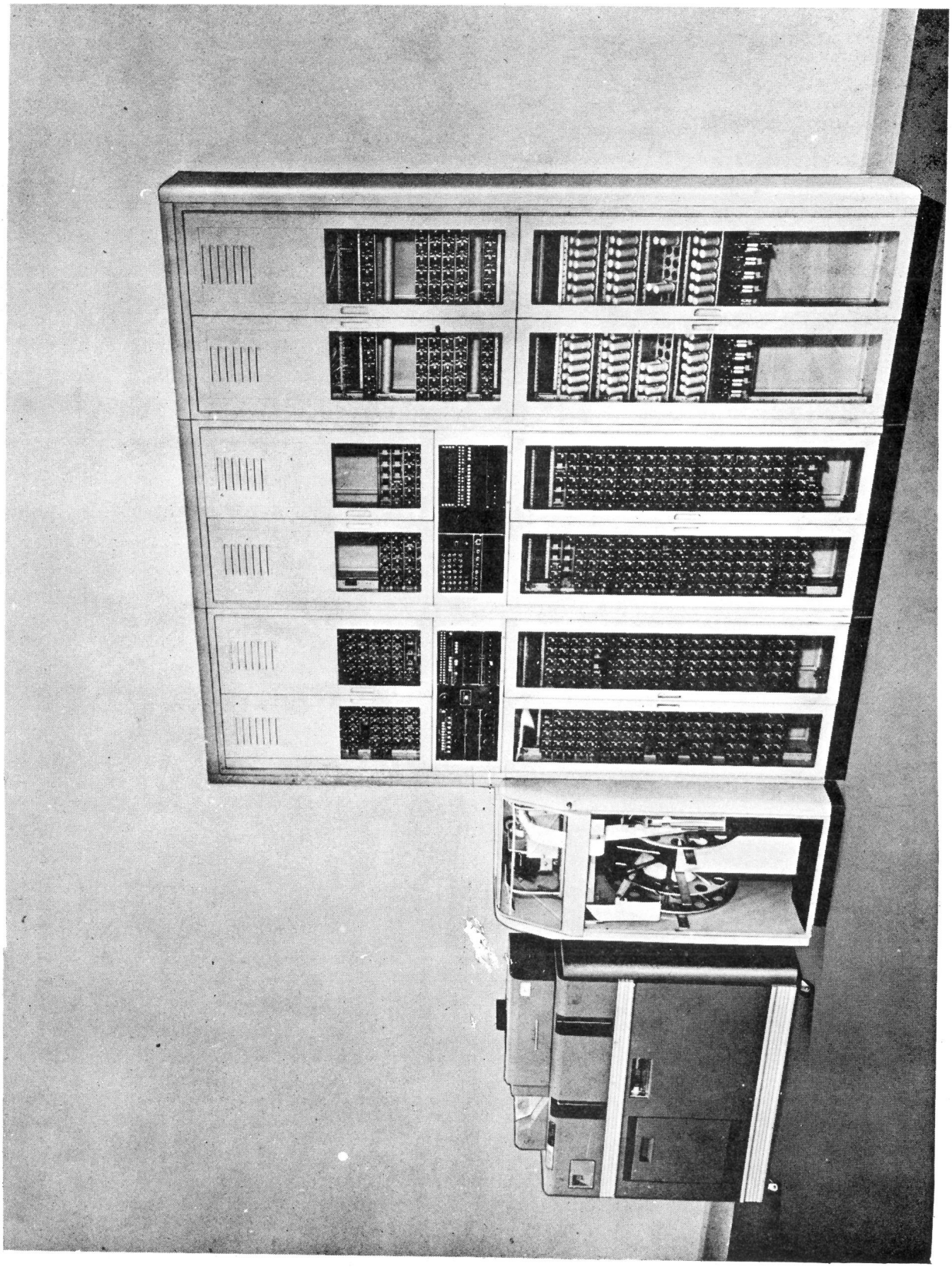


Figure 14-20 Tape-to-Card Converter

B. TYPICAL OPERATION

1. Data Accumulation

When a customer wishes to make a call, see Figure 14-21, his line is connected to a digit receiver which is associated with a block of temporary memory called the originating register. This register, which temporarily stores the customer's dialed digits and the control information for processing the call, performs basically the same function as the originating register circuit in the No. 5 Crossbar system.

