The Card Translator for Nationwide Dialing

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(Manuscript received August 24, 1953)

Nationwide operator and customer dialing requires the existence of a number of switching centers equipped with automatic systems having a much higher order of mechanical "Intelligence" than previous systems. One of the most important components of this new switching system is the Card Translator. Its function is to take the telephone address of a call and determine how to advance this call toward that address. This translator has to meet unique requirements in that it must accommodate a very large number of addresses; must provide a great amount of information for routing the calls; and must enable quick and convenient changes to be made in its stored information. It must also meet, of course, the normal basic requirements of reliability, economy, long life, etc. The fundamental principle of this translator is that of a card file, containing individual coded cards for each destination, with routing information recorded on each card. Whenever the routing information for a specific code is needed, the system selects the appropriate card, and reads the information by means of electronic circuits employing phototransistors and transistor amplifiers.

INTRODUCTION

The "Card Translator" was developed for the 4A toll crossbar system used at Control Switching Points (CSP) in the nationwide dialing network of offices. Although the many problems and conditions presented in the development and implementation of a nationwide dialing plan have been discussed in papers* by A. B. Clark, J. J. Pilliod, H. S. Osborne, W. H. Nunn, F. F. Shipley and others, it is necessary to restate some of these because of their effect on the translation problem and the features the card translator had to have in order to meet the nationwide dialing requirements. Translation is the process of converting the called destination code into information that is needed for the proper routing of the call.

* B.S.T.J., **31,** pp. 823–882, Sept., 1952.

NUMBERING PLAN

For nationwide dialing it is necessary that each customer have a distinctive universal number. This numbering system is accomplished by dividing the country and Canada into about ninety numbering areas. Each of these areas is assigned a distinctive three digit code which, in order not to conflict with local office three digit codes, has either the digit "1" or "0" as the second digit. Within these numbering areas each local office will have a distinctive non-conflicting, name and number code. Since each customer in an office has a distinctive number, a corresponding distinctive nationwide universal number is thus provided. To reach a customer outside the local numbering area will require the dialing of three digits for the area code, three digits for the office code and four or five digits for the line number. Thus by dialing ten or eleven digits a connection can be made to any customer anywhere within the country and Canada. Fig. 1 shows the present numbering area code assignments for the United States and Canada.

TOLL LINE SWITCHING NETWORK

A second requirement for nationwide dialing is the provision of about 70 strategically placed automatic switching toll offices called control switch points (CSP) throughout the United States and Canada. The switching system used at each of these 70 or so CSP offices have several new features as follows:

1. Six digit translation.
2. Ease in changing and adding routings.
3. Automatic alternate routing.
4. Code conversion.
5. Storing and sending forward digits as needed.

BASIC SWITCHING ARRANGEMENT

In the CSP offices the transmission paths are established through crossbar switches mounted on the incoming and outgoing link frames as shown in Fig. 2. The setting up of the connection through these switches and the linkages is controlled by equipment common to the office which is held in use only long enough to set up each connection.

The major items of common control equipment are the senders, decoders, markers and card translators.

The sender's function is to receive and register the digits of the called destination, to transmit the area and, if required, the office codes to the decoder, and then, as directed subsequently by the marker, to send digits ahead as may be required.

The decoder's function is to receive the code digits, either 3, 4, 5 or 6, from the sender and to submit them to the translator for translation and to make selections of alternate routes as required to route the call to the destination. The decoder also gives instructions to the sender and marker to enable them to carry out their functions.

The marker gets access to an outgoing trunk group through the trunk block connector and selects an idle outgoing trunk in this group, then chooses an idle linkage between the incoming and outgoing trunks, operates the crossbar switches to close the transmission path, and gives the sender information for pulsing ahead as may be required.

The operation of these common control circuits is briefly as follows. On the arrival of a call the incoming trunk is connected to a sender through the sender link frame. When the code has been registered the sender makes connection to the decoder through the decoder connector circuit. The decoder passes the code to the translator for translation. There is a translator associated with each decoder which contains the three-digit cards for the local offices and area codes, also perhaps some six-digit code cards. However, most of the six-digit cards (there may be several thousands of them) will be in a group of foreign area translators used in common by all decoders. The decoders obtain information from the area code card for selecting the particular one of these translators. Connection to them is made through an appropriate translator connector. The translator gives information for the selection ot an outgoing trunk and passes other information for routing the call both to the decoder as well as to the marker. The marker proceeds with trunk test and the operation of the switches to establish the connection. When the proper information has been given to the marker, then the decoder and translator release from that call. When the marker has given information to the sender for routing the call and has established the talking connection, the marker releases. The sender releases as soon as it has finished pulsing ahead. In this way these common control units handle many calls in rapid succession.

SIX DIGIT TRANSLATION

This feature is needed in nationwide dialing because from a particular CSP to points in another numbering area there may be several routes or trunk groups. To reach a point in such an area it is necessary that the office code as well as the area code be translated to select the route to

Fig. 1 — Nationwide toll dialing are

the United States and Canada.

the desired point in the area. To other areas there may be only one route and in this case the area code will suffice.

The provision of facilities for the translation of six digits greatly affected the design of the switching system for the nationwide dialing CSP offices. It led to the development of the basically new card translator. In previous toll common control systems translation is done by means of relays. The code digits, never more than three of them, resulted in the operation of groups of relays in certain combinations and led to the eventual operation of a route relay for the particular combination of code digits. This route relay with cross-connecting facilities from its contacts is used for the identification and selection of trunk groups and other information as might be required for the particular code routings. To change a routing with this system of translation required the removal and reconnection of many cross-connections.

With the nationwide dialing plan in operation, routing changes or opening of new offices in one part of the country will necessitate translator changes in many offices, some of them far removed from the scene of the event that forced them to be made. The changes in any one CSP may, therefore, be frequent under certain conditions, and to make them by running cross-connections would be cumbersome and expensive. The new translator uses punched cards instead of relays making it possible to effect changes by the simple process of removing old cards and insert-

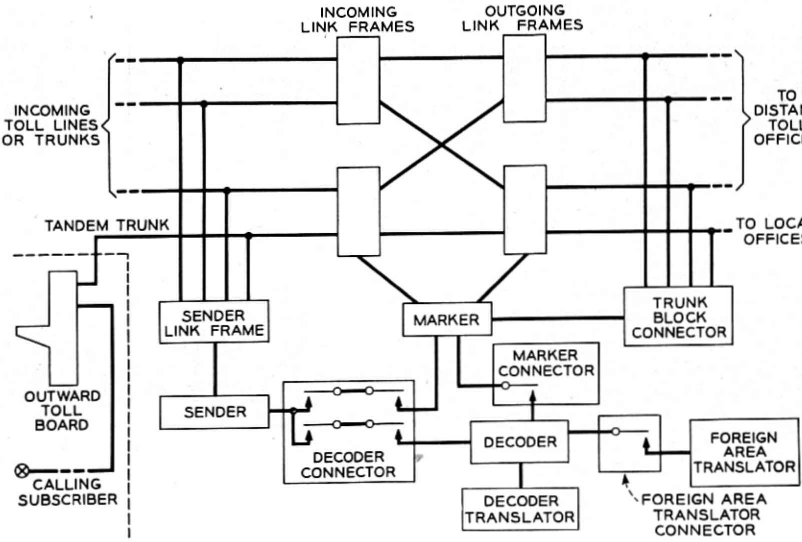


Fig. 2 — Schematic diagram of crossbar switching system for CSP's.

ing new ones in the machine. This can be done in a very short time and requires less out-of-service time for the equipment.

CARD FILE

A card is provided for each area code and also one for each office code that must be translated in a particular CSP, the cards representing destinations. The cards are lined up in a box as in a filing drawer with tabs along the bottom of the cards resting on select bars which run the length of the box. It is by operating the select bars in combinations, depending upon the code, that the particular card for the destination is selected. Each card, as shown in Fig. 3, has tabs, one for each select bar along the bottom edge. The information presented to the card translator for the selection of a card is in the form of code digits on a two-out-of-five basis. Each card is coded by removing all of the tabs except those that represent the particular combination of select bars for the particular code. When a code is presented to the translator, a combination of select bars corresponding to the code is lowered and the card having all tabs removed except those that were resting on the lowered selects bars will be selected while all other cards will remain in their normal positions.

The groups of tabs labeled, A, B, C, D, E and F (Fig. 4) are for the six code digits. For each digit, two tabs remain, since the digits are

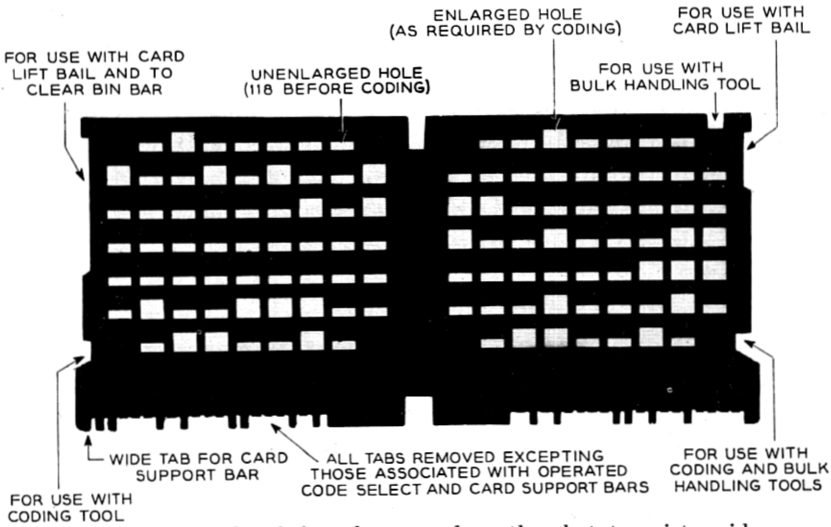


Fig. 3 — Typical coded card as seen from the phototransistor side.

registered in the sender on a two-out-of-five basis and the leads from the sender will cause the select bars to be operated. If the card represents an ordinary three digit code, all the tabs will be cut off except two each for the A, B, and C groups of tabs, and, for reasons that will be discussed later, two of the four CG tabs, card group, will also be removed. In addition, either the VO or NVO tab may be removed. The VO and NVO tabs are used when the group of toll lines over which the call will be routed is divided into one sub-group of a transmission grade suitable only for terminal traffic (NVO, meaning "not via only") and another subgroup for either terminal or switched-thru traffic (VO meaning "via only"). If the card represents a six-digit code, two tabs will be left in each of the six code digit positions and a different pair of card group tabs will be used.

The cards, then, are in different groups and are selected by combinations of code select bars together with the card group select bars. As noted there are four of these card group bars, CG0, CG1, CG2 and CG4. They are used in the six possible combinations, two at a time as follows: For the regular three-digit code cards CG1 and CG4, for the regular six-digit code cards CG2 and CG4; the other four combinations CG0 and CG1, CG0 and CG2, CG1 and CG2, and CG0 and CG4 are used for selecting the four groups of alternate route cards, which may be of the three-digit or six-digit variety.

CODE CAPACITY

The card translator by means of the code select bars and card tabs provides facilities for a great number of different codes and routings. There are 40 select bars provided, 36 of these are used in the combinations as has been described, two are reserved for possible future use and the remaining two are used for aligning the cards as will be discussed later. The total possible card code combinations is sufficient for growth in nation-wide dialing for the foreseeable future.

TRANSLATOR CARD CAPACITY

In some CSP offices there will be many thousands of cards for the destinations to be reached. It was not mechanically practicable to design a single translator capable of accommodating all these cards and moreover it would not have been economical, particularly for many of the smaller CSP offices. Also for service hazard reasons and to provide for the simultaneous translation of several calls, needed to handle traffic during heavy load periods, more than one translator is required in a

CSP. Considering these factors, it was found desirable to design the card translator to accommodate over a thousand cards.

TRANSLATORS

Since several translators are needed in a CSP, for further economy and consistent with service hazards, the translators are segregated according to the groups or kinds of cards they contain. These are as follows:

Decoder Translators

These translators contain the local three-digit office code, the three-digit area code, the alternate route code and, where space permits, some of the high usage six-digit foreign area code cards. Several of these translators are furnished, one for each decoder, depending upon the volume of traffic handled by the particular CSP.

Foreign Area Translators

These are furnished, one or two per office (maximum 19), for each 1000 or so foreign area code cards. These translators are in a common pool and the particular one is selected when needed for the six-digit code to be translated.

Decoder Foreign Translators

If there are sufficient high calling rate, six-digit, foreign area cards, to justify it, these translators may be provided, one per decoder.

Emergency Translator

Provisions are made so that the emergency translator can be substituted for any other translator by changing the cards of the translator in trouble to the emergency translator.

TRANSLATOR OUTPUT

The translator output information required for a CSP office for nationwide dialing must be very extensive to accommodate the many varieties of routes over which calls must be completed. The need for automatic alternate routing, code conversion and the storing and sending forward of digits also affects the need for increased translation output. The output is provided by means of the 118 holes in the face of each card.

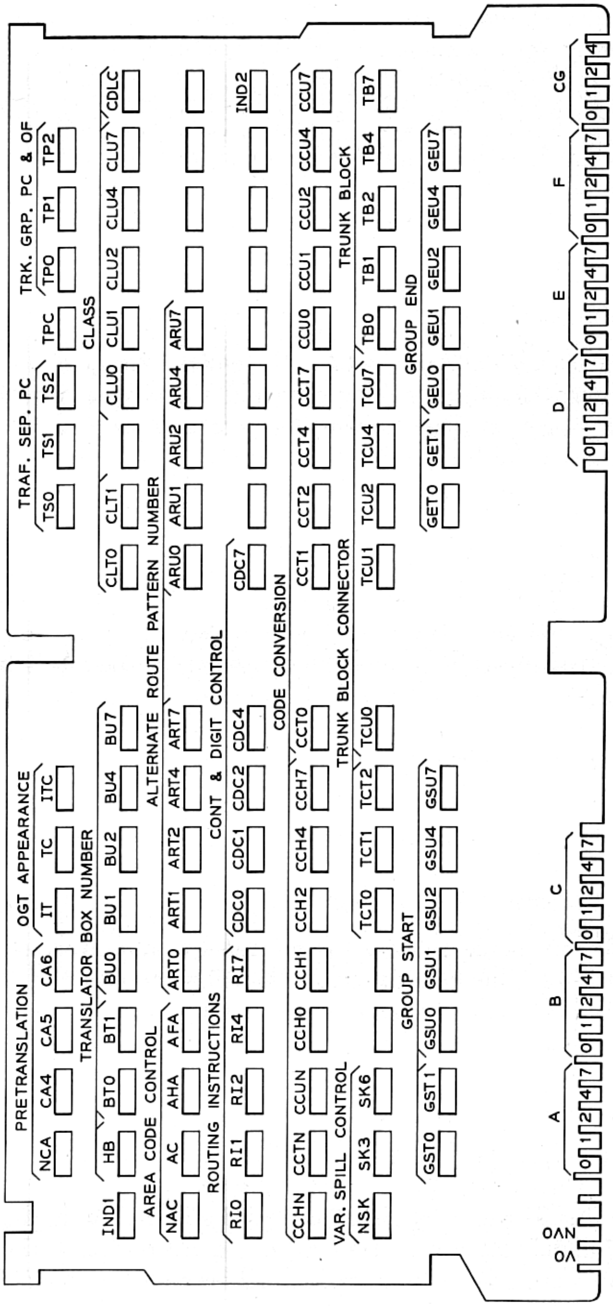


Fig. 4 — Card layout as seen from the exciter lamp side.

By enlarging these holes in combinations the output information for the particular route is obtained.

As seen in Fig. 4 the top holes beginning at the left of the card are used for "pretranslation" purposes. The senders are not provided with facilities which enable them to predetermine when to present for translation the first three digits received or when to wait for more than this number as when six-digit translation is required. Therefore the sender always requests translation when the first three digits are received. So for six-digit calls, the sender must be informed to disconnect from the translator after three digits have been received and wait for six digits. The CA6, (come again six) hole in the card is used for this purpose. The CA4 and CA5 holes are used similarly for calls to certain four- or five-digit operator codes, informing the sender to apply again for translation with four or five digits. The NCA (No Come Again) hole is used for three-digit calls.

The "OGT" holes are used to inform the common control equipment on which train of switches the outgoing trunk appears to enable the associated circuits to select the proper switching train. The remaining holes on the top line are for controlling operation of traffic meters.

On the second line, the TRANSLATOR BOX NUMBER holes are used on area code cards to indicate which translator contains the particular cards for the called area when six-digit translation is required. The INDI hole on the second line and the IND2 hole on the fourth line which commonly are referred to as index holes are never enlarged. They serve as an indication that a card has dropped and that all is ready for translation output detection. These index holes also aid in trouble detection in case of light failure, for routing of certain calls where cards are deliberately omitted and for calls where a blank code was dialed in error.

The CLASS holes are used for indicating the type of outpulsing and the kind of signalling channels used on trunk groups out of the office.

The AREA CODE CONTROL holes on the third line are used for determining the number of digits to be transmitted forward to the next office and for supplying undialed code digits needed primarily in connection with automatic alternate routing. The ALTERNATE ROUTE PATTERN NUMBER holes are used for the selection of the series of alternate routes to be used.

The holes on the fourth line are for making proper disposition of calls when all trunks are busy and to inform the associated circuits how many digits should be received for the particular code.

The CODE CONVERSION holes on the fifth line are used to supply the sender with information as to the outpulsing of certain arbitrary digits as may be required through step-by-step toll trains. Facilities are provided for the outpulsing of one, two or three digits as may be required.

The VARIABLE SPILL CONTROL holes on the sixth line inform the sender when to pulse forward all digits as received, or to omit sending the first three or six code digits.

The remaining holes on the card define the location on the switching frames having the desired outgoing trunk appearances. The notches around the outer edges of the card are for proper positioning of the card in the stack and for card removal purposes as will be discussed later.

