BASIC TYPES OF SWITCHING SYSTEMS

CONTENTS

1. GENERAL

1.1 This section is intended to provide REA borrowers, consulting engineers, and other interested parties with technical information for use in the design and engineering of REA borrowers' telephone systems. It refers specifically to the two basic types of central office switching equipment generally known as "direct response" and "common control" or "indirect response," their relative advantages and fields of application.

1.2 The term "direct response" applies to switching systems, such as Automatic Electric and ITT Kellogg step-by-step, Stromberg-Carlson XY, or Leich relay type, in which selecting switches in successive stages respond during or after each digit received from the subscriber's dial. All of the equipment is held until the end of conversation.

1.3 The term "common control" applies to switching systems, such as North Electric Crossbar or United States Instrument Motorswitch, in which pulses from the subscriber's dial are first stored and then transmitted in the same or another form to the switches which complete the connection. The registers and associated "common" equipment are held only until the connection to the called telephone is established. They are then released and become free to handle other calls.

1.4 REA borrowers up to this time have used direct response local switching equipment almost exclusively and it has proved economical and adequate under most conditions. However, the introduction of new or expanded service, such as the following require common control or make its use desirable:

Direct Distance Dialing (DDD)

Extended Area Service (EAS) where there are too many offices to permit uniform dialing of directory numbers with direct response equipment. This situation has been further complicated by the fact that only the least desirable office codes are available for assignment of new offices.

Touch Tone (or Touch Button, Touch Calling) in which key pulsing replaces dialing by the subscribers. (Customer Key Pulsing)

Senderized pulsing on toll boards, and the increased use of MF pulsing.

1.5 The initial installation of central office equipment may have common control or common control features may be added to an existing direct response office. Up to this time common control in REA borrowers' systems has been limited to DDD and a few local crossbar installation. However, the growth of EAS networks and the demand for customer key pulsing, together with other advantages, can be expected to increase the use of common control in the future.

2. DIRECT RESPONSE SYSTEMS

2.1 Figure 1 is a schematic of a step-by-step office representative of those installed in the systems of REA borrowers.

2.2 This is a terminal-per-station office with 500 terminals equipped. The 3 digit office code, "774" and the thousands digit "2" are absorbed in the first selector. The incoming EAS and toll selectors receive only four digits and, therefore, need to absorb only the digit "2".

2.3 The directory would list all seven digits, such as 774-2345, but calls would also be completed if the user dialed only the last four digits.

2.4 For each digit dialed, except the last two, a first selector moves up to the corresponding level. If the digit is absorbed, the selector drops back to normal, otherwise it hunts for an idle connector. The last two digits cause the connector to select the corresponding terminal. Selectors and connectors are not released until the end of the conversation.

2.5 Level "9" is marked to absorb and unlock to permit assigning coin station numbers in the "9000" series. They may actually be assigned in any of the five connector groups.

2.6 With the direct response system each individual digit actuates a switch and the digit is "used up" and cannot operate another switch.

2.7 A more detailed description of level assignments in a direct response system is contained in REA TE & CM-208, "Local Exchange Numbering Plans and Selector Level Assignments."

3. COMMON CONTROL SYSTEM - ADDED TO STEP-BY-STEP

3.01 Direct response systems can be provided with common control features by adding equipment especially designed for that purpose. This equipment is available from most of the manufacturers whose dial switching equipment appears in the "List of Materials Acceptable For Use on Telephone Systems of REA Borrowers," REA Bulletin 344-2. It is possible to add this equipment as provided by any manufacturer to the direct response system provided by the same or any other manufacturer.

3.02 Figure 2 is a schematic of a step-by-step system to which common control has been added by inserting register-senders and associated equipment between the linefinders and the local first selectors.

3.03 It is assumed that the introduction of a rather complex EAS network is the main reason for adding common control equipment in this example. Several facts concerning the office codes would make this an extremely expensive and difficult, if not impossible, trunking problem with direct response switches:

3.031 The necessity for outpulsing all 7 digits to the nearby metropolitan area. (In the example only 5 office codes are used, and it would probably not be necessary to outpulse all 7 digits in such a small area. However, many metropolitan areas <u>do</u> have enough office codes that 7 digits <u>are</u> required).

3.032 Even though the 5 "Metro" codes could be arranged to trunk by direct response, several first selector levels would be used up. The common control saves several second selector ranks.

3.033 The characteristics of local office code 722 and EAS code 272 make it difficult to distinguish between the two by conventional means.