As each digit is received, a report is made to the digit analysis program which controls the originating register. After three digits have been received, the digit analysis program requests a translation of these digits to determine a routing for the call. At this time the telephone customer has dialed either an office code, an area code, or a service code. The dialed office code may or may not be within the local calling area. If the call is not an intraoffice call, the requested translation includes routing information and an indication of whether or not the call is to be billed. If the call is billable, the digit analysis program then requests that an AMA register be linked to the originating register.

The AMA register is thus one of the key parts of the entire ESS-AMA system. This register is actually a block of temporary memory that accumulates pertinent data on the call as it progresses. It usually remains associated with the call for its entire duration. It contains 13 call store words, each with 23 information bits. The first four words comprise a standard format for all No. 1 ESS call registers and are used primarily for administering the register. The next three words store information about the network path used for the call connection. The remaining six words store the necessary charging information as it becomes available. (See Figure 14-22 for a typical call store register layout.) The number of AMA registers in any one ESS switching system depends on such factors

as the type and volume of traffic. There are always sufficient registers to insure an extremely low probability of a blocked call because of an unavailable register.

When the customer has completed dialing, the digit analysis program transfers initial call data from its own originating register to the linked AMA register. This initial entry includes such items as called and calling number, type of call, and a message billing index. After the transfer, programs route the call to an outgoing trunk. The originating register is then released and the AMA program assumes control. All changes of state detected by supervisory scan programs will then be reported to the AMA program.

The first report received will indicate either that the calling line has abandoned the call or that the called number has answered. For an answer report, the AMA program takes the time of day from the system clock and records it in the answer slot of the AMA register. The system clock, another temporary memory location, offers an accurate time base that is updated every 10 milliseconds. Times entered in the AMA register are in units of hours, minutes, seconds, and tenths of seconds. This timing accuracy suits the ESS-AMA charge details for such calls as DATA-PHONE, which formerly required their own high-accuracy timing devices.

When the calling or called party terminates the call, a supervisory scan program detects the change and reports to the AMA data accumulation program. The disconnect time is entered in the AMA register, and programs take down the network connections, restoring the trunk and line circuits to idle condition. All information needed for determining charges on the call now exists in the AMA register. This data must be transferred to the magnetic tape.

Because billing data in the AMA register are in a compact code not acceptable at the accounting center, they must be converted to standard form. A series of output data formats offering high efficiency and flexibility is avaialble for this conversion. Each type of call gets a