CARD OUTPUT DETECTION

The enlargement of the holes in the face of the card to obtain the translation output as previously stated is recognized by means of modulated light beams falling on phototransistor detectors. With all of the

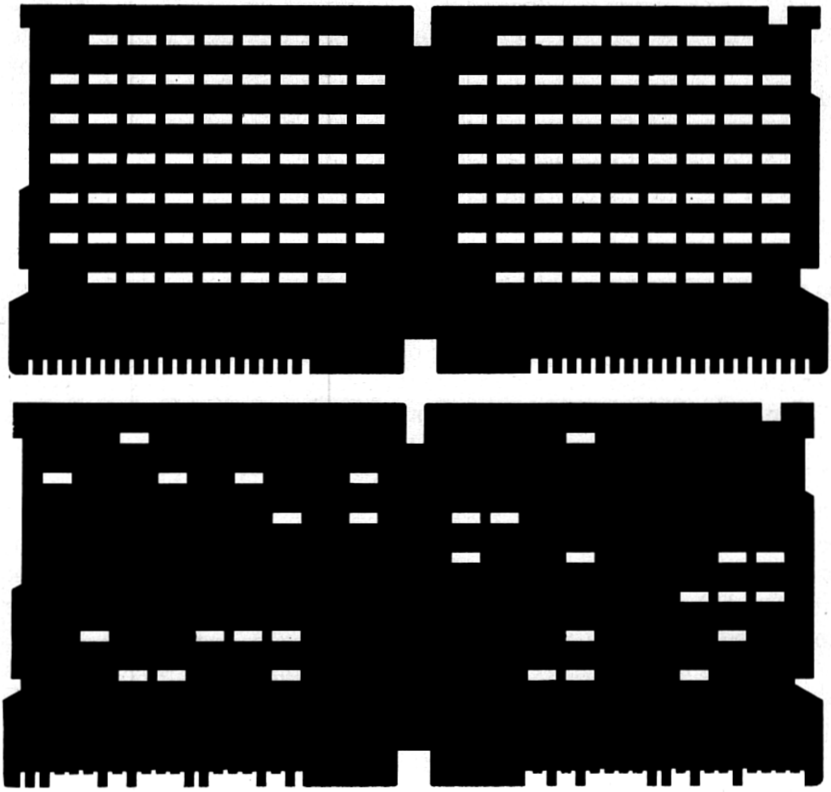


Fig. 5 — Normal (above) and dropped card views as seen from the phototransistor side.

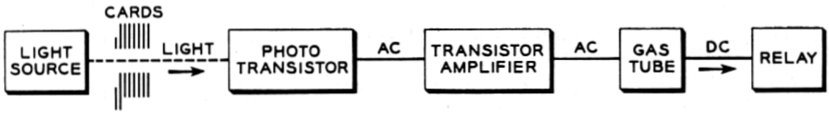


Fig. 6 — Block diagram of channel circuit.

cards in their normal positions they are aligned and the holes in the cards form unobstructed, horizontal tunnels called channels through the entire stack. When a particular card has been selected and dropped a distance slightly greater than the height of an unenlarged hole, these light beams through all of the channels are blocked by the dropped card except for those holes which have been enlarged. This results in a pattern of clear channels which represents the translator output information.

The change in the silhouette of the stack from the condition of all cards normal to that of one card dropped is shown in Fig. 5.

THE CHANNEL CIRCUIT

Fig. 6 is a block diagram of the circuit used to determine whether a particular channel is interrupted by a dropped card or not. Each block, with the exception of the light source, represents a piece of equipment provided individually for each channel. The light source is common to all channels. If the hole in the dropped card for a particular channel has been enlarged, the light will pass completely through the stack of cards and fall on the phototransistor. The phototransistor converts the light into an electrical signal which, after being increased by the transistor amplifier, is used to trigger a cold cathode gas tube. The gas tube in turn operates the channel relay. This relay is located in the associated equipment which uses the information supplied by the translator to process the call.

In making a detailed examination of the channel circuit, it is convenient to consider it in two parts: the optical section and the electrical. The optical section includes everything up to the point where the light falls upon the germanium of the phototransistor. This part of the channel is shown functionally as Fig. 7. The light source is a standard projection type lamp normally rated at 500 watts. To obtain long life it is operated in the translator at about half of its rated voltage at which level its input is approximately 170 watts. This type of lamp was chosen because of its high concentration of light in a small plane area.

The light from the lamp passes through a motor driven perforated disc which modulates it with an approximate square wave at a 400-cycle rate. Modulated light is used because it is more economical to use ac

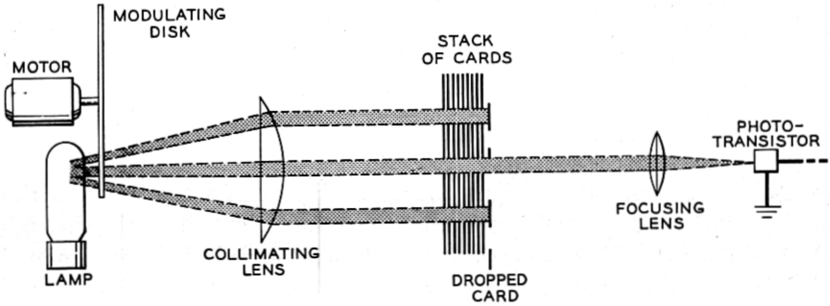


Fig. 7 — Optical section of channel circuit.

than dc amplifiers and also since the difference between the light and dark currents of the phototransistor is the important factor rather than the absolute value of either. The modulated light is collimated by a lens to minimize the loss as the beam passes through the holes in the card. Unless interrupted by a dropped card, this light beam will bass through all of the cards and fall on the lens which focuses the light on the sensitive area of the phototransistor. The light intensity at the lens of the phototransistor is 34-foot candles minimum. This is equivalent to about 12 millilumens at the phototransistor, a figure relatively small when compared to the light intensity that is required by conventional photoelectric cells.

The electrical part of the channel circuits starts with the phototransistor and is shown in Fig. 8. The light acts as the emitter of the phototransistor. The collector is of the conventional type for point contact transistors. As is normal in grounded base transistor circuits, the collector of the phototransistor is biased in the high impedance direction. A variation in the light intensity causes a variation in the collector impedance of the phototransistor. The type used has an impedance of about 10,000 ohms when dark which is reduced to approximately 3,000 ohms when illuminated. The output of an illuminated phototransistor when coupled to the amplifier ranges from 1.3 to 12 volts positive peak at 400 cycles depending upon the age and condition of the transistor.

Since the discrimination by the channel circuit between a clear or blocked light path depends upon the presence or absence of an ac output from the phototransistor, noise of sufficient magnitude, if present when the channel is dark, would cause a false indication. To guard against such false indications each phototransistor is checked during manufacture for dark noise. During a five minute interval the dark voltage must not exceed 75 millivolts.

The phototransistor is coupled to the amplifying transistor by transformer T1. This permits convenient matching of impedances and separation of the dc bias voltage. A voltage limiting varistor, V, is connected across the input of the transformer to limit surges which might otherwise damage the amplifying transistor. The circuit of the transistor amplifier is a conventional arrangement.

Voltage gain of the amplifier, including the input transformer to the gas tube, varies from 40 to 100. However, when operating in the translator, the phototransistors normally will drive the amplifier to saturation

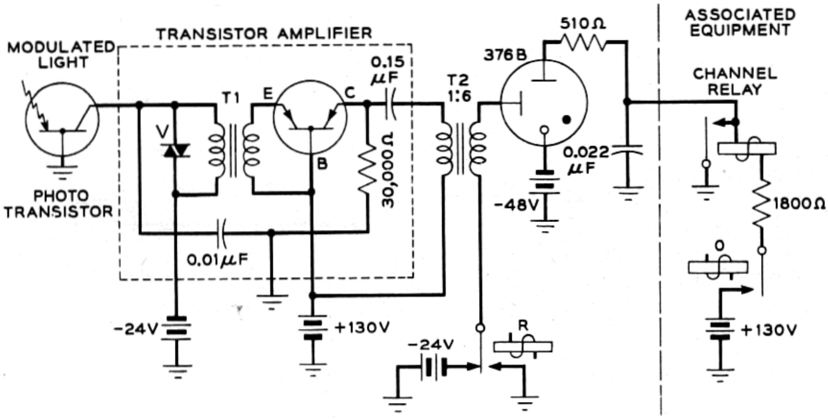


Fig. 8 — Electrical section of channel circuit.

which limits the output to 160 volts positive peak. For the purpose of guaranteeing operation, a minimum output voltage of 38.5 has been set as a rejection point for a phototransistor-amplifier combination.

The output of the transistor amplifier is normally sufficient to break down the control gap of the cold cathode gas tube. Sufficient current flows in this control gap to insure reliable transfer to the main gap when the output control relay O in the associated equipment operates. To aid deionization of the gas tubes, the bias of −24 volts is removed from the control anode just before channel operation is required. The relay R, which replaces the bias voltage with ground, is operated by a circuit which checks that the card being dropped is completely down. This "down" check circuit utilizes the two index holes in the card which are never enlarged and employs two phototransistors to detect the presence or absence of light through these holes.

Fig. 9 shows the card down check circuit. It differs from the routing information channel circuits in that the operation of a relay is required when the light is blocked. Therefore the transistor amplifier-gas tube circuit is not applicable. For the down check channels, the output of the phototransistors is amplified by the first section of a conventional double triode therminonic emission tube V1. The ac signal at the plate of V1 is rectified by a conventional full wave rectifier consisting of transformer T3 and tube V2. The rectifier voltage is negative with respect to ground and when it is impressed on the grid of the second section of tube V1, that section is driven beyond cutoff. Therefore, as long as light falls on the phototransistor, no current flows through the relay. When the

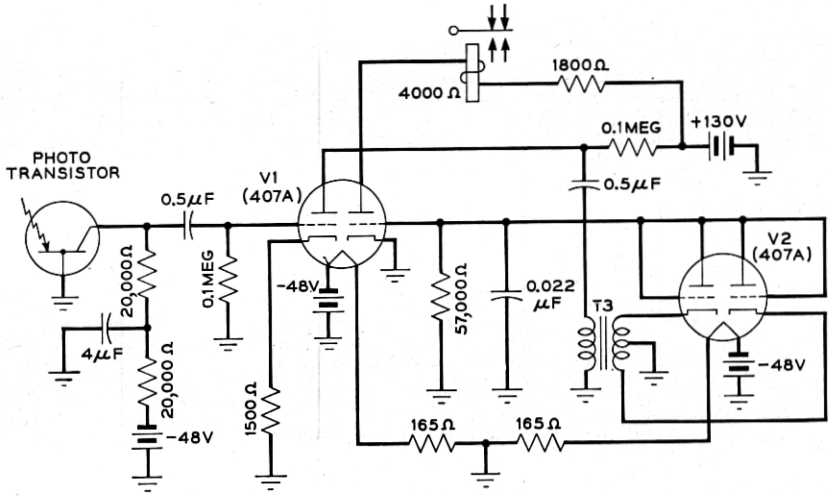


Fig. 9 — Card down check circuit.

dropped card blocks the light, the negative voltage on the grid disappears and the tube conducts, thus operating the associated relay. While the prime purpose of this down check is to signal the associated equipment that the card is in position for recording its output code, advantage is taken of this circuit's ability to distinguish between a light and dark phototransistor at any time to provide alarms in the event of a lamp or modulating disc failure.

After the card has been checked down and the associated equipment is ready to accept the output of the card, that equipment connects a positive 130-volt battery through its channel relays to the main anodes of the gas tubes. All gas tubes associated with illuminated channels will have their control gaps fired and will transfer to the main gaps. This operates the corresponding channel relays in the associated equipment. The relays in operating lock to ground and thereby extinguish the main gap discharges thus increasing the life of the gas tubes. Those channels which have been blanked out will not have the control gaps of the gas tubes broken down. Therefore when the 130 volts is applied, the relays associated with the darkened channels will not operate. The operation or non-operation of the relays in the associated equipment completes the function of the channel circuits.

The capacitor and resistor network at the main anode of the tube is to prevent transients due to the operation of other channels from falsely firing the main gap of a dark channel.

CHANNEL PACKAGES

The phototransistor is mounted in a metal tube along with a lens that focuses the colliminated light on the transistor. Fig. 10 is a cutaway

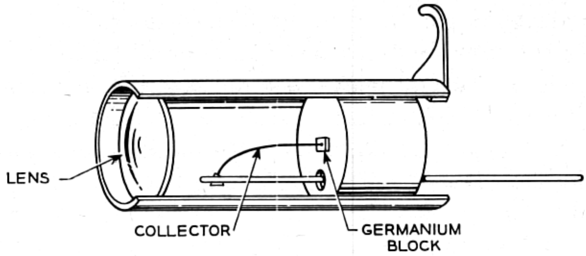


Fig. 10 — Cut away view of phototransistor.

view of the 3A phototransistor showing the relationship of the lens to the transistor. To mount in the translator, the tube is slipped into an accurately positioned hole and clamped in place using the slotted ear. This mechanical fastening is also the ground connection. The output lead from the collector is attached using a slip-on connector.

The amplifying transistor, transformer T1, varistor V, the resistor and two capacitors of the amplifier are packaged in a convenient "plug-in" unit. Fig. 11 is a photograph of these amplifiers. As shown, the transistor is mounted under a removable cap on the package so that it may be conveniently replaced if necessary.

The gas tube, transformer T2, and the associated resistor and capacitor are also assembled as a packaged unit.

TRANSLATOR CIRCUITRY

The card translator is mounted on an associated translator table as shown in Fig. 12. The translator table contains the transistor amplifiers and the cold cathode tubes one for each of the channel circuits as previously discussed, and, in addition, the miscellaneous relays through which the operation of the translator is controlled. As already stated, the connection between a translator and the associated decoder is through suitable connector relays which are either a part of the decoder or on a separate connector frame.

The phototransistors may be adversely affected by temperatures greater than 130°F. Therefore, to provide satisfactory operation during sustained heavy traffic load periods and with high ambient room temperatures, an air circulating and filtering unit, as shown in Fig. 13, may be provided. This unit mounts on the translator in place of the regular end cover and otherwise requires no further apparatus change. For convenience in ordering, the "1B" translator is specified when the air cooling unit is desired. Otherwise the "1A" translator will be furnished.

The translator table contains relays for controlling the dropping, checking, and restoring of the cards in the translator. First are the relays that operate the card "pull-up" and "pull-down" magnets. Then there are select code bar control relays, one for each bar, operated from the sender or decoder, which in turn operate the associated select code bar solenoids. These relays are necessary since the lead resistance from the sender to the translator would adversely affect the operating time of the code bar solenoids. Finally, there are relays that check the code bars for proper operation on a "two-out-of-five" basis. Two, and only two code

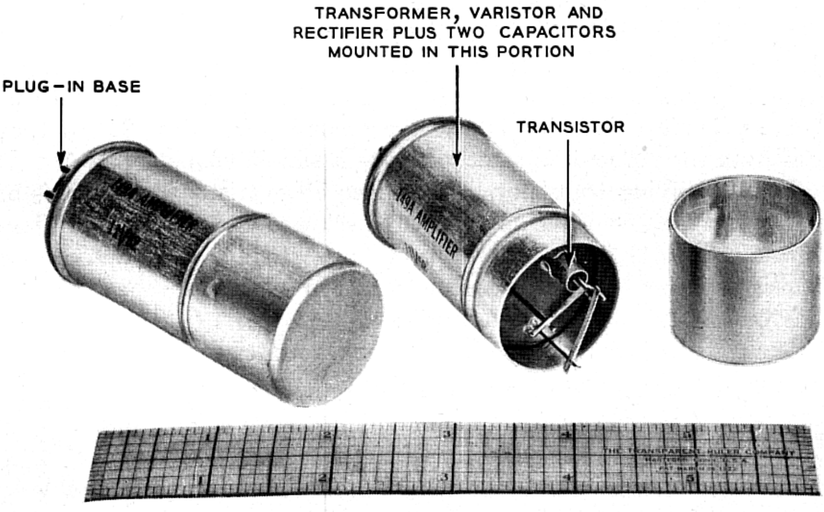


Fig. 11 Transistor amplifier.

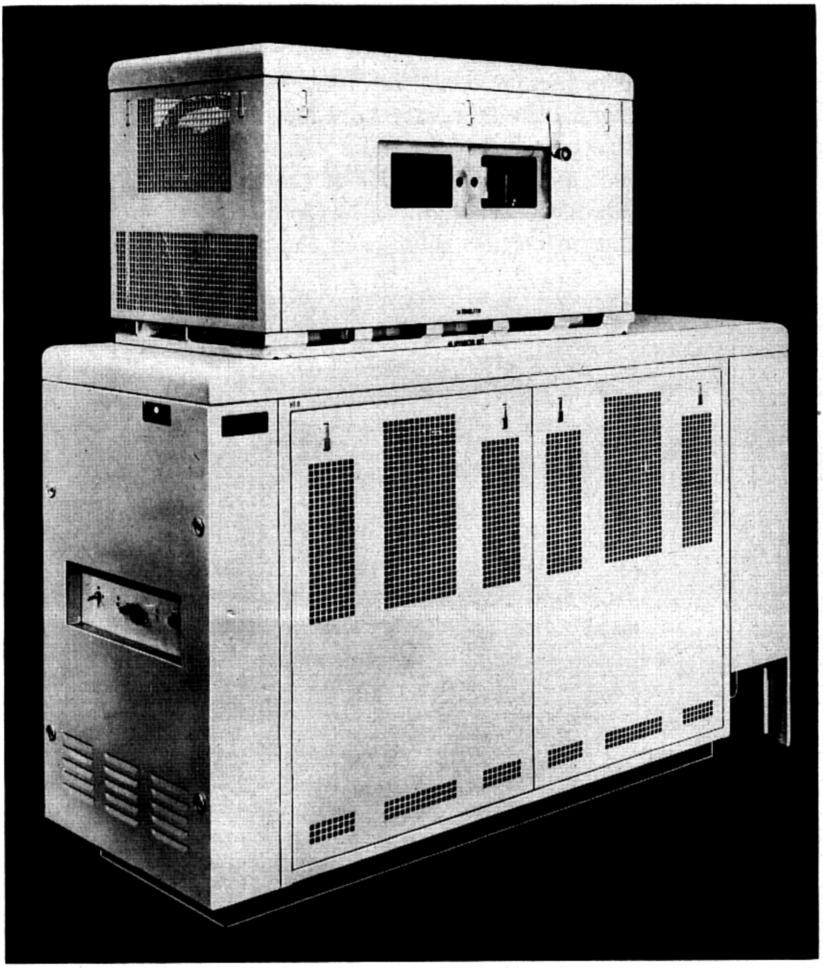


Fig. 12 — Card translator and table.

bars for each digit must be operated, before an attempt is made to drop a card.