3.04 On calls for the local office "722", the common control equipment recognizes from the first 3 digits that it is a local call, absorbs the fourth digit and cuts the connection through to the first selector and subsequent pulses from the user's dial operate the local selectors and connectors directly. With this plan the register-sender holding time on local calls, which comprise the majority of the traffic, is very short and the amount of common control equipment is kept at a minimum. The equipment usually is designed to operate in this manner whether it takes one, two, or three digits to identify the call as local.

3.05 In a similar fashion calls to EAS group 272 are recognized by the first two digits 27 and subsequent digits by-pass the common control. Likewise calls to EAS group 836 are recognized by the first two digits "83".

3.06 In contrast to local calls and calls to EAS groups 272 and 836, calls to the metropolitan area are registered in their entirety in the register-senders. After the first three digits are dialed, the common control recognizes that the call is destined for the metropolitan area. The sender sends a "5" followed by the 7 digits dialed by the calling party. The "5" routes the call to the metropolitan trunk group. Usually the sender starts to outpulse immediately after the office code, or in other words, while the calling party is still dialing the last four digits. This hastens completion of the call.

3.07 On a call to the operator, the common control outpulses a zero and releases. Subsequently, the calling party can flash the operator in the usual manner.

3.08 With direct response equipment it is customary to allow completion of local calls by dialing only the last four or five digits, but in the example shown in Figure 2, it is necessary that all 7 digits be dialed.

3.09 In the example shown in Figure 2, it is assumed that incoming calls over EAS or toll trunks consist of the last four digits which can be completed directly as in any step-by-step office. Therefore, levels 3, 4, 7, 8, and 9 of the incoming EAS and toll selectors are multipled to the same levels of the local first selectors. It should be understood that, particularly if the exchange is a tandem EAS point, the common control could also be inserted between the incoming trunks and their associated incoming trunk selectors. Incoming EAS calls would have to consist of a sufficient number of digits, usually five or six, to distinguish each office destination. For the sake of illustration, let us say that incoming EAS calls consist of the last six digits of the called number. Since calls originating locally and calls coming in over EAS both reach the same common control equipment, it can be seen that some difficulty would be caused by conflict between a local call toward the 272 EAS group and an incoming EAS call toward the 227 group (both would be first two digits "27"). This conflict introduces the need for a feature usually called class-of-service, which can be defined in a general way as a feature which permits different treatment of dialed digits depending upon the source.

3.10 In the example shown in Figure 2, it is assumed that the first digits dialed are registered in the common control equipment. Only after the common control determines the destination of the call, does the connect equipment "cut-through" and allow subsequent digits dialed to actuate the selectors. There is another general method of arrangement whereby the selectors may be actuated at the same time the digits are received in the common control.

3.101 On a call to the operator when the calling party dials zero, the selector would be stepped to the tenth level while the pulses are received. The common control would recognize the zero and immediately leave the connection without the necessity of outpulsing a zero. This would hasten the completion of the call.

3.102 If the digit dialed is one which would not route directly to the desired destination, the common control would cause the selector to release. This action would be similar to digit absorbtion, except that the common control could, if required, release and outpulse a different digit or digits to route the call properly.

3.103 This arrangement, even though it increases the register holding time on most calls and increases the wear on selectors, has a considerable advantage in screening nonexistent numbers. In the example in Figure 2, it can be seen that a nonexisting code such as 273 would be destined for a "wrong number" in the 3300 connector group, a nonexisting code 832 would be routed to EAS group 272, and a call to nonexisting connector group 722-35XX would be routed to the "Metro" exchange. With conventional direct response equipment, little can be done to prevent such calls. With common control arranged for simultaneous digit registration in the registers and in the selectors, it is possible to inspect one more digit of the called number, and if found invalid, it can be routed to intercept (perhaps over a vacant connector terminal, thereby saving a selector level).

3.11 In the case of a toll center, the common control might be utilized in several ways:

3.111 Seven digits are received over intertoll trunks for calls to subscribers served by the toll center and these can be routed to the common control equipment and through a trunk selector to gain access to the local office and to the tributaries.

3.112 Register-sender features may be added to the toll board, either by connecting the operator's circuit into the common control, or by inserting the common control access between the outgoing trunk and the OGT selectors. The latter method would be employed in conjunction with a rearrangement of the outgoing appearances of all trunks so that trunks to all offices are reached via one OGT group rather than direct appearances. This simplifies operating procedures. Also, the common control could identify which office codes require MF pulsing, and provide automatic alternate routing.