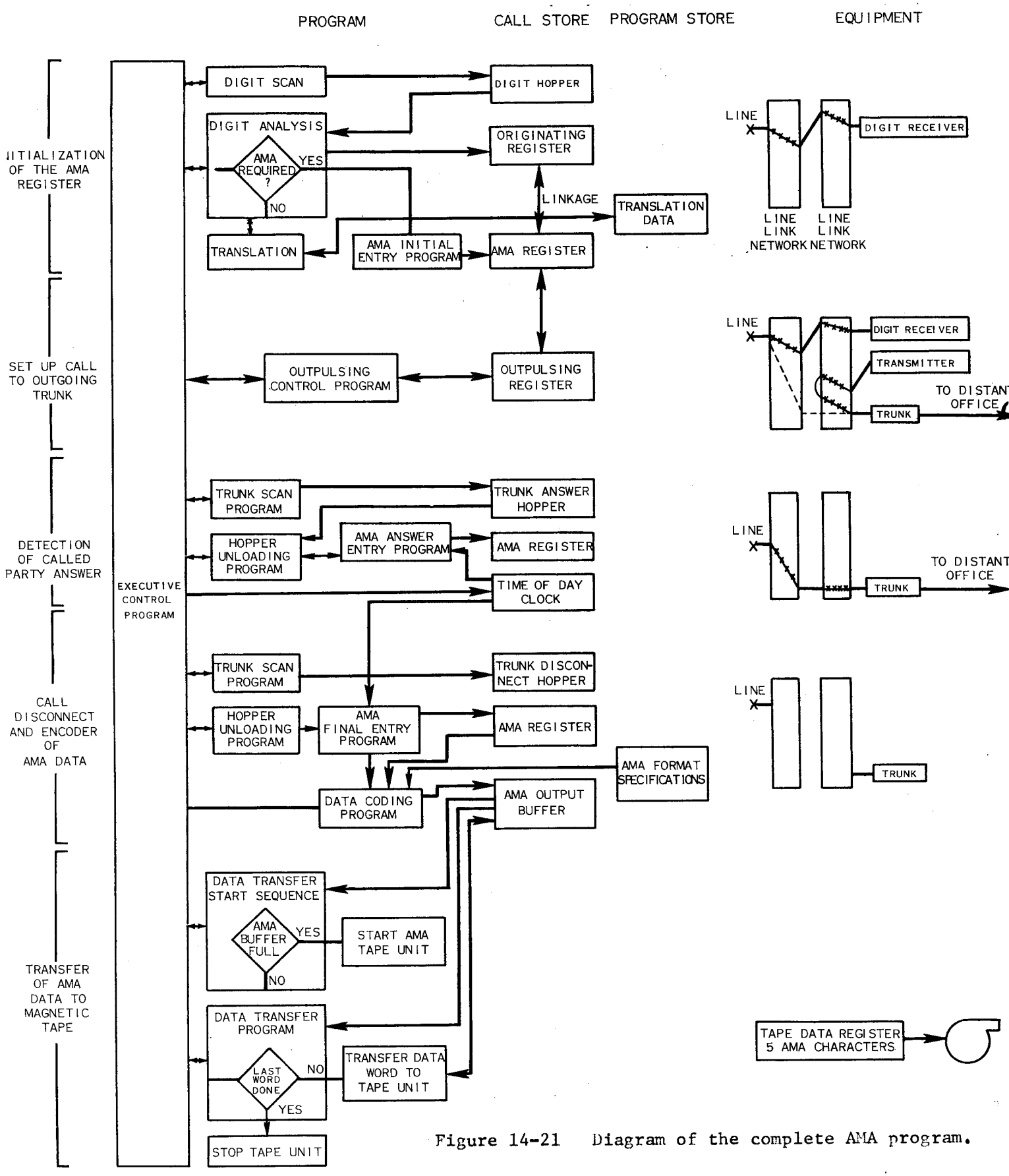


Figure 14-21 Diagram of the complete AMA program.

distinct format consisting of series of binary coded decimal (BCD) four-bit characters arranged in a fixed sequence for identification by the processing computer at the accounting center.

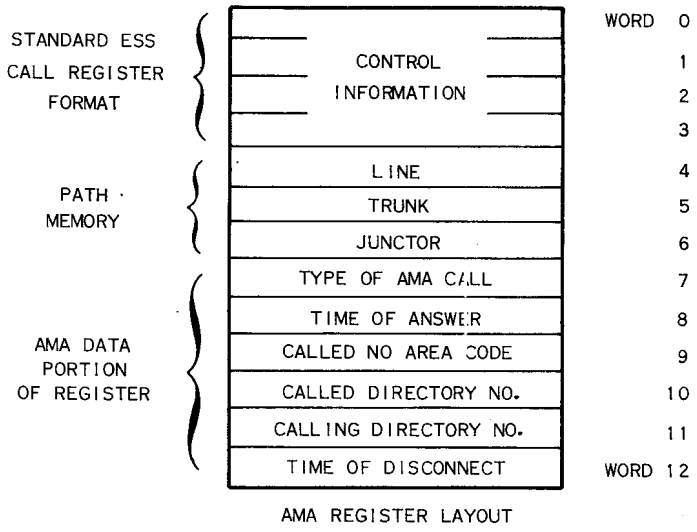


Figure 14-22 Simplified layout of an AMA call store register.