The operating cycle of the relays and the translator in selecting a card and restoring it is then as follows:

When the translator is first seized the pull-up magnets are energized and when the cards are suspended the latches are operated. The decoder then closes the leads over which the code bar relays operate and they in turn operate the code bar solenoids. When the proper number of these are operated a check for this is made which releases the latch.

With the latch restored to normal the pull-up magnet is de-energized. All the cards then drop until they meet the code bars, about 0.016″. The card for the particular code, however, continues 0.180″ further, because the bars for all the tabs have been lowered until it rests on the pull-down magnetic pole face. The index channel relays then operate causing the decoder to read the output of the card.

When the decoder has checked that it has received proper information from the card, and on certain calls when the marker has selected an

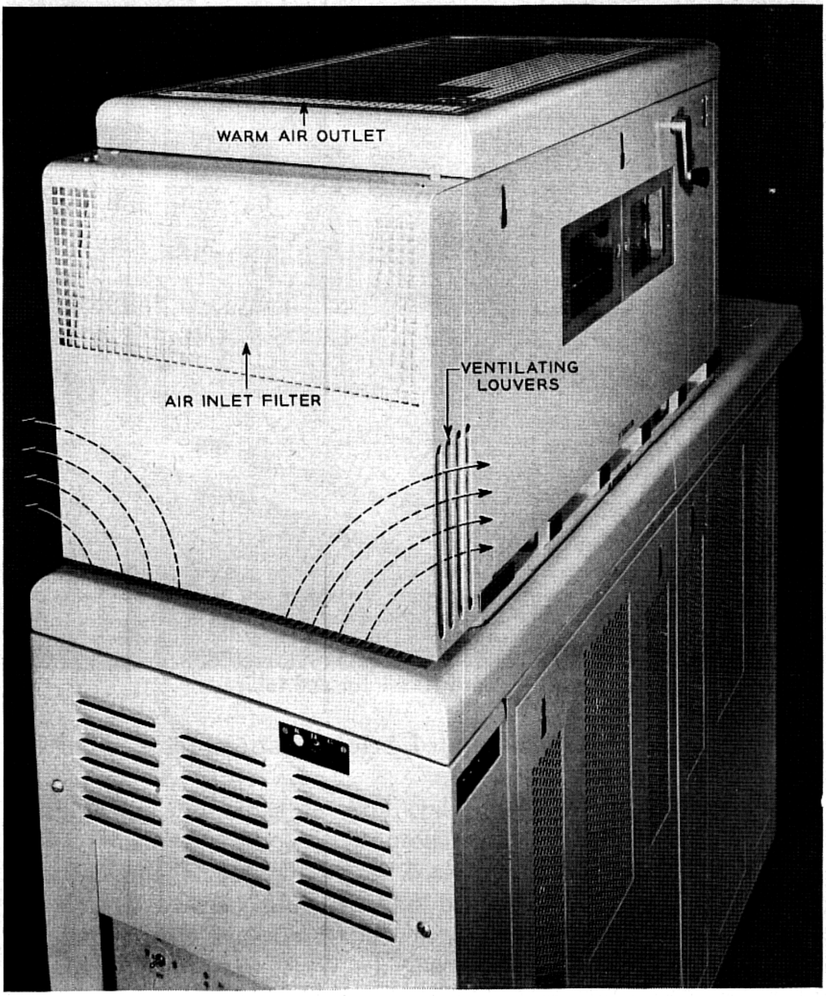


Fig. 13 — Card translator equipped with cooling unit.

outgoing trunk, the decoder releases the translator. Just prior to this, the decoder operates an automatic restoral relay in the translator, which causes the card to be restored to its normal position in the stack. This takes place by again energizing the pull-up magnet, and, when the cards are again suspended, the latches are operated and the code bars are released, restoring to their normal positions. The card that was down is restored by the code bars to its position in the stack. All the relays in the translator table then release except for a slow releasing relay which remains operated holding the pull-up and latch magnets energized so that a subsequent call does not have to wait for these magnets to operate and suspend the cards. This feature saves time under heavy traffic.

TRANSLATION TIME

The call carrying capacity of a translator and the number of translators for a particular CSP is directly related to the time required for translation, that is, the selection, reading and restoral of the translator cards. For this reason, particular attention to translation time was used in the design, not only of the translator, but throughout all the associated circuits of the switching system.

Since the translators in service are always controlled by the decoder circuits and since the number of decoder translators and decoder foreign area (DFA) translators are directly proportional to the number of decoders, the times for the various types of translation and alternate routing will be given in terms of the holding time of the decoder.

PRETRANSLATION

This requires approximately 235 milliseconds. On this type of call translation of three digits, when either four, five or six digits are needed for the routing, informs the sender to release the decoder and wait for the rest of the code.

THREE DIGIT TRANSLATION

The time for this type of call is approximately 330 milliseconds. This is when three digits are sufficient for a routing.

SIX DIGIT TRANSLATION

The time for this is approximately 550 milliseconds, assuming that the six-digit card is in the decoder translator. This does not include the pretranslation time. Pretranslation does not occur if the office code as well as the area code is registered in the sender before the decoder is connected. This often occurs during periods of heavy traffic. On six-digit translation, two cards must be translated, the three-digit area code followed by the six-digit destination code card.

SIX DIGIT TRANSLATION IN FOREIGN AREA TRANSLATOR (FAT)

This type of call requires approximately 560 milliseconds. The area code card in the decoder translator gives the information for selecting the particular FAT in which the six-digit card is located. The translation time will be extended if there is a delay, due to another decoder using the FAT. Pretranslation time, as stated above is not included.

SIX-DIGIT TRANSLATION-PRINCIPAL CITY AND VACANT CODE ROUTING (FAT)

In this case translation requires approximately 615 milliseconds. This is for routings to areas where there is a principal city (PC), usually another CSP, through which all calls to that area can be completed, although in the area there are other destinations reached over direct high usage trunks. In this case, to save cards and perhaps translators, the six-digit cards for all destinations reached directly through the PC are deliberately omitted. The time given is for a call to such a destination. The three-digit card for the area has on it information for the proper routing of the call to the principal city. For those destinations where the six-digit cards are omitted, as well as for vacant codes in such areas, the call is routed to the principal city. Pretranslation and foreign area translator delay times, if any, are not included.

THREE-DIGIT CARD-TO-CARD TRANSLATION

This type of card-to-card operation is used where there are several sub-groups of trunks or routes to the destination and the decoders do not have facilities for determining which group of trunsk has an idle trunk. The routing information for each trunk group must be presented successively to the marker in selecting an idle trunk.

The translation time, considering that an idle trunk is selected from information on the first card, is approximately 330 milliseconds, assuming no marker delays. When the trunks for the first card are found busy and routing is made from the second card, the total time is about 550 milliseconds. This increases to about 770 milliseconds for routings from the third card and finally to 1060 milliseconds for the fourth card routing.

SIX-DIGIT CARD-TO-RELAY TRANSLATION

This type of operation is used where the first group of trunks to the destination is of the type that requires test by the marker for selecting an idle trunk. There are alternate routes, however, in which the decoder can determine which group has an idle trunk. In this case the area code card provides information for the selection of the first six-digit card. This card has information for routing the call over the first group of trunks. There are alternate route cards for each subgroup of alternate routes. There may be as many as five alternate routes, each of which may have as many as four sub-groups of 40 trunks each.

The translation time, assuming the routing is from the first card, is about 550 milliseconds. For routings from any one of the alternate route cards, the time increases to approximately 800 milliseconds. Pretranslation and FAT delay time, if any, are not included.

THREE-DIGIT CARD-TO-RELAY TRANSLATION

The time required is about 350 milliseconds for routings from the first card and about 580 milliseconds for routing from an alternate route card.

SIX-DIGIT RELAY-TO-RELAY TRANSLATION

This type of operation is used where all of the trunks including the alternate routes are tested by the decoder in determining in which group there is an idle trunk.

The translation time, assuming the routing is from the first six-digit card, is approximately 575 milliseconds. For routings to succeeding alternate routes the time is approximately 800 milliseconds.

MAINTENANCE FACILITIES

Although the card translator and all of its components are designed for relatively long and trouble-free life, adequate testing facilities and maintenance procedures are essential because of the importance of the individual CSP's in nationwide dialing. Adequate guards and methods of procedure have been made available in case of almost any catastrophe that would incapacitate any CSP office. Moreover the complete breakdown of a translator or even several of them in a CSP office would not completely stop calls through that office although the call carrying

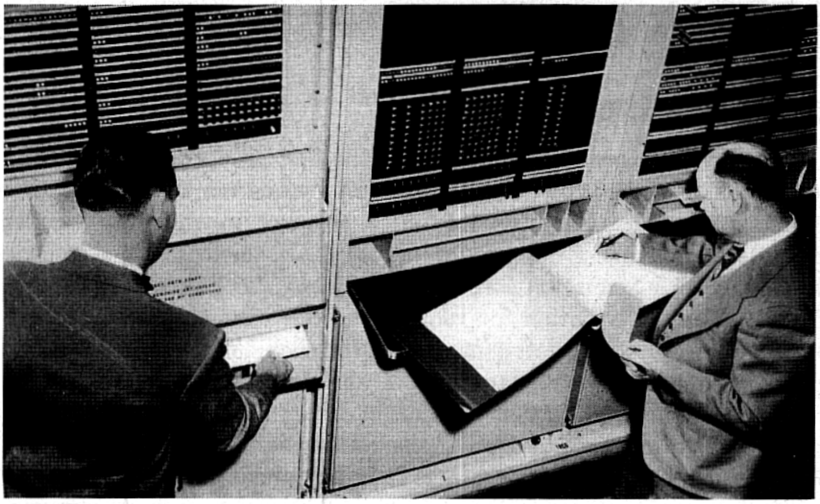


Fig. 14 — A trouble record card is being removed from the perforator and information from a punched card is being entered in the office records.

capacity of the CSP office or the switching system would be reduced. However, to insure satisfactory operation of the card translators automatic trouble recording, test circuits and maintenance methods are provided.

TROUBLE RECORDER

In CSP offices, where the card translators are used, the card punching type of trouble recorder will be provided as shown in Fig. 14. In the event of a failure of any translator, the associated decoder circuit will block and time out. This causes the connection of a multiplicity of leads between the trouble recorder and the decoder as well as to the translator. The trouble recorder will then automatically punch and drop a properly designated paper card (Fig. 15) that shows which translator and decoder are in trouble. The state of the various elements of the translator and decoder will also be recorded. In addition, a record is made showing which code bars, pull up and pull down magnets, latches and important relays are operated. Also the important key relays which are operated in the decoder will be shown. The associated sender will be identified as will also the marker if one is connected. Then too, the state of the marker will be recorded. From this trouble record the cause of the failure can, in most cases, be determined.

When the trouble recorder card has been punched, the associated equipment is directed to make another trial. This usually will be with an alternate decoder and translator so that the call is usually completed with a delay of a little more than one second required for punching the trouble recorder card. The trouble recorder, once it has completed punching a card, is immediately available for recording another failure. The trouble recorder is also available for recording failures of other CSP equipment such as the controllers, senders and markers in a manner similar to that described for the decoder and translators.

TRANSLATOR TEST

There are facilities provided on the trouble recorder frame, through keys and connecting relays, for adding and removing cards from the translators. On adding a card, a check can be made to verify the card output to make sure that it is in agreement with the template from which the card was coded. Test calls using all decoders and markers can be made to verify the selection of a trunk in accordance with the routing information on the new card as well as on any card in any translator. These tests can be caused to recycle automatically and to drop a trouble recorder card in case of failure. This feature is useful in isolating infrequent failures in any of the associated translators, decoder or markers. Facilities are also provided for removing the translator selector unit for periodic inspection and adjustment as may be necessary. Also timing tests can be made from the trouble recorder frame to check the time required for the translator to drop and restore a card.

To determine if any of the output channel elements of the translator, which includes the photo-transistors, transistor amplifiers and cold cathode tubes, for all the channels, have satisfactory operating margin, means are provided for making a mass test of the channels. This test is made under a controlled voltage (36.5 volts) which is considerably below the worst service condition. In case of a failure of an element under this test, a trouble record card will be dropped which will show, by a punched hole, each element that is operating satisfactorily. This mass test is provided to detect any channel element that is approaching end of life and thereby assures that there is at all times ample operating margins of these important channel elements.

Portable Test Set

In addition to the test facilities provided on the trouble recorder frame, there is also a portable test set for the translators as shown in Fig. 16. This test set is connected to the translators by means of multicontact

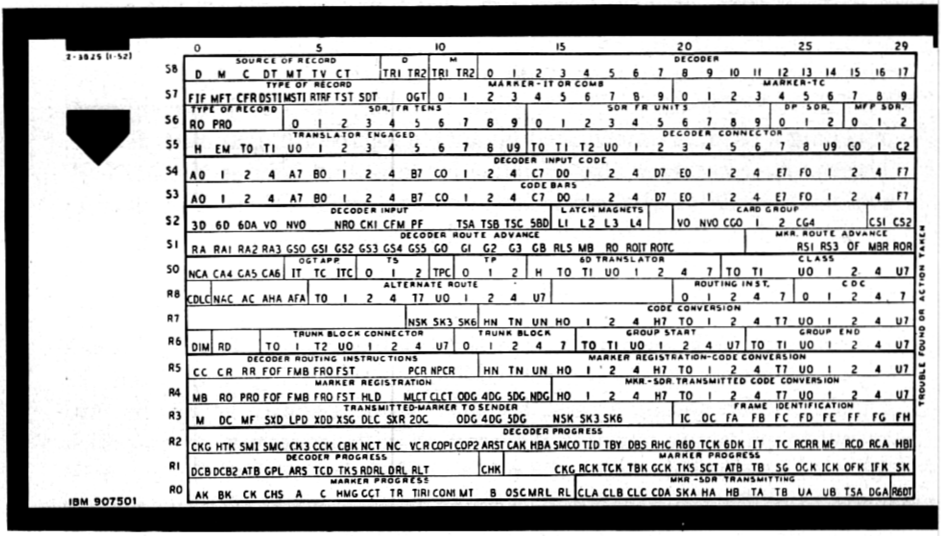


Fig. 15 — Trouble recorder card showing the multiplic

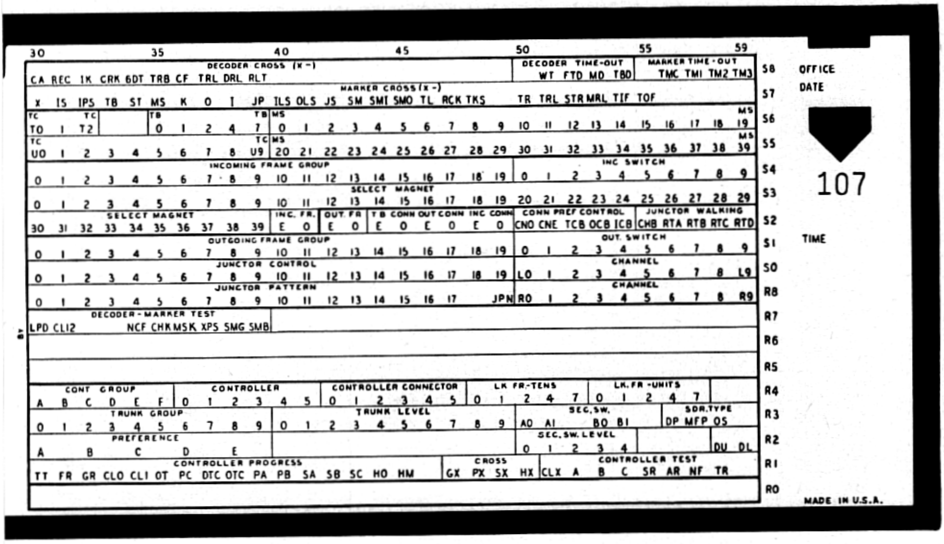
plugs, cords and jacks. This set can be used for adding and removing cards and verifying that the new card will drop. Bins are provided for storing cards in the process of adding, removing, and transferring cards. Timing tests can be made not only of the over-all time of the translator, as from the trouble recorder frame, but also of the individual component parts of the translator. The test set can also be used for removing the translator selector unit and for bench testing this selector. In this connection, a re-cycling test can be made of the code bars, card support bars and latches to check that they operate smoothly and evenly. Current flow adjustments can be made of the code bar solenoids, latches, and pull up and pull down magnets.

DESIGN OBJECTIVES

When, in the course of the development, the controlling requirements that had to be met became apparent, the design objectives were considered. The reasoning applied is set forth in retrospect in the following paragraphs.

It will be apparent from the foregoing that administrative problems would be involved should it be necessary to arrange and maintain the individual cards in any particular order in the card stack and, therefore, indiscriminate loading became a design objective.

Since the cards will be changed from day-to-day and sometimes on



tems that may be recorded by punched holes.

short notice, the provision of cards capable of being readily coded in the field became another objective.

It was estimated that from five to ten per cent of the cards used in nationwide dialing would have to be replaced annually because of routing changes, that on the average a card would be selected for routing purposes about one million times before its replacement due to routing changes would be necessary and that the average routing change interval would be from five to ten years. It was recognized that in the course of this period, cards might have to be loaded and unloaded several times. These facts established ruggedness consistent with high-speed operation as still another objective.