3.113 The common control can provide register-sender features for a DDD system, whether in a toll center, toll point, or end office.

3.12 The cost of adding common control to step-by-step is quite high, so high in fact that it should not lightly be entertained. However, the numbering plan sometimes becomes so difficult that alternate schemes are even more expensive. In addition there are several further advantages to the addition of common control which may be considered:

3.121 With common control it is fairly inexpensive to arrange the central office equipment for Customer Key Pulsing.

3.122 Common control permits the use of the much faster MF type pulsing for calls to other offices (assuming the other offices are arranged to receive MF).

3.123 Common control increases the flexibility of selector level rearrangement. The ability to translate office codes may permit deferral of extensive selector level rearrangements as EAS groups are added in the future and as the local switchboard grows.

3.124 Where EAS calls (outgoing, incoming, or both) are registered in their entirety and pulsed out from the sender, there should be fewer maintenance problems concerned with pulsing difficulties.

3.125 Automatic alternate routing is available. For instance, in Figure 2, if, on an EAS call to office 272, the trunks were all busy, the common control could be arranged to route the call to the "Metro" trunk group, assuming the "Metro" exchange is equipped to route the call to the 272 office.

3.126 By using the automatic alternate routing feature described in Paragraph 3.125, it is possible to provide full availability from selectors into large trunk groups without the necessity of using special level hunting selectors or rotary outgoing preselectors. If the first ten trunks are busy, the common control can route the call to another selector level for access to ten more trunks.

3.127 Common control will permit the use of standard access codes for [illegible] operator, repair, information, station-to-station DDD and DDCS DDD with a minimum of equipment. For instance, the information code could route the call to the operator office trunk. In toll centers the information code could route the call to a connector terminal, thereby saving selector levels.

3.128 The class-of-service feature could be used to keep paystations out of the DDD system and even route attempted DDD calls to the operator for manual completion.

3.129 Permanent "off-hook" calls could be automatically routed to the howler.

4. COMMON CONTROL SYSTEMS - CROSSBAR

4.1 Figure 3 is a simplified diagram of a common control system using crossbar switches or selectors. The crossbar switch itself is not essential for common control as other types of switches can be and are used, such as rotary switches (the Federal rotary system) or reed-type relays (the Automatic Electric electronic system).

4.2 When the calling party goes off hook, he is connected both to a local selector and to an originating register and then hears dial tone. A shortage of registers or of paths to the selectors results in delayed dial tone.

4.3 The digits dialed by the user are stored in the register. If the office code indicates the call is local, reference is made to the "number group" to determine the location of the called line. In the crossbar system illustrated, there is one number group for each 1000 terminals. Signals are then sent very rapidly to the selectors and connector which close the circuit to the called line. The register is held only until the connection is completed to the called line or a busy condition is met. It then releases and is free to handle other calls.

4.4 If the office code indicates the call is to another office, a connection is established through the local selector B to an outgoing trunk. Digits are transmitted in accordance with the needs of the distant office. This may include part or all of the office code and four digits or only four digits. It also is possible to translate the office code into other digits and to add or subtract digits to meet local requirements. The digits transmitted may be dial pulse (DP) or multi-frequency (MF) pulses, depending on the type of the distant office.

4.5 On incoming trunk calls, an incoming register is connected until the pulses are stored and the connection is completed to the called terminal. The incoming registers can be equipped to receive either dial or multi-frequency pulses.

4.6 To serve local telephones designed for Customer Key Pulsing, originating registers can be provided which accept the tone signals as well as dial pulses. After the digits are registered, the calls are handled the same as if they originated at a dial instrument. For calls to other lines within the exchange, the signals are sent to actuate selector and connector crossbar switches. For EAS calls to other exchanges, it is possible to deliver dial pulse (DP) digits or multi-frequency (MF) digits to the other exchange as described in Item 4.4 in more detail.

5. ADVANTAGES OF COMMON CONTROL - TRAFFIC

5.1 Flexibility in the assignment of office codes, since they are not related to fixed levels on selectors, makes it possible to use any office codes in an EAS network or for the tributaries of a toll center. Adding common control to a direct response system usually reduces selector requirements.

5.2 Common control can eliminate some direct EAS trunk groups between exchanges of an EAS network by routing EAS calls through a tandem center. The resulting larger trunk groups are usually much more efficient than the smaller groups which are eliminated.

