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AMTRAN HARDWARE - AN ELECTRONIC INTERFACE TO SIMPLIFY AND SPEED UP MAN MACHINE COMMUNICATION

By Juris Reinfelds, R. N. Seitz, L. H. Wood and C. A. Ely

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ABSTRACT

This report contains a complete description of the AMTRAN II on-line remote terminal for the IBM 1620 computer. It provides easy and rapid communication with the computer through a large keyboard, immediate display of intermediate and final results on a cathode ray oscilloscope and hard copy on a special typewriter.

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RESEARCH PROJECTS LABORATORY
RESEARCH AND DEVELOPMENT OPERATIONS

ACKNOWLEDGMENT

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SUMMARY

This report contains a complete description of the AMTRAN II on-line remote terminal for the IBM 1620 computer. It provides easy and rapid communication with the computer through a large keyboard, immediate display of intermediate and final results on a cathode ray oscilloscope and hard copy on a special typewriter.

INTRODUCTION

A basic aim of the AMTRAN (for Automatic Mathematical Translation) System is to improve the speed and ease of man-computer communications. The hardware described in this report was designed to make this possible. The design employs technology which is readily available although it sometimes uses it in unusual ways to achieve our goals at a low cost.

A prototype AMTRAN terminal as shown in Figure 1 would cost about $10,000.00. However, in quantity production a more advanced version could be constructed at a price of $5,000.00 to $7,000.00. This price would be comparable to the cost of a teletype terminal unit or a modern electronic desk calculator.

This report describes our first operational terminal, called AMTRAN II, which has been working for some time. The basic features of the design have been checked out but there is still room for many improvements. Some of these have already been incorporated into the design of AMTRAN III which is at present under construction and will be the subject of a subsequent report (see Figure 1).

Commonly Encountered Notations

A brief list of the more frequent notations to be used throughout the following chapters is given here. Other notations are introduced in the text