Ruggedness indicated the use of metallic cards. The comparatively large number of input tabs and output holes required made for substantial size. These considerations together with the comparatively large number of cards that are to be stacked together made it obvious that considerable weight would have to be contended with. Yet it was known that highspeed operation is mandatory. These conditions suggested that the cards be made from magnetic material so that their manipulation might be assisted by suitably applied magnetic forces such as may be developed by the pull-up and pull-down magnets that already have been referred to and illustrated. Thus provision for the use of cards made from magnetic material became an added objective.

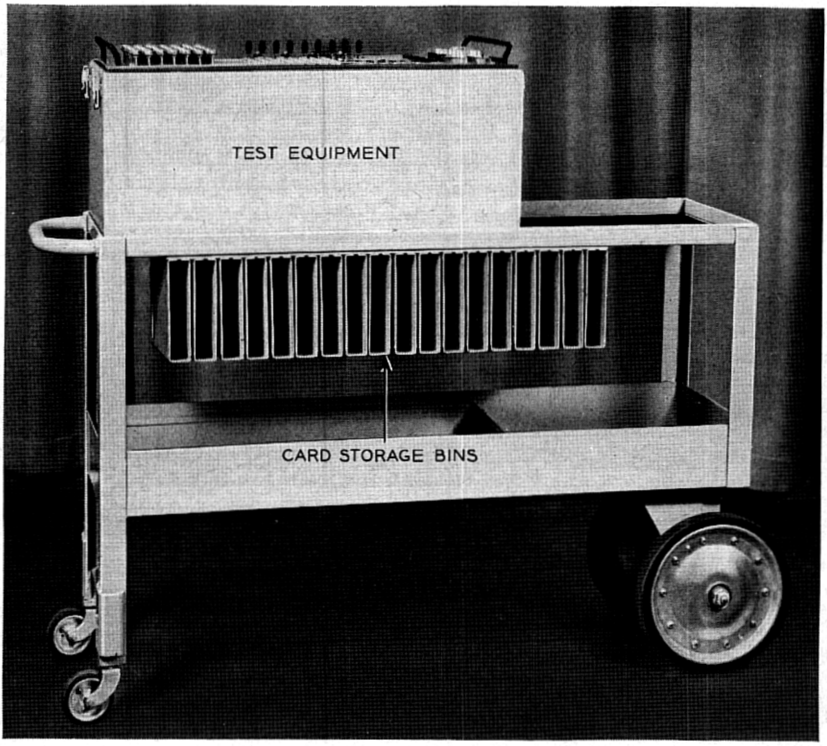


Fig. 16 — Portable test set.

It was estimated that a card translator, on the average, would be called upon to function from twenty to thirty million times a year. Accordingly, provision for direct-acting, high-speed, long-life and readily replaceable components became another objective.

A further objective was the provision of means for reading the routing information without mechanically contacting the cards, as for instance by utilizing photo-detection circuirts, such as have been referred to, as it was reasoned that in this way reliability over an extended period could best be assured.

ELECTRO-MECHANICAL DESIGN

Phototransistors are utilized as the photo-sensitive elements, the light source is a standard projection lamp, the light beams are modulated and then directed through the card formed tunnels by dual collimating lenses and then upon emission from the card stack are focused on the phototransistors. (See Figs. 17 and 18.) To a large extent the card, which is

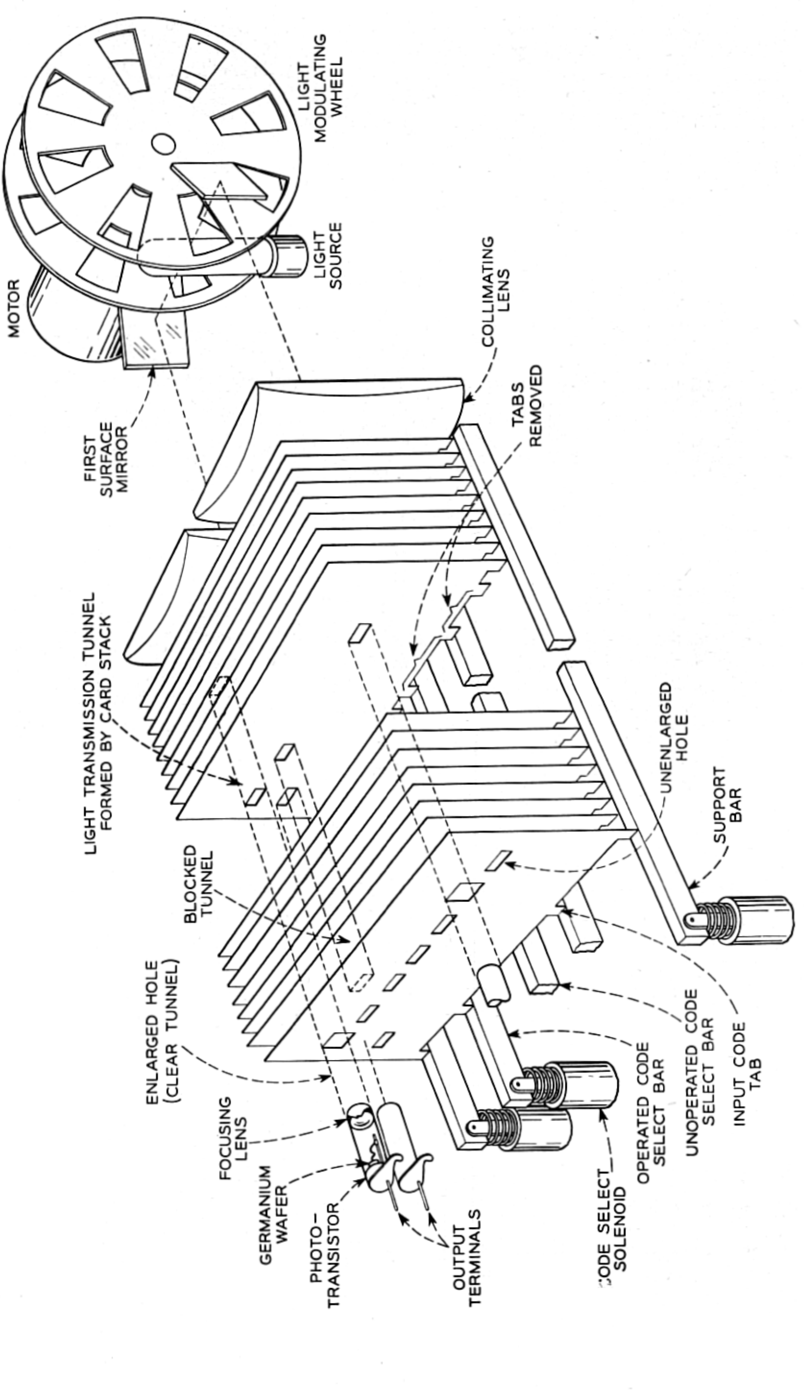


Fig. 17 — Functional mechanical schematic.

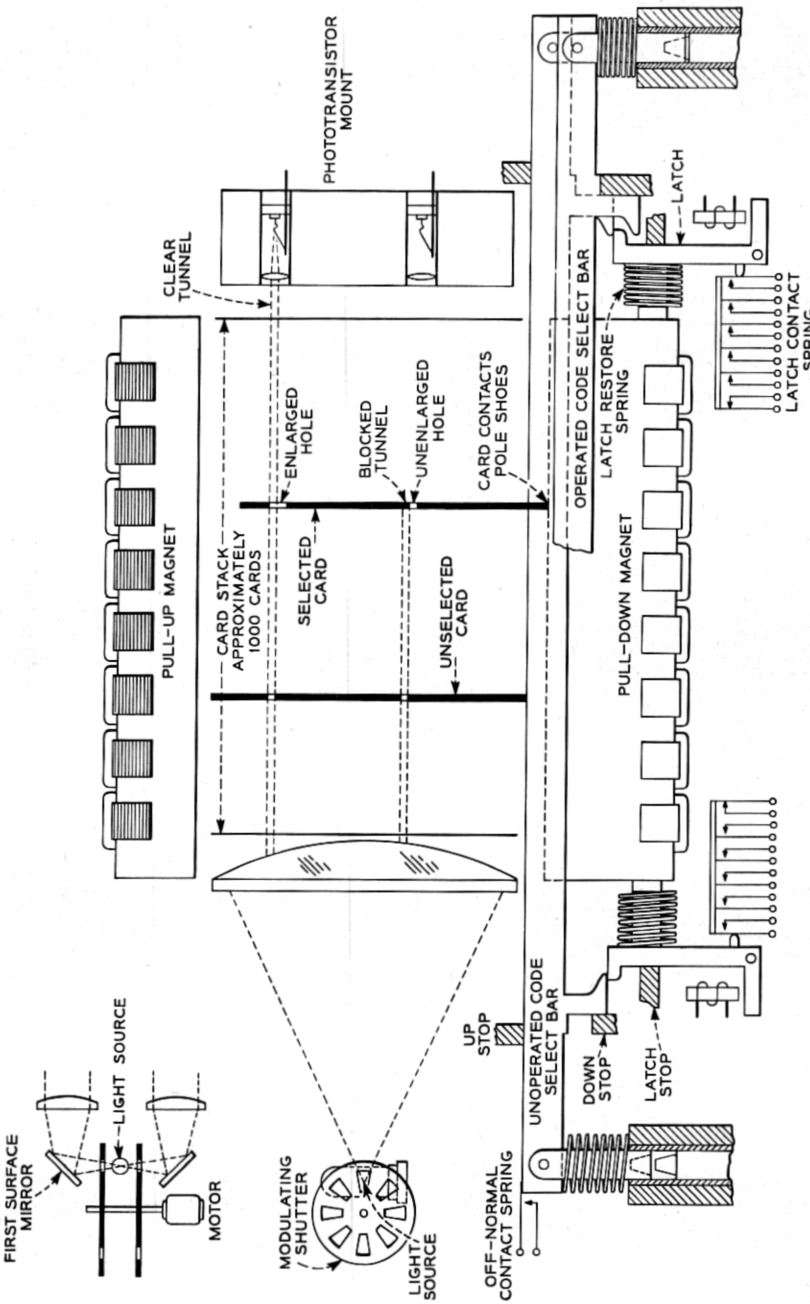


Fig. 18 — Simplified mechanical schematic.

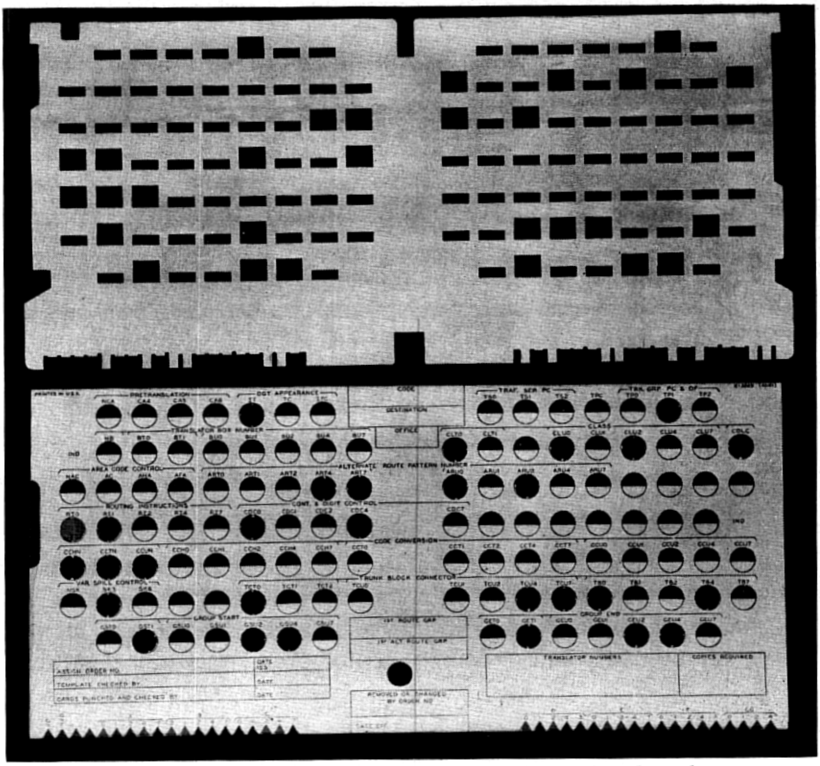


Fig. 19 — Coded template (below) and associated card.

manufactured as the 200A blank, was controlling and, therefore, it will be duscussed in some detail.

CARD (200A BLANK)

The general form of the card is illustrated by Fig. 4. The working card, however, is unmarked as may be observed by reference to Fig. 3. Marking is not required because the cards are coded in accordance with information furnished on a paper template, such as is shown in Fig. 19 and this template is retained as part of the office records for ready reference. A card may readily be identified for reassociation with its template by reading its tab code. The template provides considerable administrative data. The dark half of the holes and the triangular representation of the tabs are printed in red as is a strip along a portion of the left-hand edge. After coding, the card is placed over the template. If the red edge portion is visible the card must be turned end-for-end. If, after having done so, any red can be seen, more holes have been enlarged and/or more tabs have been removed than the template calls for. If, on the other hand, openings in the template are visible through holes in the card that have not been enlarged, the hole coding is not complete. If tab notches appear in the template other than in registration with the portion of the card from which tabs have been removed, the tab coding is not complete. Accordingly, the template also serves as a convenient means for checking the coded card for accuracy. As a convenience, the holes of the template were made round and its tabs triangular.

The holes of the card before being enlarged are of a form and size that simulates the filament face area of the light source. To accommodate the 118 holes, the optimum dimensions of the holes were determined to be $\frac{3}{8}''$ wide, 0.140″ high and the optimum vertical and horizontal spacing proved to be 0.535″ and $\frac{1}{2}''$, respectively.

The tabs are of a form and size determined largely by the mounting space required for the solenoids that are used to operate the code select and card support bars, the vertical displacement required for shuttering the holes and ruggedness considerations. Thus, the nominal size of the tabs associated with the code select bars became $\frac{1}{8}''$ wide × 0.205″ long with a spacing of $\frac{3}{16}''$. The tabs associated with the card support bars — one at either end — being used for each translation instead of

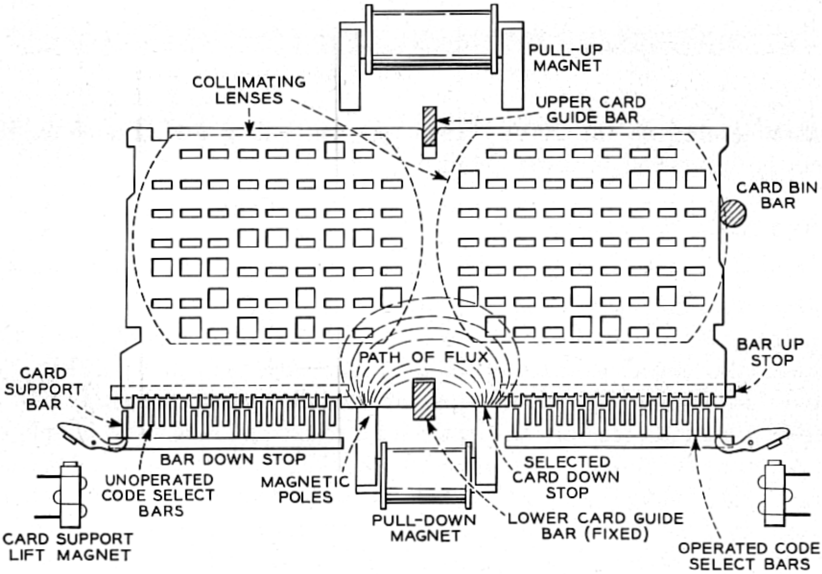


Fig. 20 — Card and directly associated components.

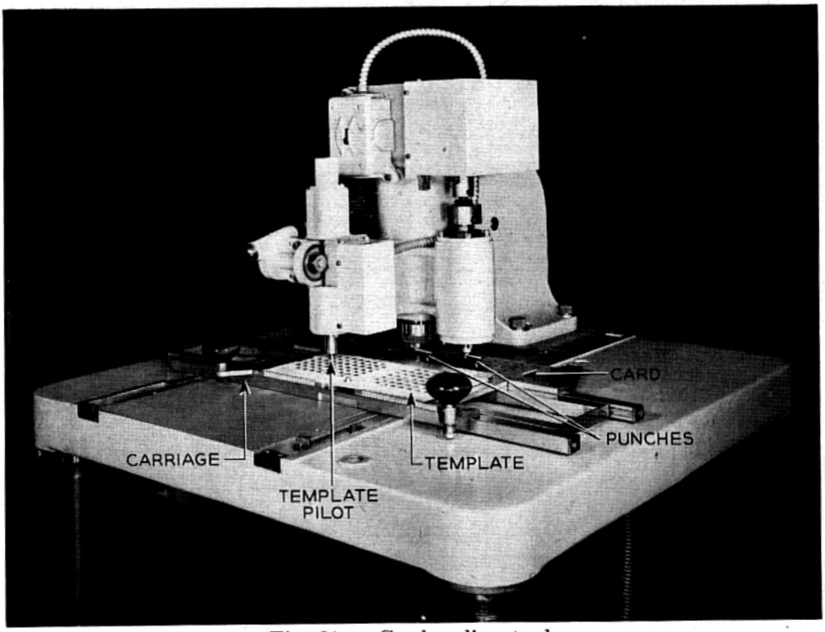


Fig. 21 — Card coding tool.

only selectively as in the case of the tabs associated with the code select bars were made 1/4″ instead of 1/8″ wide and their outer corners were rounded generously. The additional ruggedness thus provided is particularly beneficial because the end tabs are subject to more abuse than the others in handling.

Left and right-hand grouping of the holes and tabs was necessary for the dual lense system and to provide space in the central area for guide notches and for mounting the pull-up and pull-down magnets, as shown in Fig. 20.

Center, top and bottom notches are provided for engagement with card guide bars that position the cards for proper alignment of the holes and tabs. In addition, these notches guide the cards during their operative displacement.

Other marginal notches are provided for mass lifting of the cards, end-for-end positioning in the card cage, locating the cards properly in a tool for coding cards, and for another tool which facilitates handling the cards in bulk. The coding and bulk card handling tools are illustrated respectively by Figs. 21 and 22.