5.3 In an automatic toll ticketing (DDD) installation common control permits selection of proper trunk group in accordance with digits of called number (including area code), and transmission of all digits received or of other digits which may be required for routing purposes.

5.4 Permits automatic alternate routing in DDD installations and EAS networks, with the result that the trunk groups are much more efficient.

5.5 Permits serving telephones equipped for key pulsing. (Touch Tone, Touch Button, or Touch Calling).

5.6 Permits conversion of dial pulses into multi-frequency (MF) pulses where there is considerable traffic to a common control toll switching center. Similarly, MF pulses can be accepted from the toll network and used directly to establish connections or they can be converted to dial pulses.

5.7 Permits handling different classes of service or restricting service on certain lines.

5.8 Larger trunk groups may be given full availability without resorting to rotary outgoing selectors and level hunting switches.

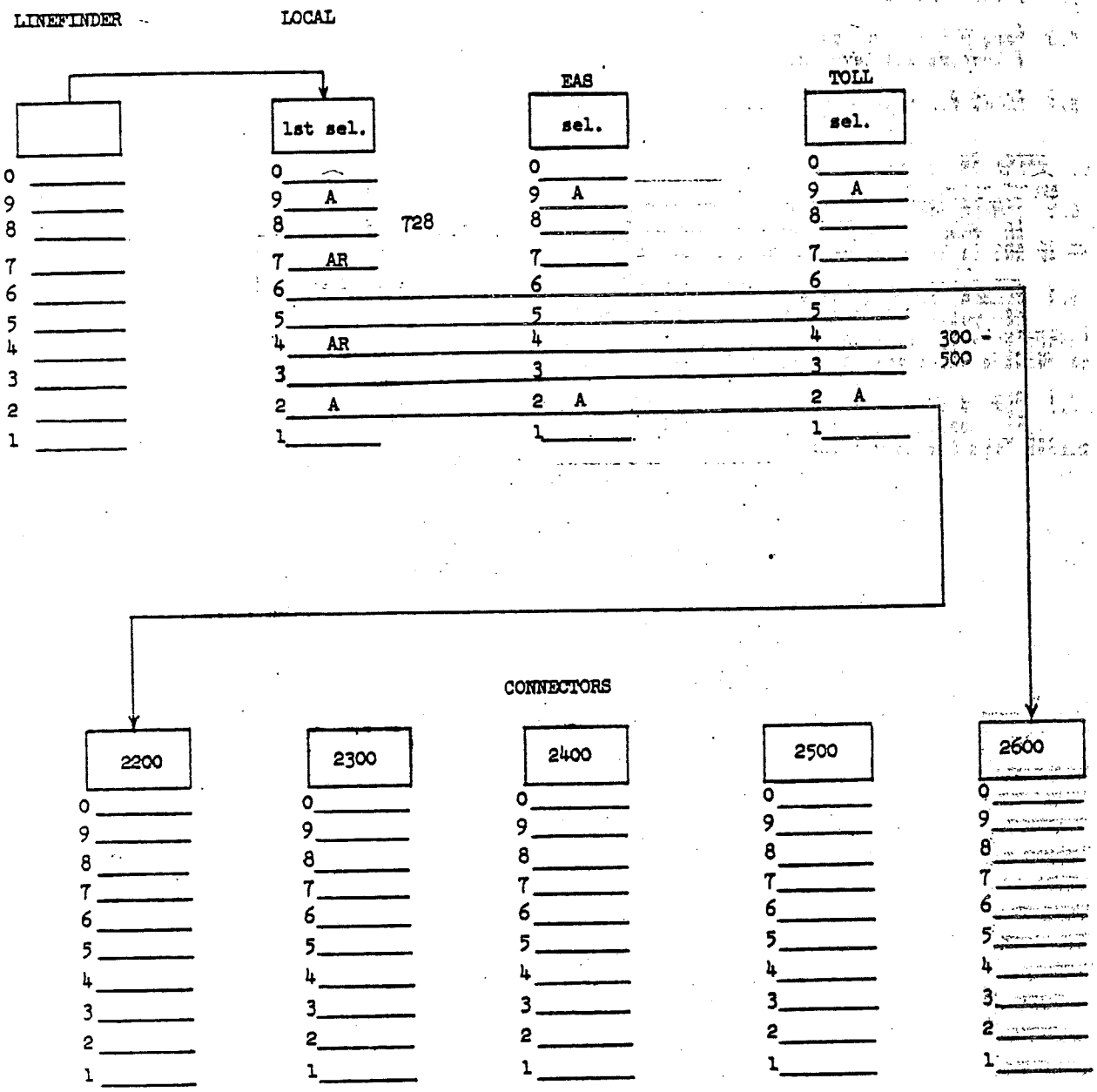
5.9 Local first selectors need not be equipped with digit absorbing features.