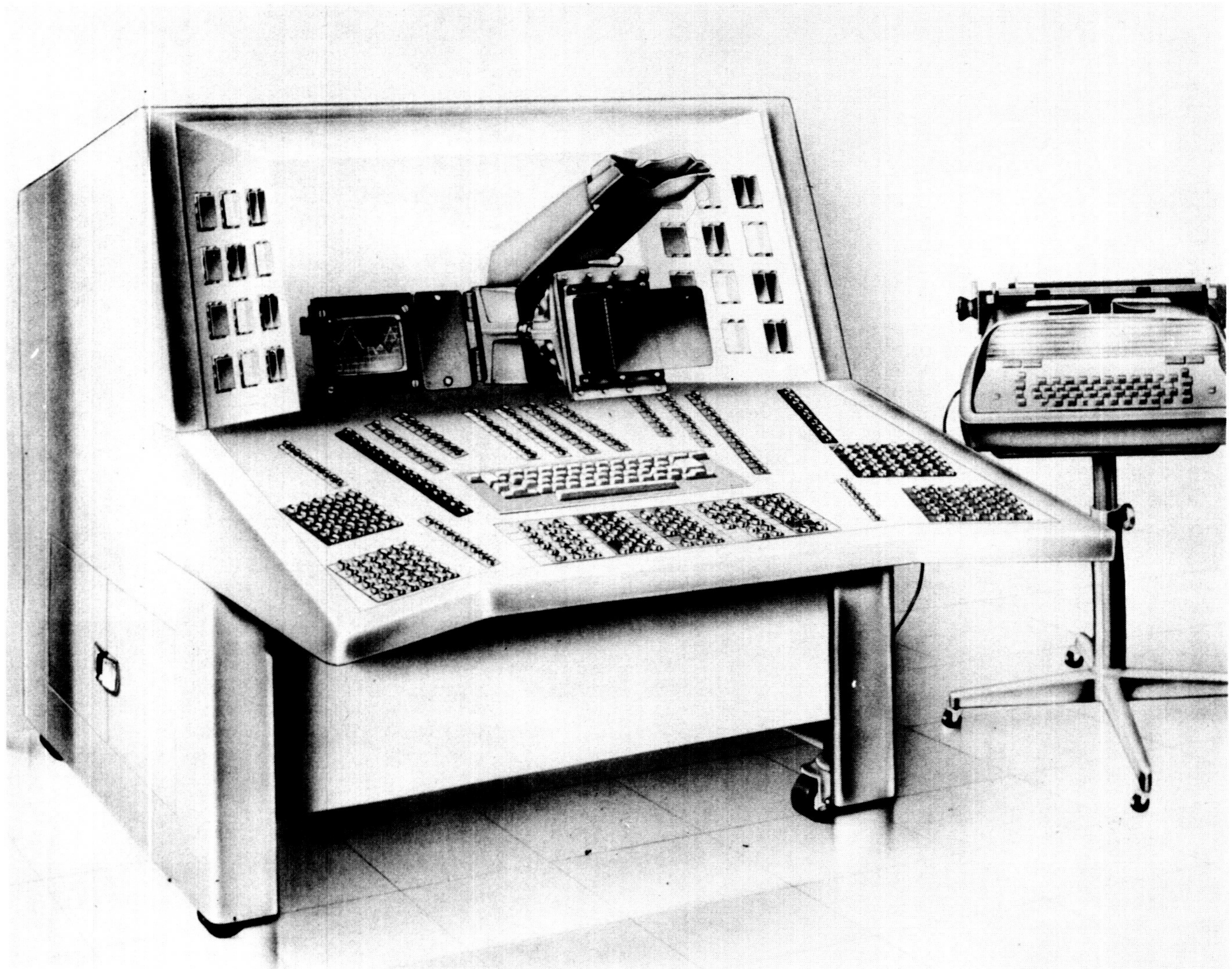


FIGURE 1. AN ARTIST'S CONCEPTION OF THE AMTRAN III TERMINAL

when they first appear. AMTRAN II employs "S" level logic. A signal is

$$\begin{aligned} \text{On} &\equiv \text{logic } 1 \equiv -12\text{V} \equiv -\text{S} \\ \text{Off} &\equiv \text{logic } 0 \equiv \text{OV} \equiv +\text{S} \end{aligned}$$

For communication with the 1620 "C" levels are used

$$\begin{aligned} +\text{C} &\equiv +2.0\text{V approx.} \\ -\text{C} &\equiv -3.5\text{V approx.} \end{aligned}$$

Output from the 1620

$$\text{On} \equiv \text{logic } 1 \equiv +\text{C}$$

Input to the 1620

$$\text{On} \equiv \text{logic } 1 \equiv -\text{C}$$

For a signal denoted by SIG say, the inverse signal is denoted by $\overline{\text{SIG}}$. When SIG is "on," $\overline{\text{SIG}}$ is "off" and vice versa.

X^2 - a superscript for a digit is used to denote the power of ten which this digit represents. Thus

$$X^2 \equiv \text{hundreds } X; \quad Y^1 \equiv \text{tens } Y; \quad Z^0 \equiv \text{units } Z.$$

The AMTRAN Computer System

Conventional mathematical terminology as used in textbooks, journals, and lectures is surprisingly consistent not just in any small region of a country, but all over the world. Mathematicians striving for clarity have eliminated most of the redundancies and idiomatic peculiarities of one's everyday language, leaving a compact unambiguous logical structure. We call it the natural language of mathematics and it seems to be the only logical choice for a universal scientific programming language for scientific programming.

The AMTRAN computer system provides a real time interpreter-compiler for the natural language of mathematics. This permits a scientist or engineer to solve simple mathematical problems without any prior knowledge of computers or programming, much the same as we use electric power with little concern for the internal workings of a power station or the theory of transmission lines.

Providing nothing but just preprogrammed mathematical operators would make such a computer system too rigid and limited since no matter how extensive a set of operators we provide, there will always be problems for which it is inadequate. Therefore, some programming capability was included with AMTRAN, so that the expert programmer can readily construct new mathematical operators as required by the mathematician. In this sense, AMTRAN is a programming system rather than just another programming language. Most programming systems provide a set of compilers from which one can choose to work. AMTRAN allows a continuous choice of level of programming which is most suitable for the problem at hand and which may vary during the development of the program. This situation is depicted pictorially in Figure 2, which shows the knowledge gap between the requirements of a computer and the needs of a mathematician. By providing capabilities at both ends of the gap in one package, AMTRAN allows an economical bridging of the whole gap by appropriate choice of a mixture of the programming and the higher mathematical capabilities.