The over-all size to accommodate the various elements and to provide adequate strength is 10-3/4″ wide × 5″ high.

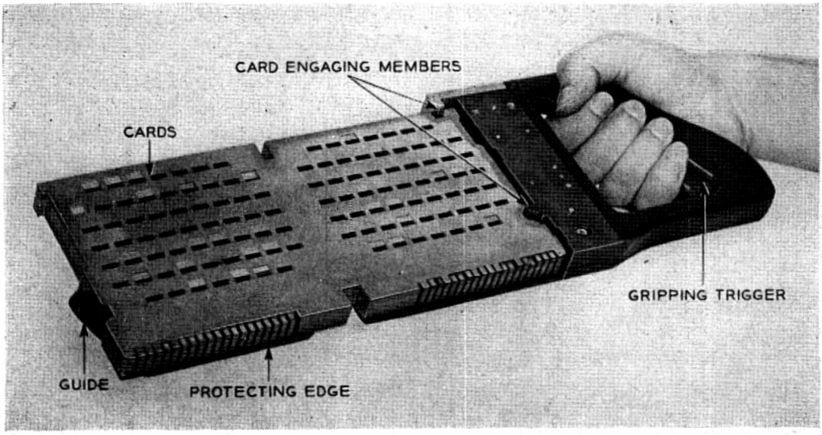


Fig. 22 — Bulk card handling tool. One side plate has been removed to show cards.

The card material had to be magnetic so that electromagnets could be used to assist in the manipulation required in the course of a translation. After giving due consideration to the use of permalloy, Armco iron and several other materials it was concluded that the most practicable compromise would be to use hard-rolled AISI-C1008 strip steel.

The protective finish selected was chromium flash over nickel-plate. The nickel provides reasonable protection against corrosion, while the chromium provides surface characteristics consistent with the need for maintaining interface friction and wear at low levels. The finishes are applied to the strip stock by a continuous plating process and it may be interesting to point out that the current value when applying the chromium is in the order of 1,000 amperes. It will be realized, therefore, that one of the problems in producing satisfactory material is maintenance of the rolls over which the material is fed and which also are circuit elements, free from foreign materials because otherwise high resistance points may develop and cause burning.

Flatness is important because any deviation from a plane, in effect, increases the thickness of the card and thus limits the card capacity of the translator. Manufacture is controlled so that the slight bowing that results from handling the material in rolls always is in the same direction as the material is fed to the perforating and blanking tools. Out-of-flatness is held to maximum 0.012″ within 72 hours after fabrication. Bowing subsequently increases the out-of-flatness but not to an important extent. The out-of-flatness is checked by means of the gauge illustrated by Fig. 23, which was developed especially for the purpose.

It comprises a flat metallic plate upon which the card is laid, two rails which are insulated from the plate and project about it an amount equal to the thickness of the stock from which the cards are made plus the allowable amount of out-of-flatness and a metallic roller that is sufficiently long to span the rails. The rails and the flat plate are elements of a neon tube detection circuit which is arranged so that if the roller in passing over the card contacts it the tube will fire. If it does not fire, the card is within the flatness setting of the gauge.

To meet the 0.012″ allowance consistently it was necesary to resort to special stress relief annealing. In developing the process it was found that the cards have to be degreased thoroughly and a clean condition has to be maintained at all times. The cards are clamped under heavy pressure between thick nickel plated plattens and are then heated and

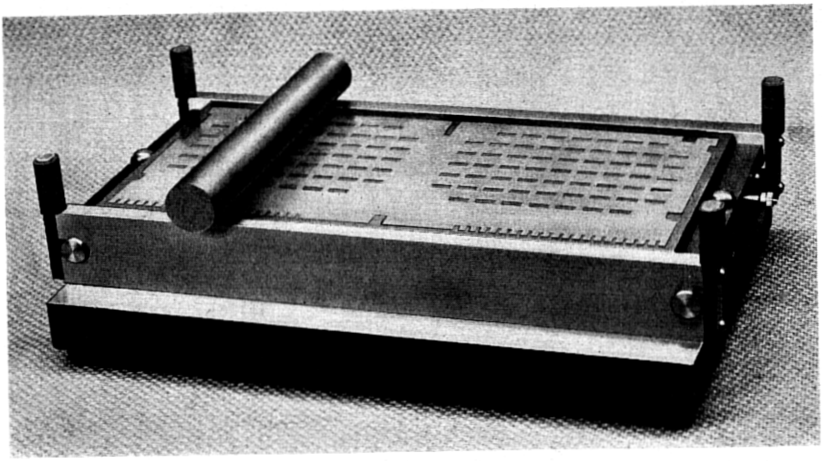
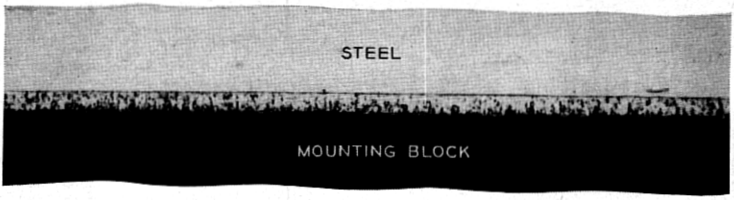


Fig. 23 — Card flatness gauge.

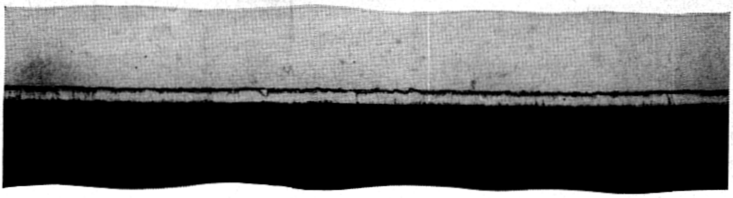
later cooled in a reducing atmosphere. Such a procedure would seem to be reasonably straightforward, but it was found that the heating cycle has to be controlled precisely as otherwise the surface is roughened.

Smoothness of the cards was found to be related to surface color. Improperly stress relief annealed cards usually assume hues of blue and brown which were traced to surface films of so little thickness — perhaps in the order of 500 to 1000 Angstrom units as to cause interference colors. It was found that when the surfaces are discolored excessively, there often is an appreciable increase in interface friction, sometimes amounting to 30 per cent. This is undesirable because free action of the cards is of paramount importance and of course, wear should be minimized. It was found that roughness is caused by cannibalistic grain growth of the nickel after recrystallization; that is, some of the grains grow at the expense of others, thus causing surface roughness. In this connection it may be interesting to refer to the photomicrographs of Fig. 24. In each, the top, light and almost structureless portion depicts the basic material (steel). The adjacent layer characterizes the nickel plating, the columnar structure being typical of the electro-plating process. The next layer shows the chromium flash and the black portion, a block used to mount the specimen.

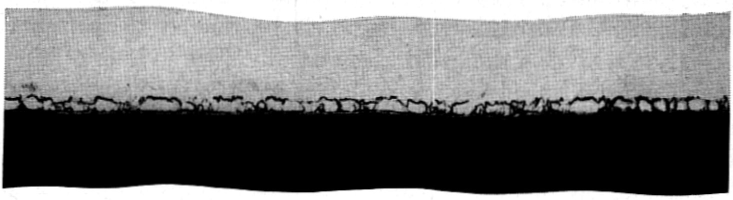
The top view of Fig. 24 is representative of the material as received from the supplier. The center view illustrates satisfactory stress relief annealing. The bottom view illustrates unsatisfactory annealing. It will be noted that after satisfactory annealing some recrystallization of the nickel has taken place and that grain growth has started but has



MATERIAL AS FURNISHED



MATERIAL SATISFACTORILY STRESS–RELIEF ANNEALED



MATERIAL ANNEALED AT TOO HIGH A TEMPERATURE

Fig. 24 — Photomicrographs of sections of cards (1000×).

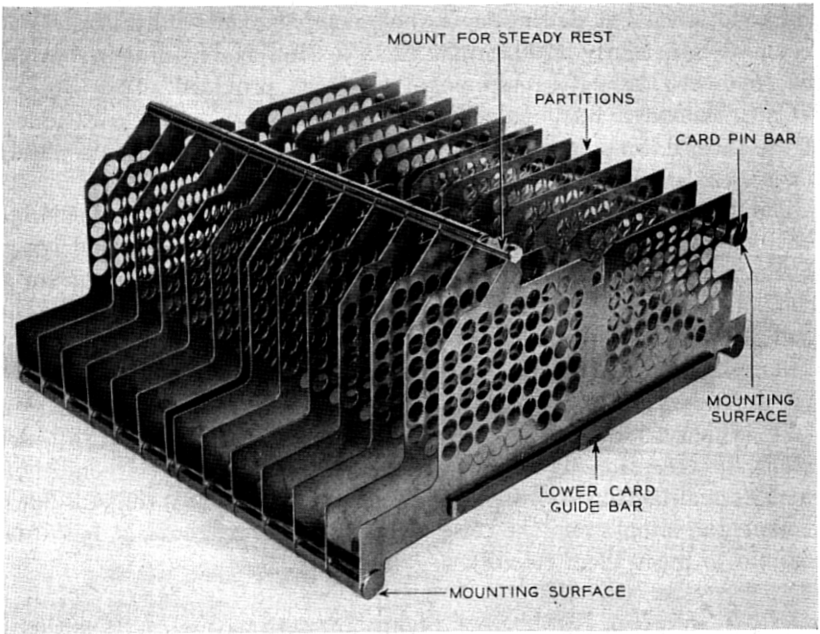


Fig. 25 — Card cage.

not progressed far enough to affect the surface sensibly. It will be observed that when the temperature is too high the grain growth is more pronounced and that as a result substantial protuberances appear on the chromium surface. Cards possessing such protuberances exhibited a marked increase in interface friction.

Distribution of the cards in the translator posed some important problems. Sufficient space had to be provided to accommodate a full complement of cards. Yet it was realized that there would be cases where the translator would not be fully equipped and under these conditions the cards, due to the surplus space available, might lean sufficiently to render them inoperable. To obviate such a possibility a partitioned cage — see Fig. 25 — is provided for the cards. The partitions are close enough to one another to assure that if but a single card is used in a compartment it will operate satisfactorily. This is illustrated by Fig. 26. The spacing thus arrived at is a little less than 1″. This spacing provides sufficient room for reliably handling 98 coded cards and a blank card adjacent each partition making a total of 100 cards to a compartment. The blank cards improve the performance of the adjacent cards.

Twelve compartments were decided upon after due consideration of the many related problems such as light tunnel transmission losses, and code select bar deflection. Twelve compartments fully loaded can accommodate nearly 1200 cards. Thus a comfortable margin beyond the 1000-card capacity requirement has been provided.

Card thickness was controlled by considerations such as stiffness of the tabs, flatness and overall length of the card stack. It ultimately was concluded that the optimum thickness is 0.007″ nominal.

The weight of a card after coding averages 40 grams and, considering that nearly 1200 cards may be in translator the total card load is approximately 100 pounds. This is considered to be enormous from a telephone switching apparatus viewpoint and largely accounts for the need of the pull-up magnet.

Manipulation in effecting a translation has to be fast. The displacement of the selected card has to be comparatively large and the card stack, which also has to be moved for each translation but to a lesser extent, is exceptionally heavy. These are not compatible conditions but by advantageous coordination of the pull-up magnet, the pull-down magnet, the latches and the card support bar lift magnets, it has been possible to meet them reliably.

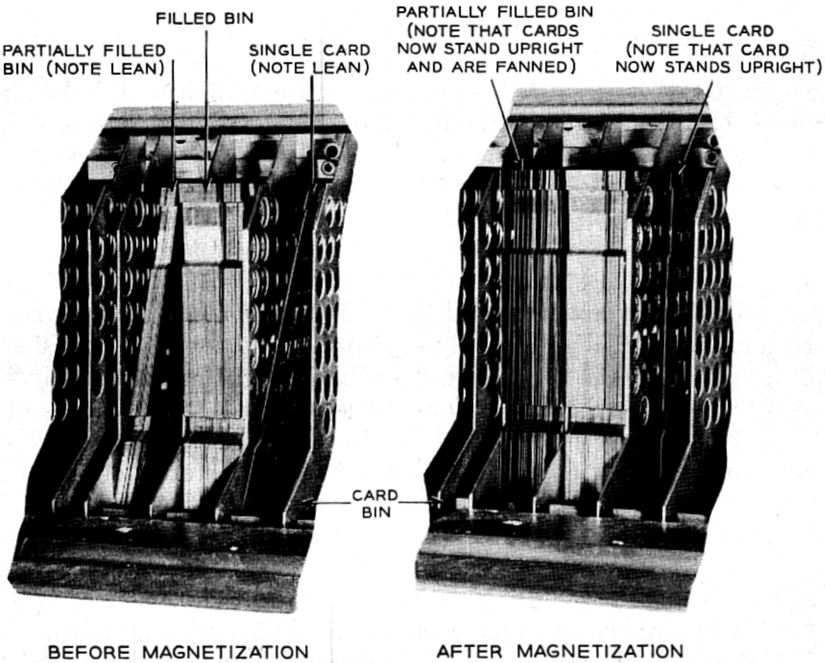


Fig. 26 — Card stack before and after magnetization.

The weight of the stack normally is borne by the latches via the code select bars, but as the time approaches for their operation the stack is elevated by energization of the pull-up magnet and the latches thereby are freed for fast operation.

Separation of the cards just prior to dropping a selected card is effected by the pull-up and pull-down magnets. These magnets induce like magnetic poles in corresponding portions of all the cards and the partitions of the card cage as may be deduced by reference to Fig. 20 and the resulting mutual repulsion causes the cards to separate as may be noted by reference to Fig. 26. This assures free action of the selected card. The pull-up magnet is deenergized when the required code select bars are checked down. The pull-down magnet is maintained energized to assist the dropping of the card.

The nominal initial jump of the card stack, or the separation between the top of the card stack and the pull-up magnet pole faces is nominally 0.016″. When the magnet is energized the stack "jumps" to the pole faces in about 15 milliseconds which is fast considering that the load may be as much as 100 pounds.

The nominal drop of the selected card is 0.180″. Accordingly, the theoretical free fall time is 33.2 milliseconds and the terminal velocity is 12.7″ per second. However, under working conditions, the selected card does not fall freely and except for the added pull of the pull-down magnet, the drop time would average about 40 milliseconds. The pull-down magnet is capable of reducing the drop time in a working translator to as little as 16 milliseconds or approximately one-half the theoretical free fall time with a measured terminal velocity as high as 35″ per second. Should this speed be permitted, the impact forces developed would be of sufficient magnitude to cause the tabs of the cards to mushroom to an unworkable degree and to cut through the nylon surfacing of the pole faces of the pull-down magnet in less than one million operations. Under the restraining influence of the card support bars, the drop time averages 33 milliseconds or a reduction of approximately 20 per cent with respect to the unaided operate time and the maximum terminal velocity measured has been 20″ per second. Working at this speed, there is virtually no mushrooming during the normal life of the card and the nylon facing survives well over 100,000,000 operations, thus showing a gain attributable to the use of card support bars of more than 100 to 1.

Inadvertent dropping of all cards of the stack is possible although highly improbable. It can happen if the stack is released from its suspended position when the latches are not in a position to support the code select bars. The combined strength of retractile springs of the solenoid operated bars is insufficient to support the load and, therefore, if this happens, the bars will yield until the load is taken up by the pole faces of the pull-down magnet. The total drop amounts to 0.180″ which then will become the effective air gap at the pull-up magnet pole faces. This is more than ten times the normal gap (0.016″) and the pull-up magnet is incapable of restoring the card stack to its normal level. This is despite the fact that when the gap is normal, the pull exerted is in the order of 400 lbs and the breakaway pull is approximately 1000 lbs. Accordingly, mechanical means had to be provided for restoring the stack to normal under this condition. Since this rarely occurs, it was concluded that manual restoration would suffice and a hand crank, together with sundry components, including card lift bails, that are illustrated by Figs. 27 and 28 are provided.