6. FIELD OF USE FOR COMMON CONTROL

6.1 Common control is essential for DDD when there are two or more outlets to the toll network in order to use the area and office codes of the called number to select the outgoing trunk group and to transmit these to the next office.

6.2 Common control, at least in a limited form, is essential to serve telephones equipped for key pulsing generally known as "Touch Tone", "Touch Button", or "Touch Calling". These instruments generate tones within the voice frequency band and the central office must be equipped to receive and translate these pulses and use them to complete calls through the local dial system.

6.3 Common control is desirable and may be essential to operate an extensive EAS network where the assigned office codes do not lend themselves to uniform dialing of the listed directory number with direct response equipment.



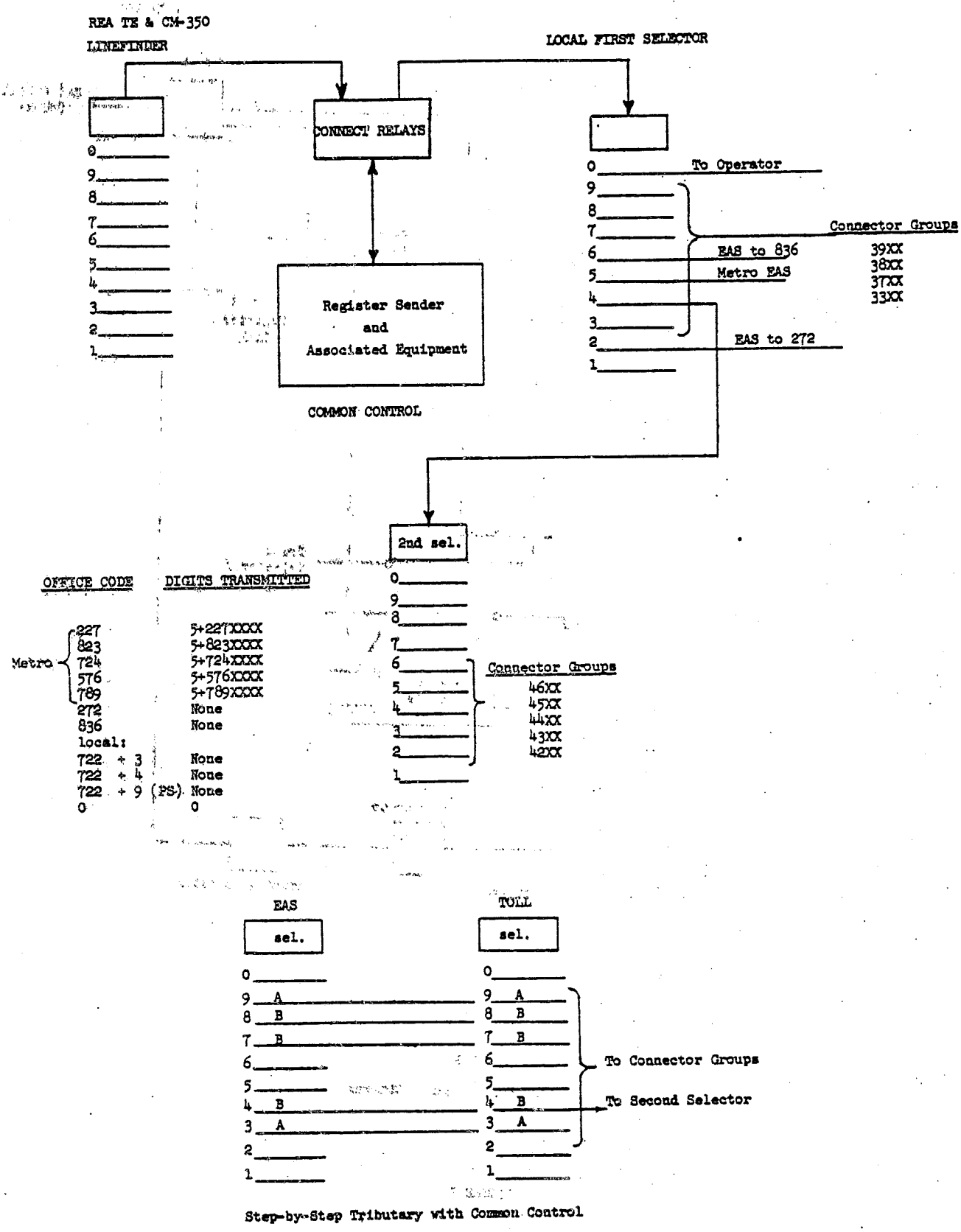
Office Code 774

AR - Absorb Repeatedly

A - Absorb and Unlock

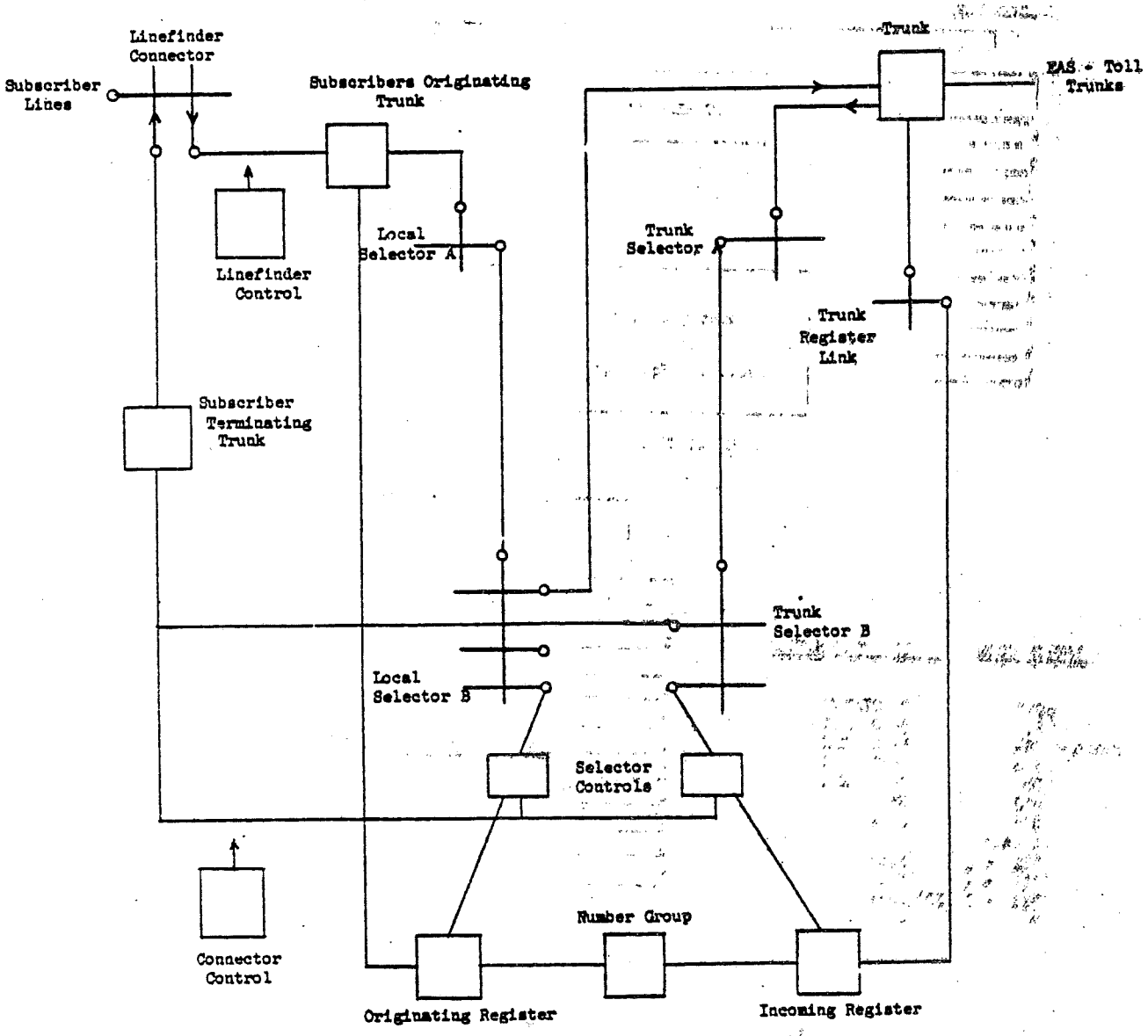
Typical Step-by-Step Office

FIGURE 1



Step-by-Step Tributary with Common Control

FIGURE 2



CROSSBAR

Common Control Switching Diagram

FIGURE 3