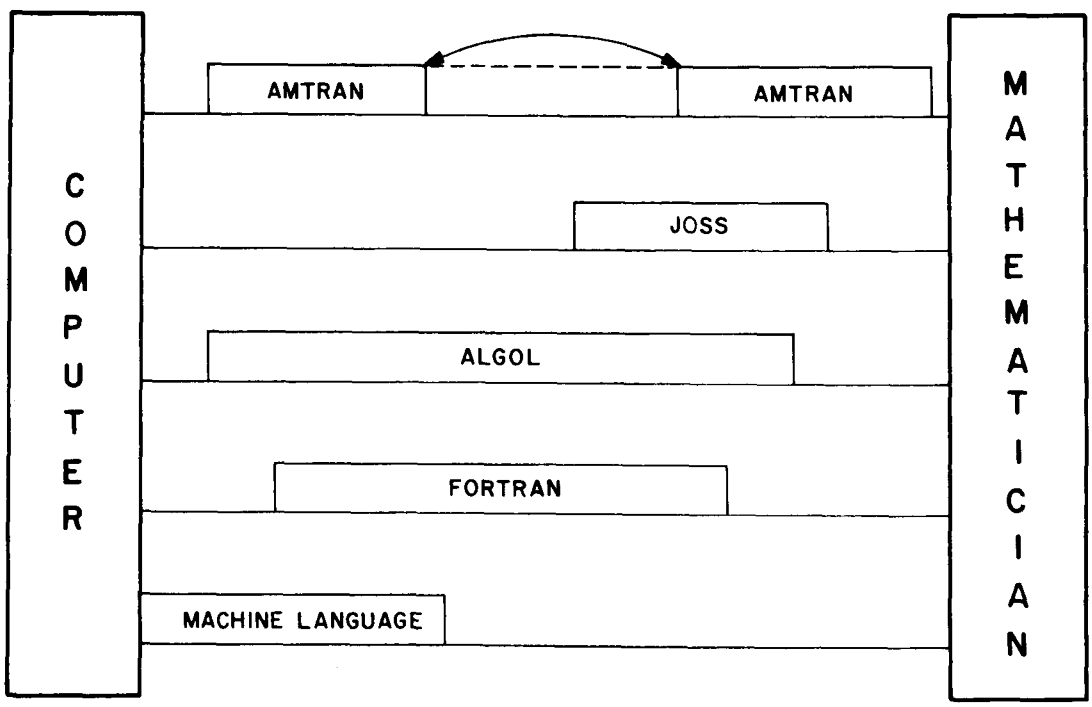


FIGURE 2. THE GAP IN KNOWLEDGE BETWEEN THE REQUIREMENTS OF COMPUTER AND THE NEEDS OF A MATHEMATICIAN

A most important part in the development of the AMTRAN system has been the provision of flexible and direct communication with the computer.

To achieve this result, an on-line remote terminal unit was designed and developed which utilizes only readily available components and satisfies all requirements set by the AMTRAN system and the implementation of the natural language of mathematics. The basic requirements for such a terminal are:

(1) easy installation in any location
(2) immediate graphical display of intermediate and final results
(3) a permanent hard copy of useful programs and results
(4) easy entry of a large set of operators which sometimes have lengthy mnemonic labels
(5) some provision of an editing capability which would allow easy entry, use and deletion or alternation of a reasonable number of operators. In this manner, every user can conveniently and rapidly adapt the system to his own highly specialized needs.

Figure 3 shows the AMTRAN II terminal which is presently attached to an IBM 1620 Model II Computer via a Special Input-Output Adapter RPQ M10376 supplied by IBM.

AMTRAN II TERMINAL

General Description

A block diagram of the AMTRAN II terminal is shown in Figure 4. It was developed specifically for operation on the IBM 1620 Computer, hence, the subsequent discussion will assume that AMTRAN's multiplexer interface is connected directly to the IBM 1620 Computer through a Special Input-Output Adapter using a cable not longer than about 50 - 100 feet. It should be noted however, that the basic terminal concept can be associated with any computer system.

AMTRAN III, presently under development, will accommodate a data phone adapter and, therefore, will allow the terminal to be attached to any computer system at an arbitrarily remote location.