Coding of the cards involves many considerations. It has been mentioned that a template is used to indicate the holes that should be enlarged and the tabs that should be removed. Obviously, punch and die sets are required to do this. They are provided as components of a tool which is illustrated by Fig. 21. This tool provides a carriage upon which the card to be coded and the template that provides the coding information are mounted in fixed relationship. The carriage may be moved about to effect registration of the holes to be enlarged or the tabs to be removed, with respect to the punches and dies. When enlarging holes, the carriage is moved to a position where a foot treadle operated pilot registers with a hole in the template and then the treadle is depressed. The pilot enters the hole in the plate that supports the template. The hole is close fitting to effect approximate alignment. As the motion progresses a pilot that is part of the punch assembly effects precise alignment between the punch and the hole to be enlarged. This final alignment is made possible by providing for a small amount of float of a card on the carriage. As the foot treadle is depressed further, the punch enlarges the hole in the card. For coding the tabs, a second punch and die set is provided. It is brought into action by a microswitch controlled solenoid that actuates the punch. The carriage referred to is notched along one edge in registration with the tab positions of the template. Wherever the template is notched, the corresponding card tab is to be removed and the carriage is positioned so that these notches successively may be registered with a stylus associated with the solenoid control switch. The carriage then is moved against the stylus and in doing so the switch is operated which causes the solenoid to actuate the punch, thereby clipping off the corresponding tab of the card. In clipping off tabs the punch does not have to be aligned precisely with the tab

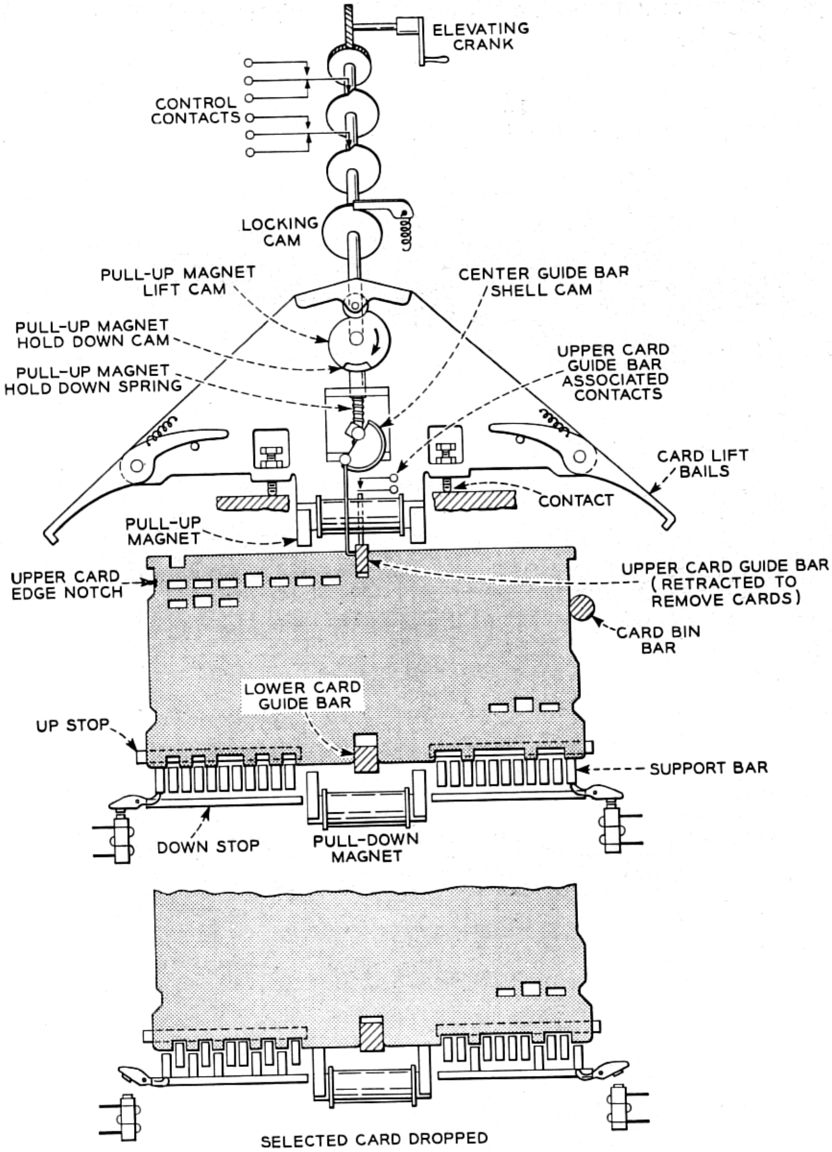


Fig. 27 — Interrelationship of card select components.

position and, therefore, the tab punch has not been provided with a positioning pilot.

Freedom from burrs after coding is assured by passing a sulphur-free abrasive bearing rubber pad over the card several times.

Care is required in handling the cards to avoid distortion of their

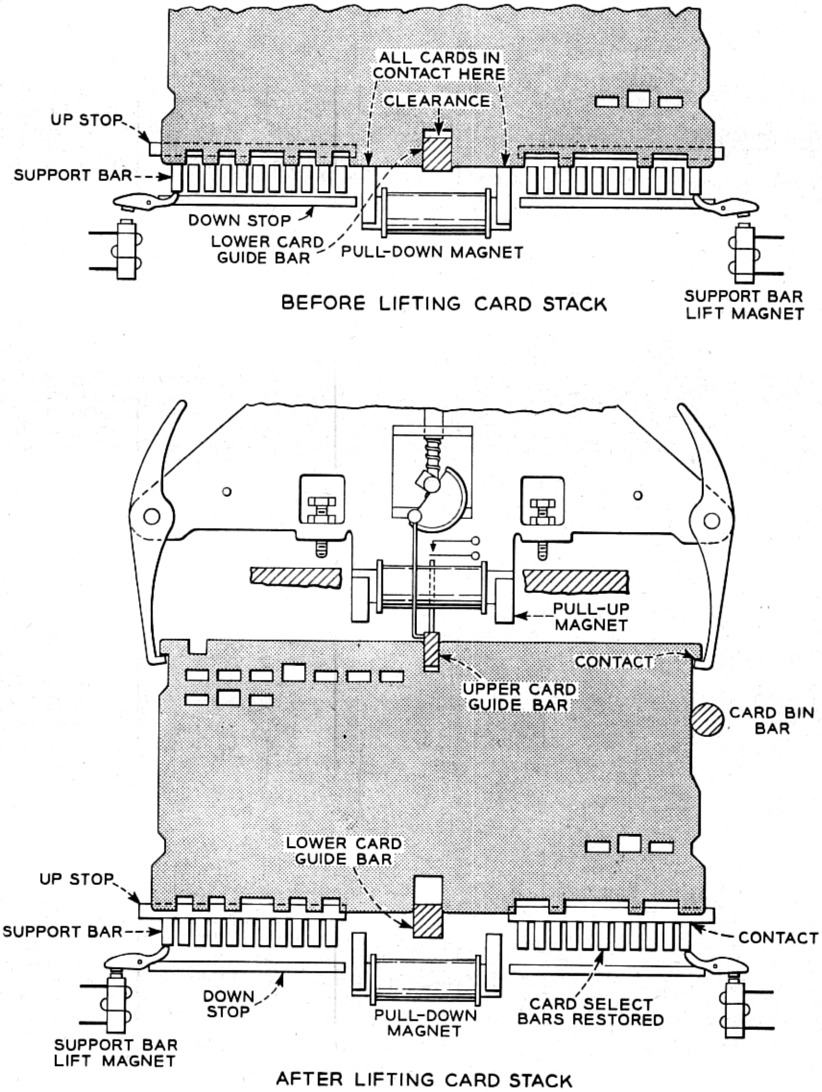


Fig. 28 — Mechanical lifting of cards.

tabs. As a precautionary measure, tools have been made available that afford adequate protection of the cards while they are being handled. One of these tools is for inserting one card at a time in the card stack. The other tool, which is illustrated by Fig. 22, is used when it is necessary to handle a number of cards at a time. It will be noted that it affords protection for the tabs. This tool may be used for loading and unloading all of the cards of a compartment of the card cage in a single operation. The cards, after bulk removal, may be conveniently stored in one of the card compartments of the test set illustrated by Fig. 16.

CODE SELECT AND CARD SUPPORT BARS

The load on a single bar may be as much as 24 pounds. Deflection due to loading has to be maintained at a minimum because any deflection reduces the effective height of the light tunnels through the card stack. However, the bars have to be light because high-speed operation is required. In addition, they have to be wear-resistant because of the many millions of operations to which they are subjected annually. These are difficult conditions to meet but a satisfactory solution was found by providing deep section die cast magnesium bars that are fitted with details made from suitable wear-resistant materials at the point of loading. Such bars, as components, are depicted by Fig. 29, in which the bottom bar is of the card support type. The other three bars shown are code select bars. They illustrate the different terminations that are required by the mounting arrangement employed.

The spacing is $\frac{3}{16}''$ to affect alignment with the tabs of the cards. This close spacing makes it necessary to vary the amount of overhang beyond the up and down stops so that the associated solenoids may be mounted in staggered array and thus their diameter need not be unduly restricted. Despite the variations in conditions it was made possible to use but a single mould by casting the ends of the bars of uniform cross-section and long enough to accommodate the longest extension required. For those cases requiring lesser extension, the bars are cut off to suit. The bars are designed so that they may be used end-for-end and, therefore, although five mounting positions have to be taken care of, the three different end terminations illustrated suffice. It may be noted that the bars during fabrication are straightened if necessary by bumping. In this way, the necessity for side surface machining is obviated and in consequence the side skin of the bars is maintained intact which enhances stiffness.

The weight is only 115 grams each and yet their deflection under the heaviest working load that may be developed is but 0.003″ which is immaterial insofar as reduction in the effective height of the card stack light tunnels is concerned. The stresses developed are so low that fatigue failures should not be experienced.

Nylon is bonded to the top surface of the bars because of its proven ability to resist the cutting action of the cards. Details made from graphitized phenolic linen are secured to the bars at the lateral guide points because of the superior ability of this material to resist wear under the sliding action involved. This material also is well adapted to resist the heavy loading that is developed where (top of center slot) the card support bars are engaged by the tongues of the card support bar lift magnets and it is, therefore, used here also. Beryllium copper details are affixed to the ends of the bars where they are coupled to the associated solenoids. Beryllium copper is used here because of its wear-resistant and non-magnetic characteristics. For the same reasons it is used for details that are secured to the bottom edge of the bars where end guides are engaged and the bars cooperate with the latches.

The beryllium copper details affixed to the bottom of the code select bars are each provided with toe-like projections. The bottom of the toes

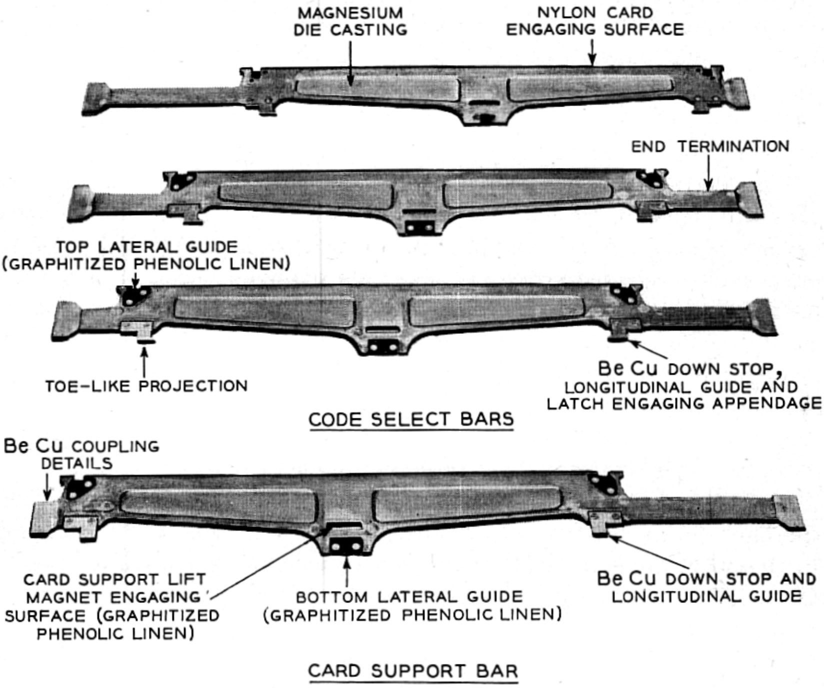


Fig. 29 — Code select and card support bars.

normally rests on the support blade of the latches. After the pull-up magnet is energized, support by the latches no longer is required and they are operated to move their support blades out from under the toes of the code select bars, so that the combination of bars called for by the code digits may be depressed. After the combination is checked down, the latches return to normal so that they are again in position to support the card stack. The toes of the depressed bars project under the support bars of the latches, thus tending to prevent any of the depressed bars from restoring prematurely. The card support bars are not provided with toe-like projections and therefore, may be depressed regardless of the position of the latch support blades. This is necessary because the card support bars have to operate after the depressed code select bar combination has been checked down and the latches restored. The selected card then rides the support bars down and controls the terminal card velocity within safe limits.

Transverse alignment of the code select and card support bars within close limits is important to proper coordination of the bars with the tabs of the cards and also to maintain transverse operating clearance between the bar coupling details and the blade like extension of the plungers of the associated solenoids. It also is necessary to control the up-stop level of the bars accurately so that the close vertical alignment of the holes in the cards that is required may be assured. These conditions are met by the provision of details that serve both as transverse guides and as up-stops for the bars in groups of twenty each which is consistent with their left and right-hand grouping. Since these combined stop and guide details are needed at both ends of each group, four are provided. They comprise details that are stepped to provide a horizontally disposed surface that serves as a common up-stop and a vertically disposed wall that is slotted to form a comblike transverse guide for the solenoid operated bars. The nylon surfaced top of the code select and card support bars engages the bottom surface of the combined up-stop and comb guide details under the action of the solenoid retractile springs. The comb portion engages the graphitized phenolic linen details that are set into the code select and card support bars near their top at both ends.

The lowermost position of the solenoid operated bars has to be controlled in order to establish their proper operated position with respect to the pole faces of the pulldown magnet and the bars have to be guided endwise so as to maintain a longitudinal operating clearance at the coupling details. This is accomplished by providing stop bars, the top and inside surfaces of which cooperate respectively with horizontally and vertically disposed surfaces of the beryllium copper details that are fastened to the bottom of the bars. Both the top and the inside surfaces referred to are faced with nylon. The combination stop and guide details are located so that the top surface of the solenoid operated bars lies about $\frac{1}{64}''$ below the pole faces of the pull-down magnet when the bars are fully depressed. This under flush condition is necessary to assure that the pole faces act as the down-stop for the selected card as is intended.

CENTER GUIDES

To maintain the intended vertical disposition of the solenoid operated bars, additional comb-like guides are provided that engage the bars at their center near the bottom edge. Actually they engage the graphitized phenolic linin details that are inserted at the center of the bars. This arrangement of the comb guides provides triangularly disposed guidance that affords both transverts and vertical stability with minimum working friction.

OFF-NORMAL CONTACTS

It is important that all of the code select bars necessary for selecting the required routing card be checked down before proceeding further with a translation and it is equally important that after translation they all be checked up before proceeding further towards restoration of the translator to normal. Off-normal contact springs that are operated by the bars are provided for this purpose. They are mounted at the light source end of the bars as indicated in Fig. 18. They also are illustrated by Fig. 30, and from this illustration it will be noted that off-normal contacts also are provided for the card support bars. These latter contacts close as the bars are operated to start timing of the "no card" timing circuit. When the card support bars are released, their off-normal contacts control the circuit of the card-support lift-bar magnets. This is a desirable arrangment because these magnets are required to supplement the solenoid retractile springs only as the card-support life-bars approach their upper stop position where they engage any cards that may be tilted. Late energization of these magnets prevents the development of high tab impact forces.

LATCHES

The latches are magnetically operated to free the solenoid operated bars and are spring returned to their bar engaging position. Four are provided: two at each end of the bar array, one for the left-hand grouping and the other for the right hand. Accordingly, each has to be capable

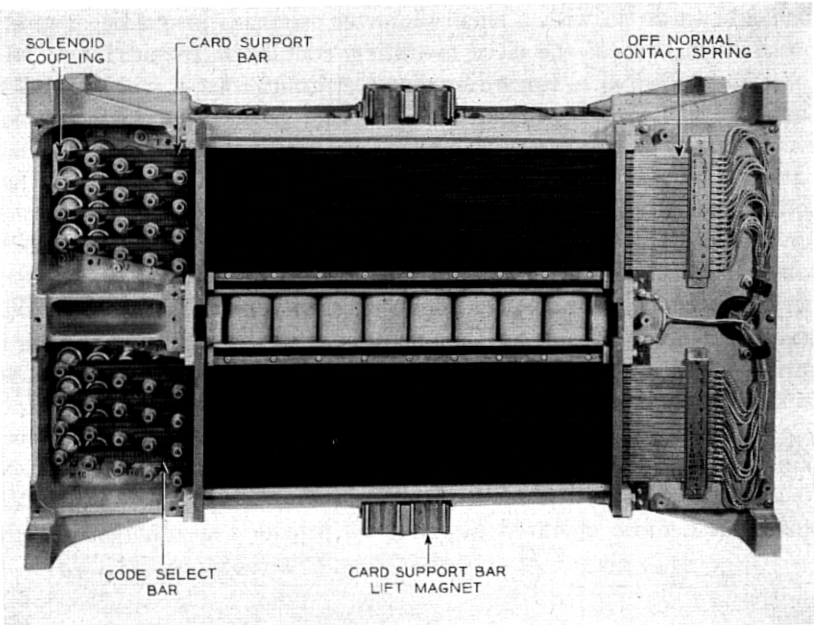


Fig. 30 — Top of dynamic unit illustrating off-normal contacts and solenoid arrangement.

of supporting one-quarter of the weight of a full complement of cards or 25 lb each. Yet the latches have to be fast. This is accomplished largely by providing for "on center" loading as may be discerned by reference to Fig. 31 keeping in mind that the beryllium copper append ages on the bottom of the code select bars engage the support blades ot the latches virtually directly above the pivot center. Furthermore, a major portion of the moving member is made from magnesium. A spring pileup such as may be seen in Fig. 32, is associated with and is operated by each latch and the translator circuit is so arranged that a translation cannot progress beyond the latch operate point until all four latches have operated. The same is true when the latches are to be restored to normal, that is, the cycle cannot progress further until all four latches are restored.

The operate time of the latches averages 40 milliseconds, the restoral average being 15 milliseconds.

SOLENOIDS

The main problem here was to provide high-speed operation in the presence of a comparatively large non-operated gap and considerable load and to do so with a small diameter solenoid. Magnetic cross-fire possibilities born of the close mounting conditions required also had to be contended with. Regarding diameter limitations, it will be recalled that the tabs of the cards are on 3/16″ centers and that five solenoids are grouped in stagger arrangement. Thus six positions or five spacings have to be considered and, therefore, the diameter of the solenoids has to be less than 15/16″. This is very small considering what the solenoids have to do, but satisfactory performance was achieved by the use of solenoids of which Fig. 33 is representative. The coil tube is made from beryllium copper because of its high resistivity, resistance to corrosion and its ability to resist wear. The main body of the operating plunger is surfaced with a heavy plating of chromium. The plunger then is ground to size, lapped and buffed to provide a very smooth surface. The blade-like extension that is secured to the main body of the plunger for coupling purposes is made from steel. It is hardened, ground and polished to assure long life. The fixed plunger is adjustable axially so that a small but definite operated gap may be provided as otherwise mush-

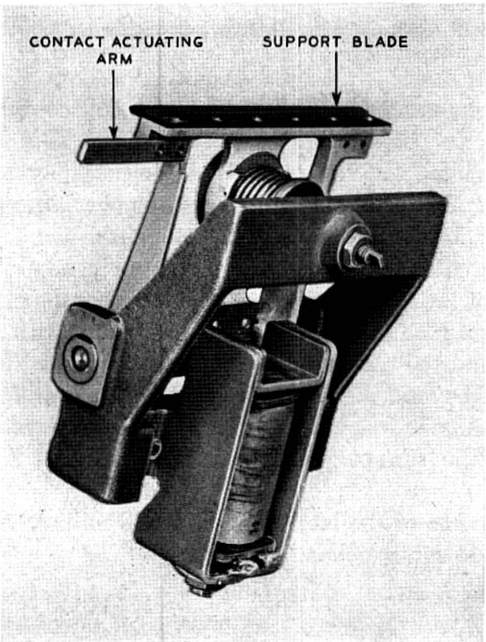


Fig. 31 — Code select bar latch.