Three information digits directly precede the data for each call recorded on the AMA tape. Table 14-1 shows a typical format. The first digit informs the accounting center that this is the start of a new entry. The next two digits identify the data format. At present, the No. 1 ESS system has formats for 21 types of chargeable calls, ranging from station-to-station calls to custom calling services such as dial conference. New formats can be added and old ones deleted as the requirements for billing information change.

Since calls are completed randomly in time, it would be neither feasible nor economical to copy the data of each call onto the magnetic tape as soon as that data has been encoded in the proper format. There must be sufficient data to warrant starting the tape unit. A block of

buffer memory, therefore, temporarily stores the data until 500 BCD characters have been accumulated. In normal operation, this means information from 10 to 20 AMA registers, depending upon the data format used by each.

After the data in the AMA register have been encoded and stored in the buffer memory, the register is released for assignment to a new chargeable call. If the buffer area is full at the time an AMA call is completed, special facilities keep the AMA register in a waiting list until the AMA data transfer programs transfer data from the buffer to the tape. This prevents loss of charging data because of overload conditions.

Table 14-1

Binary coded digits (BCD) used to convert data from the AMA register to a standard billing format.

NAME	NO. OF BCD CHARACTERS REQUIRED
START OF ENTRY CODE	1
TYPE OF ENTRY = STATION PAID REGULAR = 01	2
SPECIAL ACCOUNTING INFORMATION	3
CUSTOM CALLING SERVICE USED	2
CONNECT TIME	7
CALLING NUMBER	7
MIDNIGHT INDICATOR	1
DISCONNECT TIME	7
CALLED NUMBER	10
TOTAL	40

2. Data Transfer

When the base-level executive-control program finds the AMA buffer full (it periodically checks the states of the buffer) program control passes to the second major AMA program--the data transfer program. This program has two basic parts. The first, operated at base level, starts the tape drive unit and prepares it for recording. While the tape unit is getting up to speed, this program checks that the basic hardware is satisfactory, that the tape unit motors are running, and that there is sufficient tape on the reel to record the data block. If these checks are affirmative, actual data transfer begins.

Actual data transfer is the primary function of the overall data transfer program. (See Figure 14-21.) In time, however, data transfer is controlled by the second part of the program. Because of the stringent timing requirements on data transfer circuitry, this operation occurs at the interrupt level. (See Figure 14-23.) The data transfer sequence is entered every five milliseconds until the entire buffer area is recorded on tape. At each entry, one 21-bit data word (five four-bit AMA characters plus a parity bit) is transmitted from the buffer to the tape unit circuitry. Special circuitry divides the work into five characters, computes an odd parity bit for each character, and records it on the magnetic tape.

The tape unit has seven tracks, uses four for the BCD character and one for the parity bit. The remaining two are presently unused. It takes about one millisecond to record each character, and after five milliseconds, the tape unit is ready for another word from the central control unit. If the system fails to transmit a data word to the tape unit in time, tape-unit circuitry recognizes this and records a dummy character on the tape. The AMA accounting center ignores these characters when processing the tape. Dummy characters are necessary because adjacent blocks of data on the tape are normally separated by blank sections. Since the central control unit processes all data in a real-time

mode, there occasionally may be enough I/O activity at higher priority than AMA to cause central control to miss a five millisecond time spot.

When all 500 AMA characters are recorded on the magnetic tape, the recorder stops. The entire sequence of starting the tape unit, recording the data block, and stopping the tape takes about one second and uses about 3.5 inches of tape.