A typical AMTRAN terminal unit consists of a large functional operator keyboard, a typewriter and two storage oscilloscopes. One of the scopes has a Polaroid camera attached to provide immediate hard copy of any alphanumeric

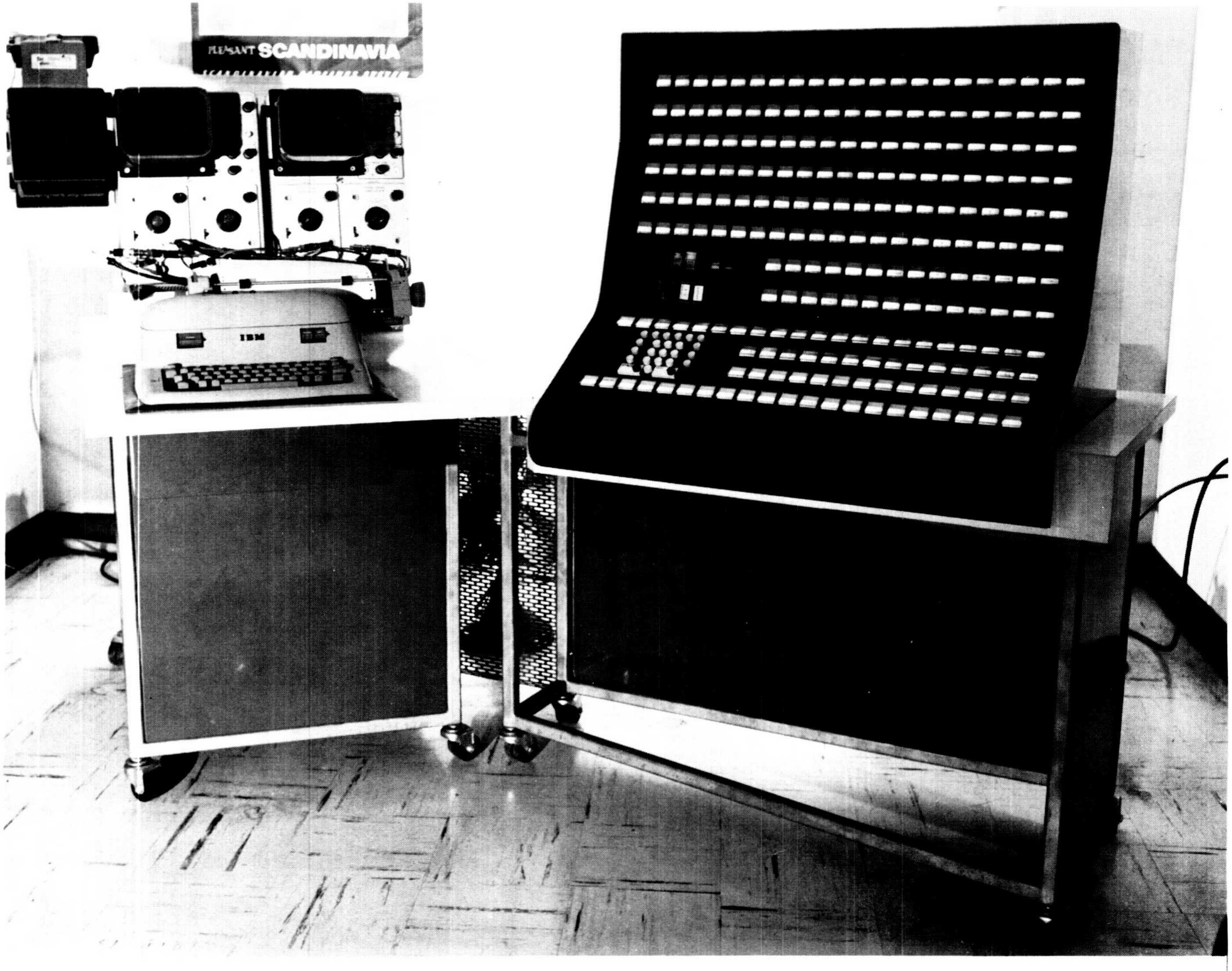


FIGURE 3. THE AMTRAN II TERMINAL

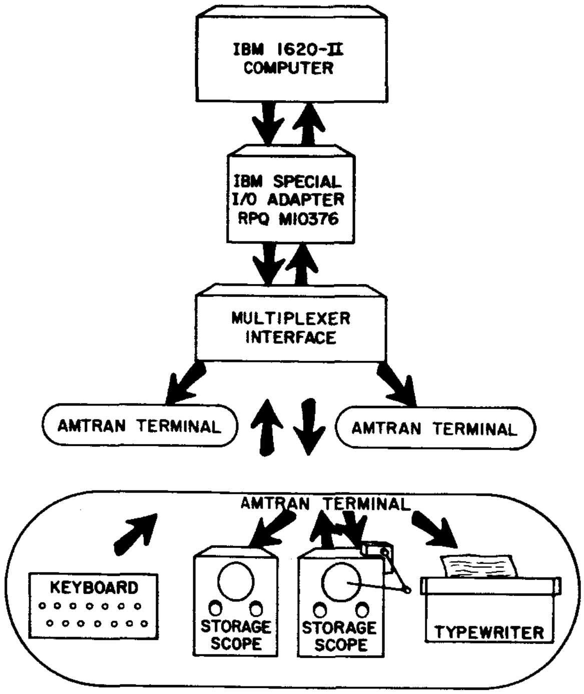


FIGURE 4. A BLOCK DIAGRAM OF THE AMTRAN II TERMINAL

or graphical display on the scope. The interface between the input-output equipment of the terminal and the computer is accomplished by an electronic multiplexer.

As seen in Figure 4, the electronic multiplexer interface can accomodate up to three AMTRAN terminal units. Complete circuit diagrams of the multiplexer are given in Appendix C and should be consulted in conjunction with the text. The necessary logic circuitry employs standard Raytheon Computer 200 kc germanium digital circuit modules except for some decode and utility cards which were designed to meet special requirements. The schematics of the latter are given in Appendix A.

Keyboard

A basic purpose of the natural language of mathematics is to prescribe an unambiguous procedure by which a sequence of well defined separate entities called operators act on a set of numbers to produce a new set of numbers. The operators may be simple arithmetic operators like +, -, etc., or they may be described by long mnemonic labels.

A keyboard affords the only way in which any operator, regardless of the length of its label, can be entered into the computer by a single action, in this case by a single button push. Furthermore, it is impossible to confuse the implied multiplication of the symbols S, I, and N with the operator label SIN because on the keyboard SIN will be represented by a single button and S, I, and N by three separate buttons activating different call codes.