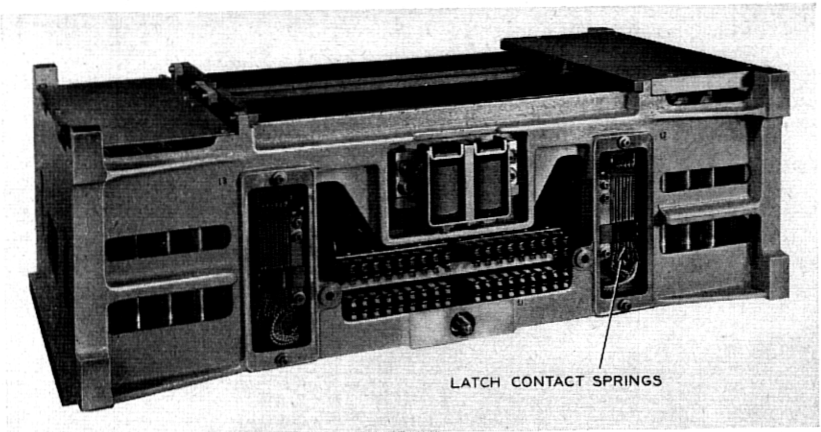


Fig. 32 — Jack side of dynamic unit showing latch contact springs.

rooming due to impact would be experienced. It is possible to maintain a small operated gap because the down-stop position of the solenoid operated bars is precisely controlled by common stop details that engage the solenoid operated bars and thus limit the motion of the solenoid plungers to which they are coupled. The solenoid is provided as a package including the necessary retractile spring and coupling details. One of the coupling details is a rubber buffer. This buffer cushions the impact developed when the bar that is coupled to the solenoid engages the up-stop. At the top of the bar coupling detail another rubber buffer is mounted. This second buffer cushions the impact when the downstop is engaged. A crowned washer is cemented to the first buffer and the assembly provides a slight vertical freedom of the plunger extension in the bar coupling detail. Combined, these features permit sufficient freedom of action to prevent binding in the event one solenoid of a bar acts faster than the other.

The average operate and restoral times of the solenoid are 32 and 28 milliseconds, respectively. The unoperate gap pull averages 325 grams, and the unoperated force of the retractile spring is 200 grams. The solenoids are operated dry to prevent gumming.

The beryllium copper coupling details secured to the ends of the solenoid operated bars provide a slot through which the flattened extension of the solenoid plunger passes. The position control of the solenoids and of the bars is such that side friction at the coupling is virtually non-existent. There is adequate end or longitudinal clearance to permit of unrestrained tilting of the bars such as may be experienced if one solenoid operates faster than the other.

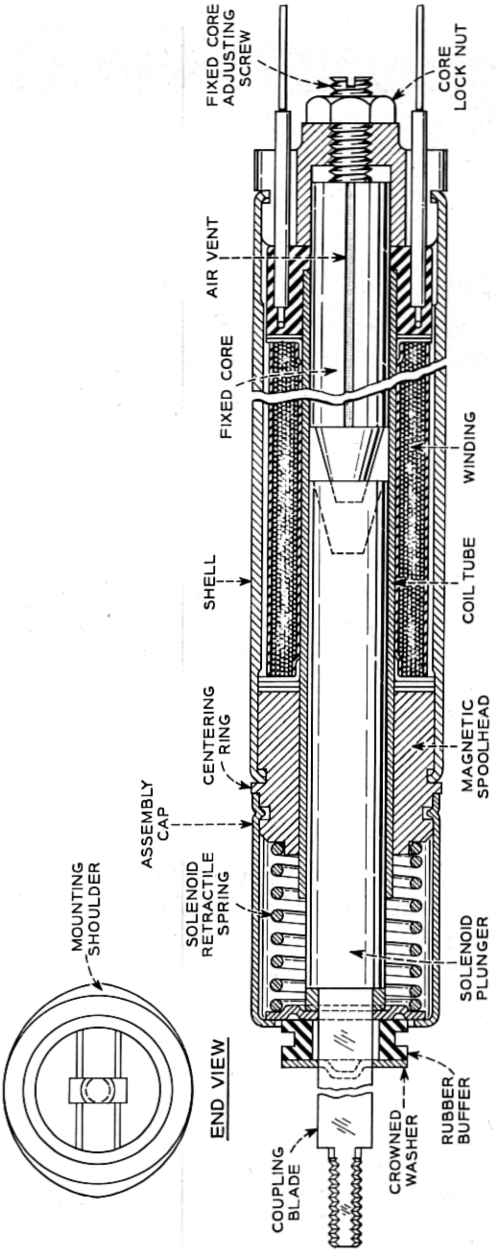


Fig. 33 — Solenoid.

CARD SUPPORT BAR LIFT MAGNETS

It is possible that a translator may be equipped with a group of cards from which all tabs except a very small number common to the group have been removed from one side. To select any card of the group all of the code select bars associated with the remainder of the tabs on the side involved have to be operated. Under these conditions the unselected cards of the group would be unsupported on one side and would, therefore, tilt to the extent permitted by the card guide bar working clearances that prevail. The closest practicable clearances have been established and yet, insofar as the card guide bars are concerned, the lower corner of the cards would be free to drop approximately 0.015″ below the nominal bottom surface of the card stack. The combined weight of the tilted cards could be more than the associated code select bars can support; therefore, these bars would be depressed slightly. Actually they could be depressed sufficiently to interfere with the intended free action of the latches when they are called upon to operate and release for restoral of the translator to normal. This could happen, despite the fact that the powerful pull-up magnet would be energized at this time, because the flux shunting action of the adjacent and higher cards reduces the pull on the tilted cards to a very small value. The high cards in rising decrease the chances of the tilted cards following. Therefore, supplementary magnets have been provided that assist the retractile springs of the card support bars in lifting the tilted cards. These magnets are powerful enough (6.6 lbs.) to straighten up the tilted cards.

The form of these magnets, which have been called card support bar lift magnets, is illustrated in Fig. 34. It will be noted that, like the latches, they are constructed as units to permit convenient servicing in the field. Two coils are used for each magnet because in this way standard comparatively small diameter coils can be used and thus the magnets may be mounted more readily in the space available.

214A SELECTOR

All of the dynamic components, that is, the code select and card support bars, the solenoids, the latches, the card support bar lift magnets and the off-normal contacts are combined in a subassembly that is arranged on a plug-in basis. This combination, which as a convenience includes the pull-down magnet and of necessity many supporting details, is illustrated by Figs. 30 and 32. It is manufactured as the 214A selector but commonly is called the dynamic unit. It may readily be removed from a translator and placed on a portable elevator table such

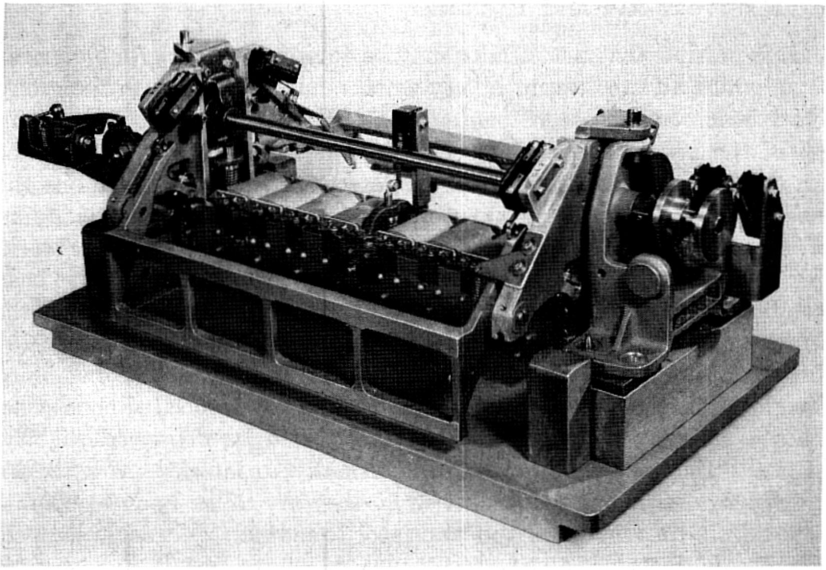


Fig. 34 — Pull-up magnet and lift superstructure.

as is depicted by Fig. 35. Accordingly, when the dynamic unit needs to be serviced, it may be taken to a location suitable for the purpose and meanwhile the translator may be continued in service by substituting a spare dynamic unit.

REMOVAL OF THE UNIT

To remove the dynamic unit, the cards first either have to be removed from a translator or in some way they have to be supported clear of the code select and card support bars. In some cases it will be possible to service the unit in a few minutes, and in such cases, should the cards have to be removed, their handling would constitute the major effort. The pull-up magnets could be energized in which event the cards would be suspended clear of the solenoid operated bars thus permitting the removal of the unit. However, conditions might be such that the pull-up magnet thus would have to be kept energized for a comparatively long time and this would be undesirable because the current drain is heavy. In any event, suspension of the cards by the pull-up magnet for this purpose would be hazardous because should the circuit be interrupted only momentarily, the cards would fall and considerable damage no doubt would result. Accordingly, mechanical means were provided whereby the cards may be elevated quickly and held suspended safely for an indefinite period. This was accomplished by providing hooked end bails pivotally mounted on the pull-up magnet structure and so arranged that they may readily be swung into a position where their hooked ends enter the top notches in the end edges of the cards. A manually operated crank is provided whereby the bails and hence the cards may be elevated. The mechanism employed is shown in Figs. 27, 28 and 34. It will be noted that the bails are arranged to act much like ice tongs, that is, the heavier the load the more securely they grip.

CLEARING A "CARD CRASH"

It is possible, under certain conditions, involving double trouble, for the pull-up magnet circuit to be broken while the latches are operated clear of their code select bar supporting position. If this happens, the card stack will fall and unless the translator is very lightly loaded, the weight of the card stack will overcome the solenoid retractile springs and all of the cards will move down to the pull-down magnet pole face level. Such a condition has been dubbed a "card crash". If it occurs, the pull-up

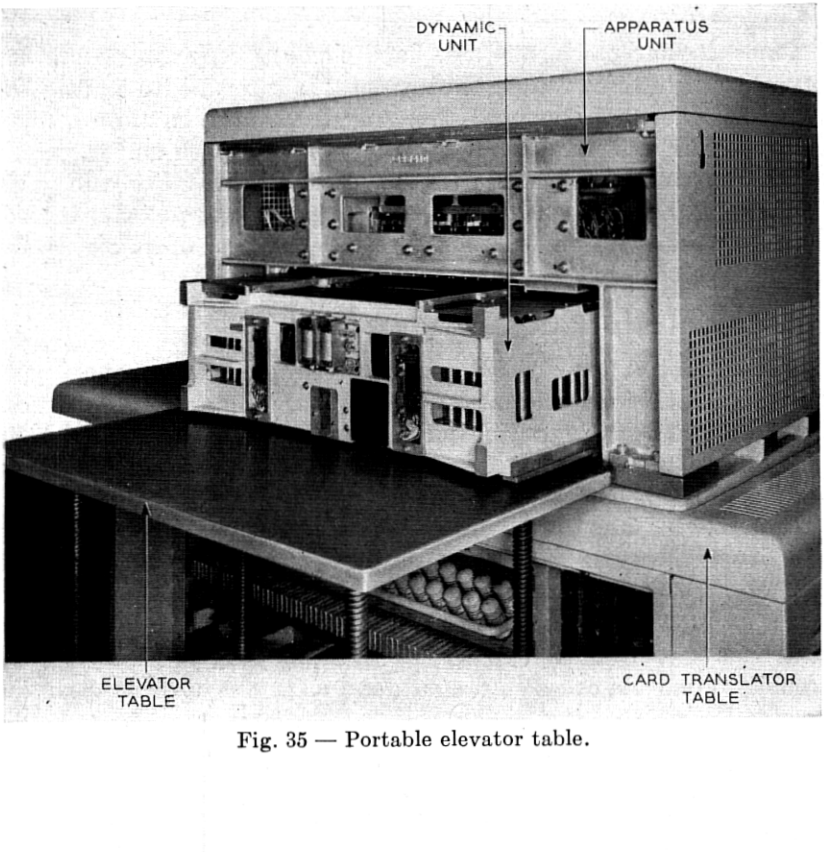


Fig. 35 — Portable elevator table.

magnet will be incapable of lifting the card stack because of the materially increased airgap and, therefore, the translator will be rendered inoperable. However, the bails provide a convenient means for clearing the trouble because the top notches in the cards are so located and are of such a size that they may be engaged by the bails even when the cards are at the pull-down magnet level and the lift motion is sufficient to permit the latches again to assume their card stack supporting role.

REMOVAL OF CARDS

To remove the cards; the pull-up magnet must be lifted sufficiently to permit of the cards being raised above the lower card guide bar. In addition, the upper card guide bar must be lifted clear of the stack. The crank referred to may be used to effect the required action. The upper card guide bar is raised by rotating the crank beyond the position required to raise the pull-up magnet whereupon a cam of the internal peripheral shell type engages mechanism adapted to lift the guide bar while the pull-up magnet dwells in the elevated position already effected. The mechanism referred to is illustrated schematically in the Figs. 27 and 28.

Cams, locking pawls, and associated circuitry cooperate to prevent operation of the crank while the translator is in service, to limit to the necessary extent the amount that the crank may be turned when removing the dynamic unit or alleviating a card crash and to permit of its being turned sufficiently further to elevate the upper card guide bar to clear the cards when they are to be removed or are being loaded. Study of related figures will make clear the mode of operation of the elevating mechanism.

PULL-UP AND PULL-DOWN MAGNETS

These magnets (see Fig. 18) are of the eight coil common pole type. They differ principally in that the cores for the coils of the pull-up magnet are laminated to provide for fast operation as is required. The operate and release timing of the pull-down magnet is such that its cores need not be laminated.

It is of vital importance that all of the coils of the magnets are effective as otherwise some of the cards may not be elevated when the latches are called upon to operate, or the cards may not fall reliably. Accordingly, a slave relay is used in series with each of the coils and if a relay fails to operate, thereby indicating possible magnet coil failure, the trouble recorder is called into action and steps are taken to clear the trouble.

The pull-up magnet is capable of exerting a pull of 350 lb when the airgap is 0.020″ which is approximately 25 per cent more than the normal operate gap and since the cards weigh approximately 100 lb. it will be seen that a reliable operate margin has been provided. The performance capabilities of the pull-down magnet were developed in the discussion of its effect on the drop time of the cards. The breakaway pull of this magnet is approximately 1,000 lb.

LIGHT SOURCE

The light source comprises the projection lamp, the light beam modulating wheels, the wheel driving motor, and the two first surface mirrors, as illustrated by Fig. 18. The mirrors direct light from either side of the major plane of the lamp filament via the dual collimating lenses and the card stack formed light tunnels to the photo-transistors. Various adjustment and supporting details are combined in a subassembly illustrated by Fig. 36. The subassembly is shown mounted on a fixture that is used during manufacture.

The lamps usually can be interchanged without readjustment of the mount or the associated components. At the most, all that has to be done is to orient the lamp so as to obtain reasonable alignment of the major

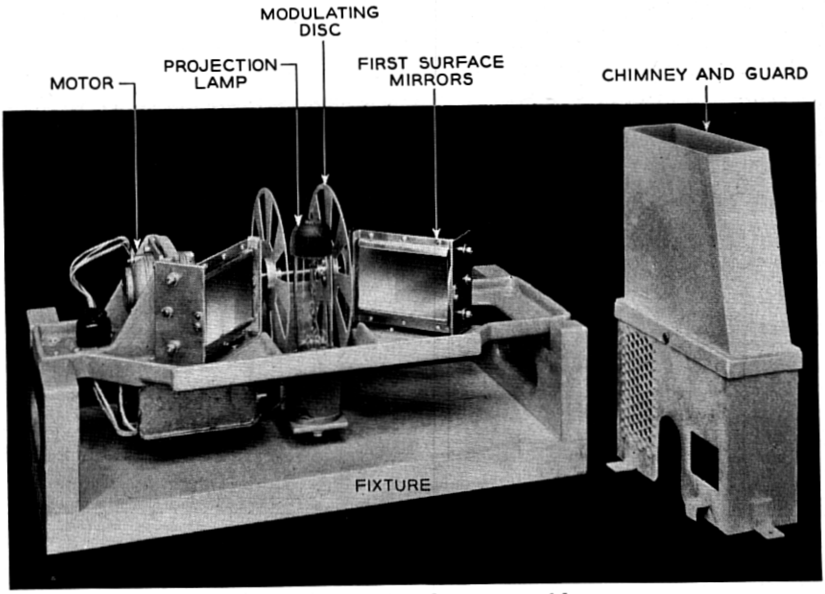


Fig. 36 — Exciter lamp assembly.

plane of its filament with the longitudinal center line of the translator. The combination chimney and guard that is provided as part of the subassembly includes a peep-hole to facilitate filament orientation.

The lamp, although operated at reduced voltage, generates considerable heat. Because of this, its guard and chimney are treated with a cotton flock finish which prevents direct contact with the metallic base and thus the guard may be touched without discomfort.

The first surface mirrors are mounted so that they are accessible for cleaning.

COLLIMATING LENSES

The light level at the photo-transistors may be lessened because of the accumulation of foreign material on the surfaces of the lenses. Because of this, the collimating lenses have been mounted in a frame (see Fig. 37) which makes it convenient to remove them simultaneously for cleaning and to replace them without readjustment. The phototransistors are red sensitive and, therefore, the focal length had to be determined on this basis.