Major goals of the AMA design in No. 1 ESS were long-term reliability and high accuracy in the recording of customer billing data. These dictated the use of a simple, rugged tape recorder. Duplication of hardware, including recorders and access and control circuitry, further insures system reliability. One tape unit records while the other stands by. In normal operation, the tape units interchange from active to standby once each day, usually at midnight. This enables craftsmen to remove the tape containing each day's information.

For greater dependability, the data transfer program continually monitors the tape unit for malfunctions during data transfer. Trouble indications include improper tape speed, broken tape, bad parity words from the central-control unit, and bad parity from the tape itself. If any malfunction is detected, the faulty unit is switched out of service and the standby unit activated. Diagnostic programs then test the faulty unit, usually locating the trouble within a matter of seconds. The results are quickly reported on the maintenance teletypewriter.

Automatic message accounting in No. 1 ESS, by taking advantage of stored programs and using magnetic tape recorders, has evolved into an efficient, reliable, and economical system. It can record the charge details of about 40,000 calls an hour. The tape reel has enough storage capacity for about 100,000 entries.

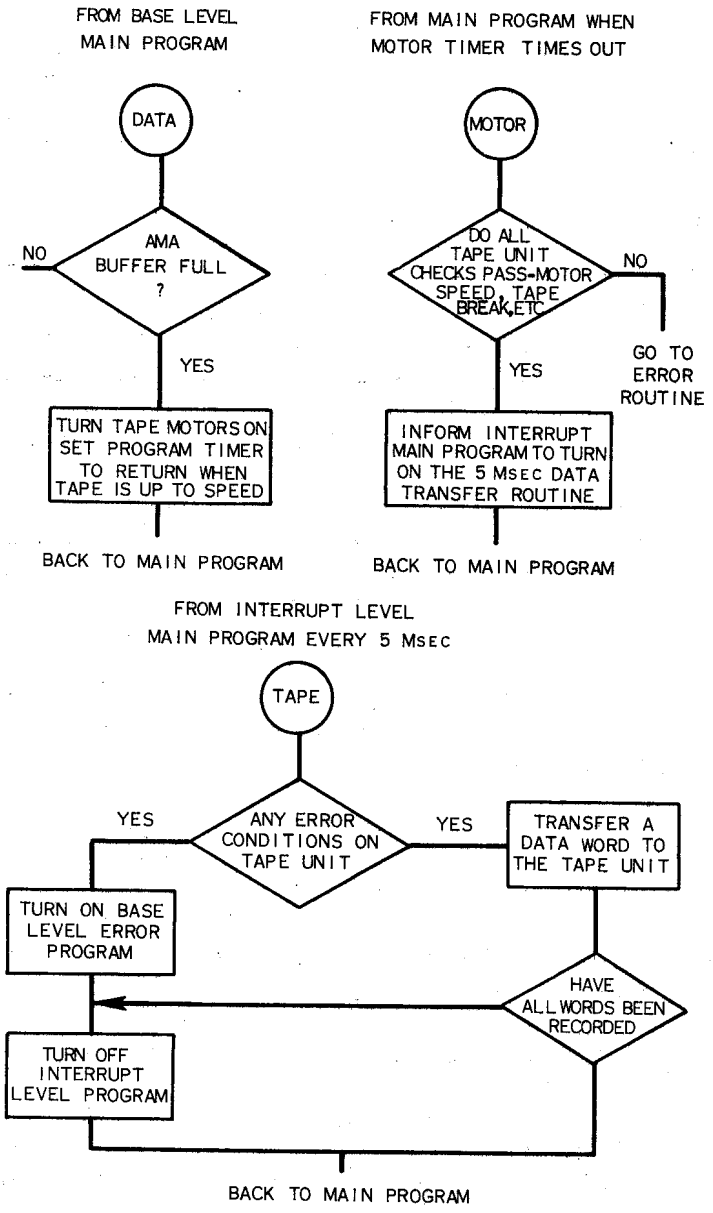


Figure 14-23 The AMA Data Transfer Program.