The AMTRAN II keyboard is shown in Figure 5. The keyboard contains 224 lighted microswitch push buttons. The plastic screen on each button is split longitudinally with the lower half yellow and the upper part white allowing each half to be lighted separately. Thus, each button can be used for two independent operators and the total number of available buttons is doubled to 448. A level selector switch on the indicator panel allows one to choose whether to interpret the buttons according to the top labels or the bottom ones, by lighting the appropriate side of the screen.

Each push button causes a unique code to be sent to the computer. In the computer, the AMTRAN software interprets the code and executes the desired response.

A schematic drawing of a keyboard decode operation is shown in Figure 6. Each key consists of a microswitch 2C 203 operator indicator unit with a microswitch 2D 139 low force, two pole, momentary contact subminiature switch unit with silver contacts.

The IBM 1620 is a BCD (binary coded decimal) machine, hence decimal numbers are used to code the keys. Each key is assigned a number $0 \leq N \leq 299$. One of the poles of each switch is connected to a common line for each units digit. For example, one pole of all keys with code numbers ending in 3 (say 003, 073, 213) are connected together. The keyboard is divided into three groups namely zero hundreds, one hundreds and two hundreds. The other pole of each switch is used to tie all tens digits together in each group. This produces three lines for each tens digit, which are brought into a small diode matrix to decode the hundreds digit and joined through diodes to provide a single line for each tens digit in addition to the 0, 1, 2, hundreds lines and the 10 units lines described previously. This decode is shown in Apprendix A VI. The level selector switch in the indicator unit (see Figure 7) adds a "four"