CARD CAGE

The cards are mounted in a cage, as illustrated by Fig. 25. The partitions are made from magnetic iron. They tend to repel the cards that are mounted adjacent to them when the pull-up and pull-down magnets are energized. This is beneficial when a card close to the partitions is selected, as it gives better assurance of the card dropping reliabily. However, as has been mentioned, it is desirable to mount an uncoded card adjacent to the partitions because the first and last card in a com-

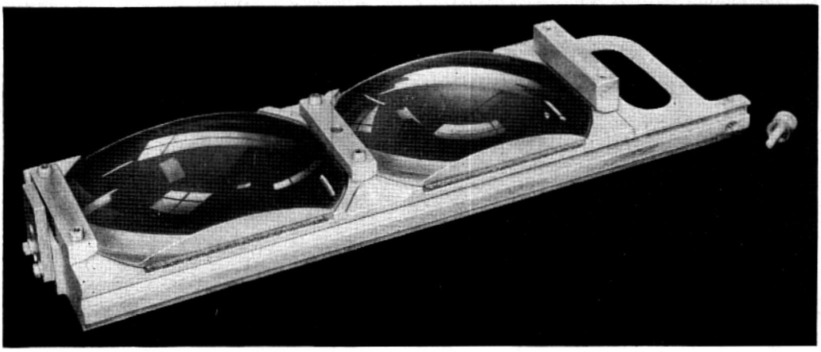


Fig. 37 — Collimating lenses.

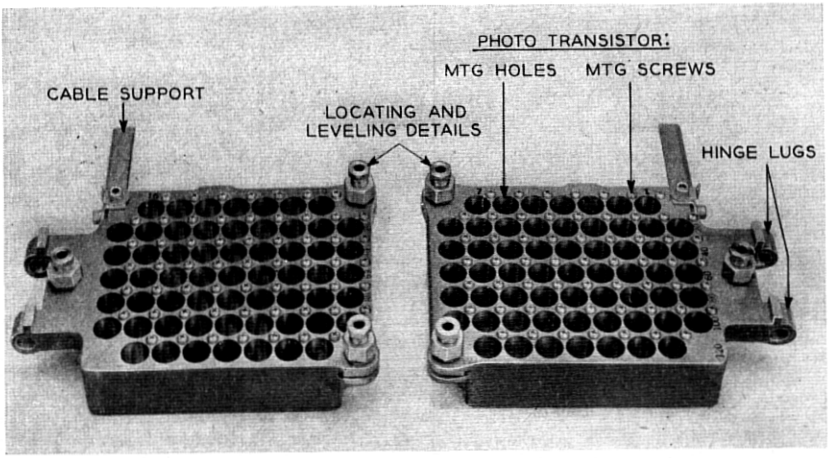
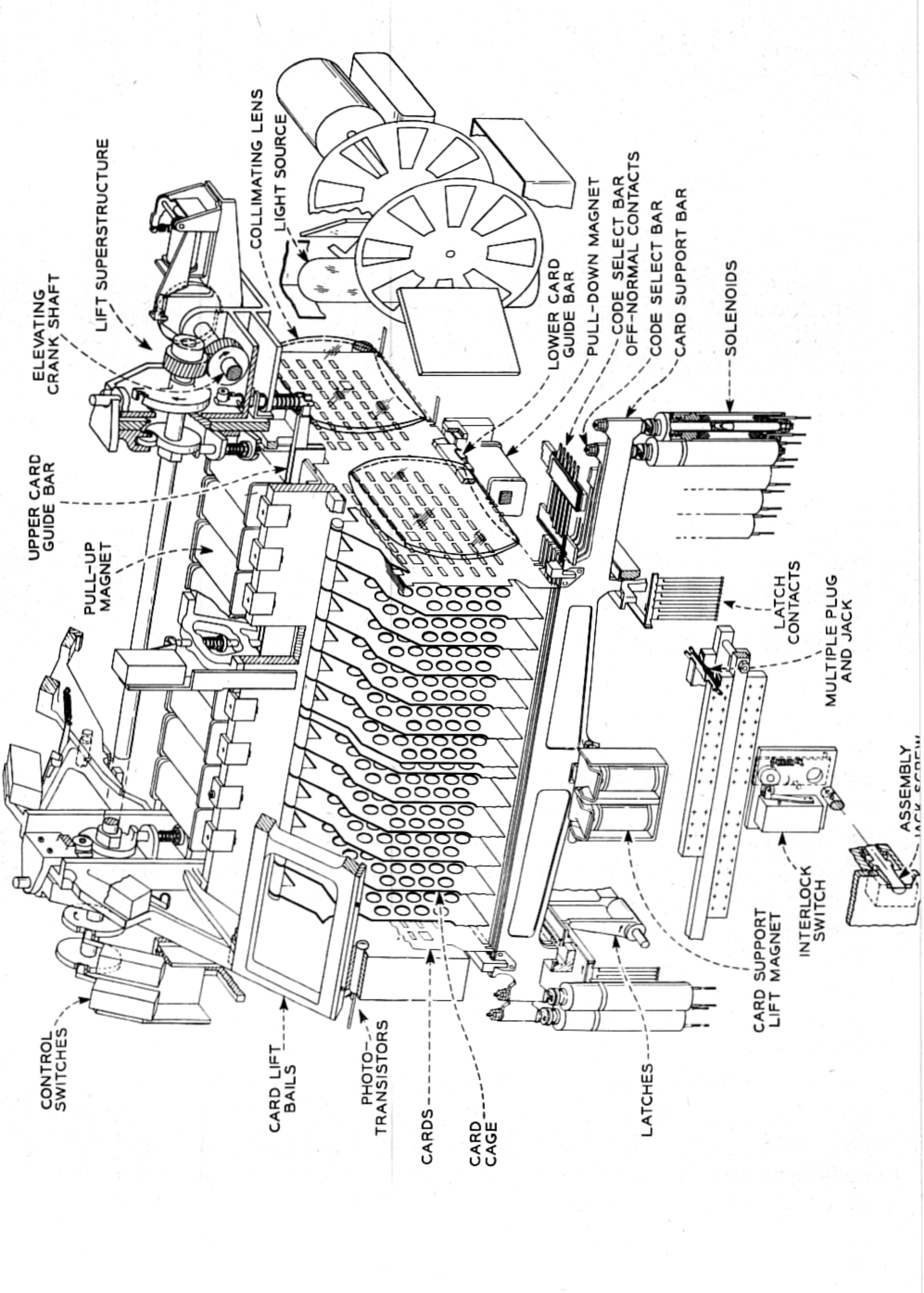


Fig. 38 — Phototransistor mounts.

partment are not as free acting as the others. The holes in the partitions, it will be noted, are round. Round holes were used merely as a convenience in manufacture. They are of sufficient size to clear the light beams that pass through the card formed tunnels.

PHOTO-TRANSISTOR MOUNT

The photo-transistors, consistent with the left and right-hand grouping of the holes in the cards, are mounted in left and right-hand groups of fifty-nine each. The mounts used comprise frames that are precisely machined, necessary because the activating light beams have to be concentrated on a very small piece of germanium and many variables are involved. These frames normally are secured to the translator framework by means of three special mounting screw subassemblies that provide means for positioning and leveling to obtain optimum light distribution over the whole field of fifty-nine photo-transistors. However, it was recognized that the focusing lenses of the photo-transistors should be readily accessible for cleaning and that it should be possible readily to view the light beams transmitted by the card formed tunnels as for instance by placing a piece of ground glass or translucent paper near the end of the card cage. In this way preliminary adjustment of the first surface mirrors, three dimensional adjustment of the light source, etc., can be effected quickly. Accordingly, the special subassemblies include screws that may readily be removed without affecting the position or leveling adjustments. As a convenience, loose hinges also are provided so that after the mounting screws have been removed, the


ELEVATING CRANK SHAFT
LIFT SUPERSTRUCTURE
COLLIMATING LENS
LIGHT SOURCE
LOWER CARD GUIDE BAR
PULL-DOWN MAGNET
CODE SELECT BAR OFF-NORMAL CONTACTS
CODE SELECT BAR
CARD SUPPORT BAR
SOLENOIDS
UPPER CARD GUIDE BAR
PULL-UP MAGNET
LATCH CONTACTS
MULTIPLE PLUG AND JACK
ASSEMBLY
INTERLOCK SWITCH
CARD SUPPORT LIFT MAGNET
CONTROL SWITCHES
CARD LIFT BAILS
PHOTO-TRANSISTORS
CARDS
CARD CAGE
LATCHES

mounts may be swung aside as gates to gain access to the photo-transsistor lenses for cleaning. The photo-transistor mounts are illustrated by Fig. 38.

COVERS

Covers are provided for the four sides of the translator and its top. These covers may be dismounted quickly when servicing is necessary. The base casting is cut away beneath the covers so as to form air passage ways to its interior. The covers are perforated near their top and in this way a chimney effect is created which is beneficial to cooling.

4A AND B APPARATUS UNITS

All of the static elements, that is, the light source, the collimating lenses, the card cage, the pull-up magnet superstructure, the photo-transistor mounts, the terminal block, and the multi-terminal jack subassemblies, the framework, the covers and sundry details are combined in a subassembly known as the 4 type apparatus unit.

COMPREHENSIVE SCHEMATIC

The over-all appearance of the working translator is disclosed in Figs. 12, 13, 39 and 40. The principal component groupings entering the assembly have been discussed at some length and have been illus-

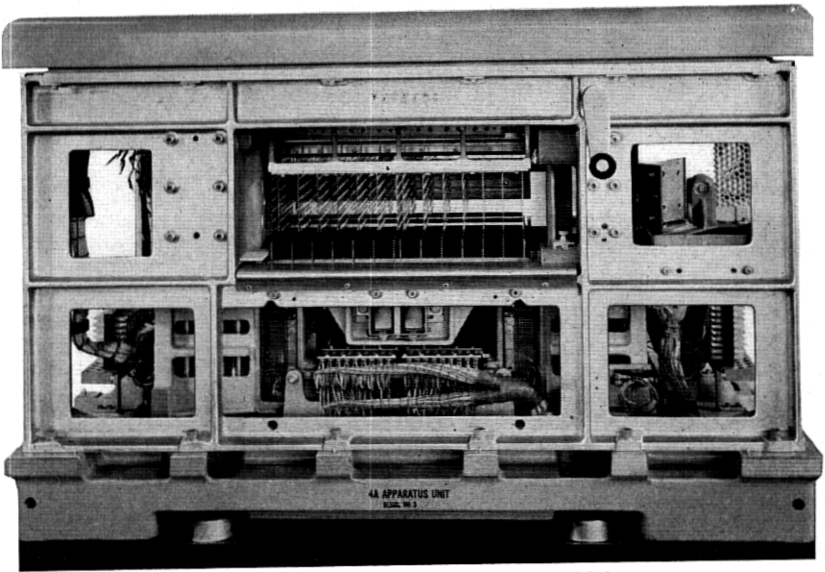


Fig. 40 — Translator (card access side).

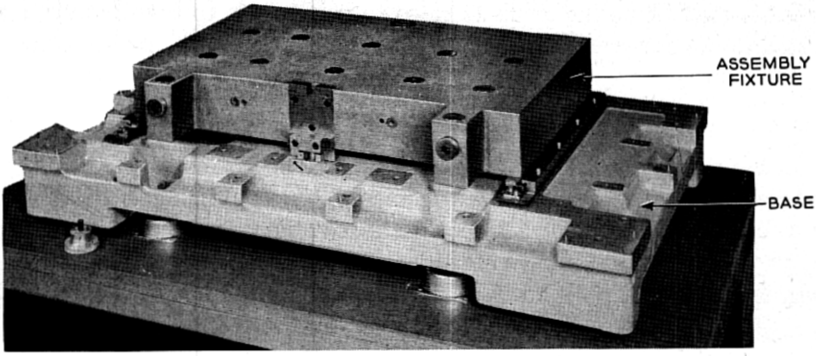


Fig. 41 — Base and assembly fixture.

trated in other figures. However, the combination of these principal components needs to be illustrated more specifically. Fig. 39 serves this purpose.

WORKING TRANSLATOR

Fig. 40 is a view of the working translator showing how the supporting structures knit together the principal components illustrated

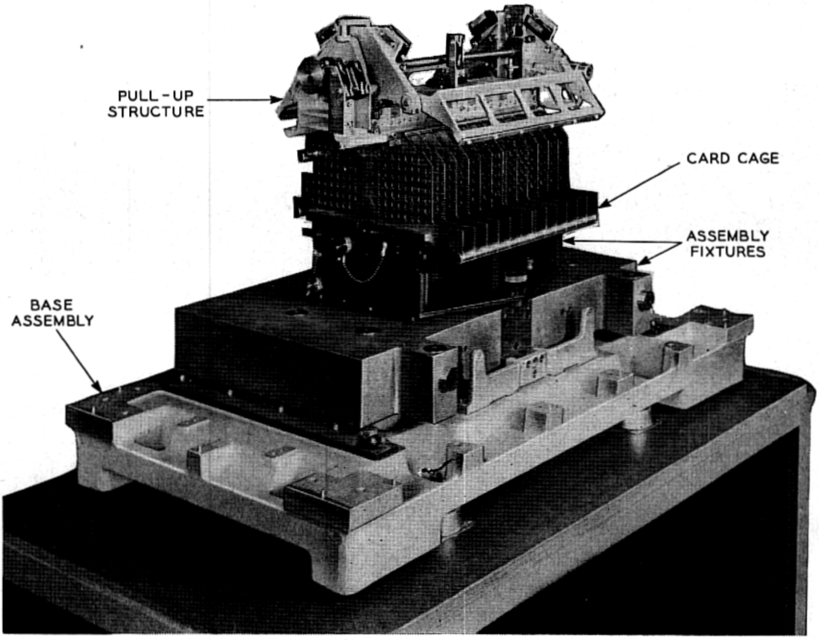


Fig. 42 — Base and assembly fixture together with card cage and pull-up superstructure.

in perspective by Fig. 39. It supplements Figs. 12 and 13, which depict the translator with its covers in place. The coded translator (1A) is 38″ long by 21-½″ wide by 27″ high. Its weight is approximately 410 lb. The weight of the dynamic unit is approximately 110 lb.

BASIC PLAN FOR CONSTRUCTION

As the development progressed, it became apparent that unusual and exacting manufacturing problems would be encountered which could be solved to best advantage by providing design features that would facilitate alignment of the light tunnels, the optical elements, the card select and card support bars with respect to the tabs of the cards, etc. Accordingly, the design was worked out so that the assembly could be built up around a base casting provided with reference surfaces and locating pins adapted to be used with a surface plate type of fixture that could be mounted in the space normally occupied by the dynamic unit and upon which supplementary fixtures could be mounted for

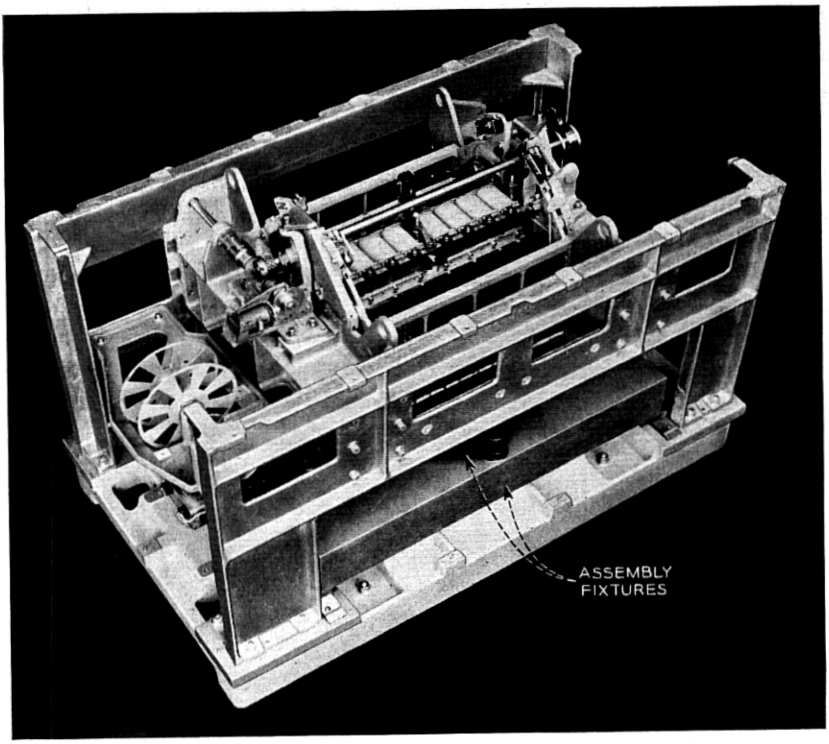


Fig. 43 — Base and plug assembly fixture, card cage and frames.

aligning the various components. With fixtures of this kind virtually all assembly can be made without resorting to measurements. The design of the translator and the fixtures were, therefore, carried forward concurrently.

An initial step in fabricating the card translator with the aid of these fixtures is illustrated in Fig. 41, in which the basic surface plate is shown mounted on the base casting. Fig. 42 shows another step in the fabrication of a translator. It will be noted that in this instance a supplementary fixture had been added which supports the card cage and the pull-up magnet superstructure. Later the side frames are added and these too are located by means of the fixtures as is indicated by Fig. 43. It will be understood that many additional fixtures are used in completing the job and that one of the most important of these is a fixture which locates the gates in which the phototransistors are mounted. However, by the time this fixture is used, the assembly has built up to a point where the fixture used is obscured by the side frames and other details. This method of construction has proved to be very effective as is evidenced by the fact that after assembly there have been no cases where the performance requirements could not be met readily because of misalignment of components.

The development of nationwide dialing is the result of close cooperation of many people in the American Telephone and Telegraph Company, the associated Telephone Companies and particularly for the card translator, the Western Electric Company, as well as of many people in Bell Telephone Laboratories. All who have had a part in this development, which may justifiably be considered a milestone in the development of the switching art, can view with pride their accomplishments. This development, serving as the means for connecting on a nationwide basis all the customers' lines into one vast automatic switching network, is truly a major contribution to the telephone art.