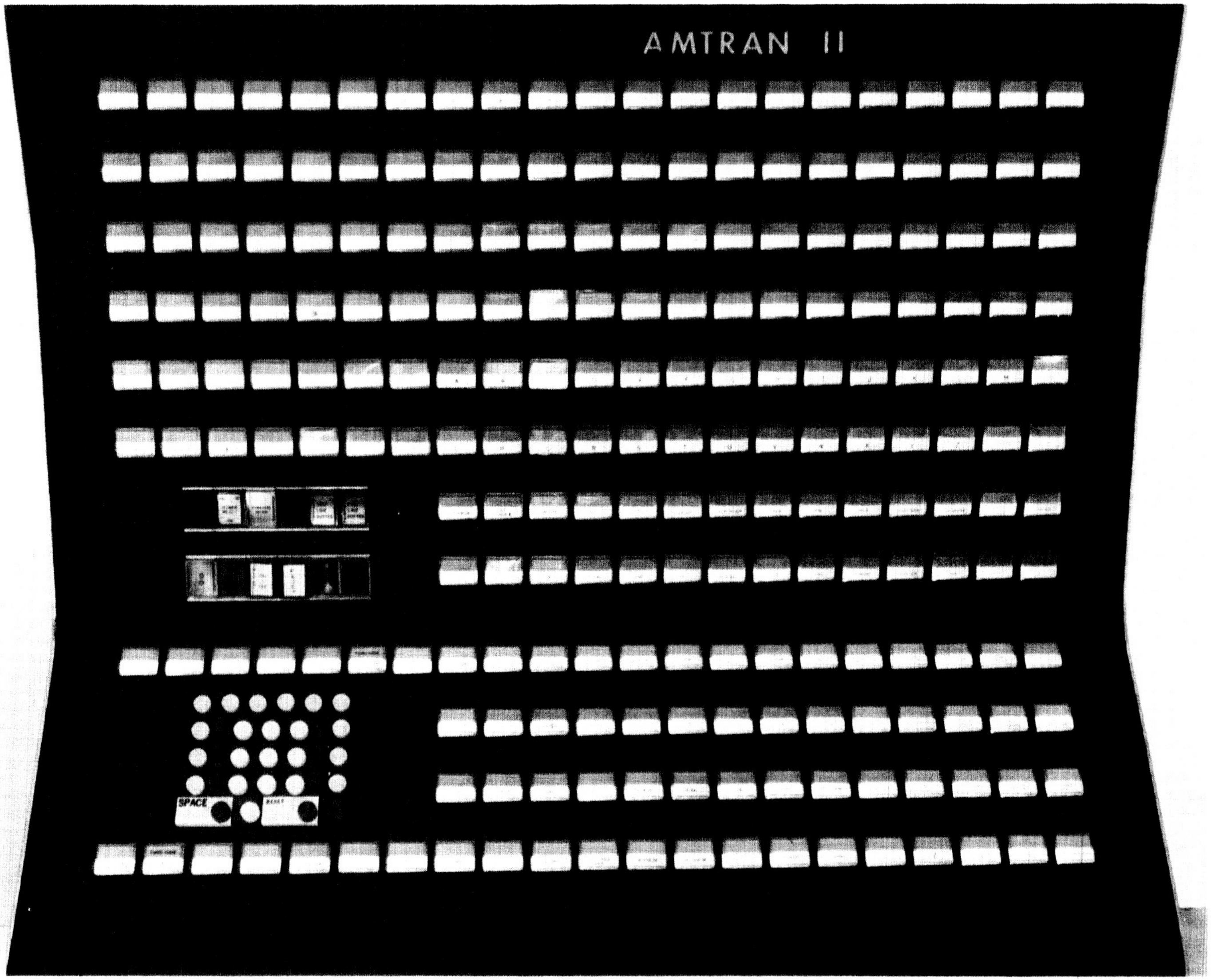


FIGURE 5. THE AMTRAN II KEYBOARD

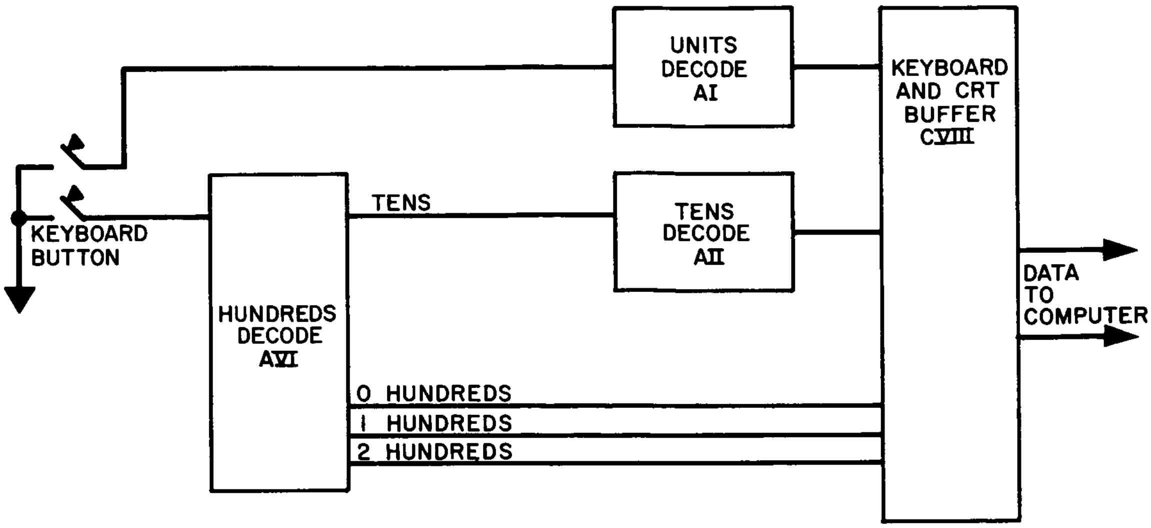


FIGURE 6. KEYBOARD DECODE OPERATION, SCHEMATIC

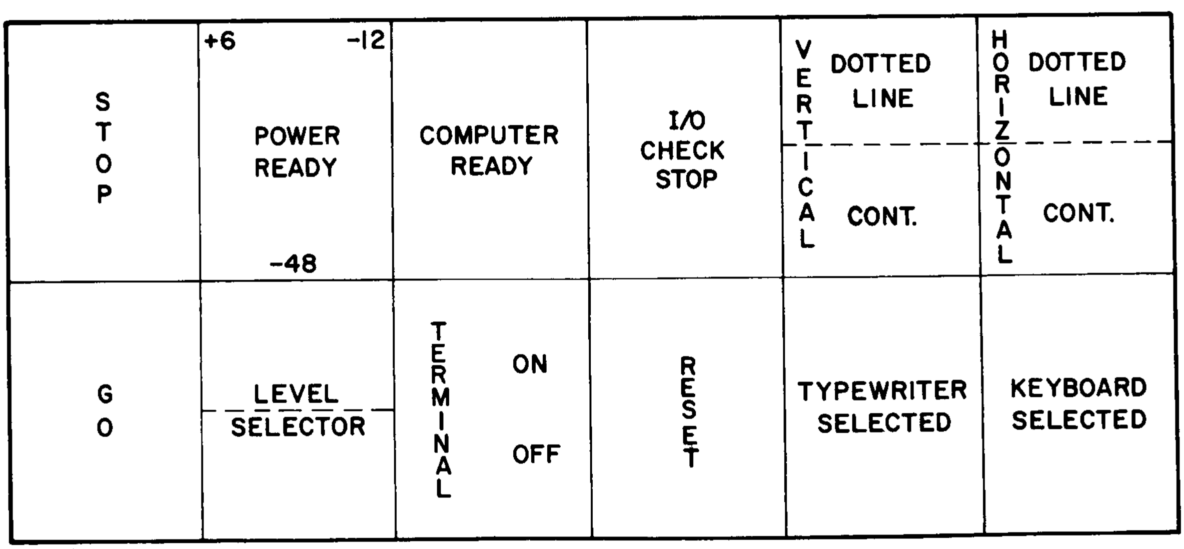


FIGURE 7. INDICATOR LIGHTS AND SWITCHES

digit to the hundreds when a key is depressed and the top level selected. The codes on the top level are, therefore, numbers between $400 \leq N \leq 699$.

The hundreds digits 0, 1, 2, and 4 are already BCD characters as well as decimal digits. Hence they can be brought directly into the KB buffer, Appendix C VIII to set the appropriate flip-flops. The tens and units digits must go through a decimal to BCD diode decode first, before they are allowed to set the BCD code in the buffer flip-flops. Schematic drawings of these decode cards are given in Appendix A I and A II. Note that the units decode of A I provides a common signal which is activated every time a button is pushed.

When a key is depressed, say 123, for example, the lines 1 hundreds, 2 tens and 3 units are grounded. Through the two diode decode matrices just described, this sets the 1 of hundreds, 2 of tens, and 1 and 2 of units in the KB buffer of C VIII, by grounding the reset outputs of the appropriate flip-flops. It also sets the signal KBRO indicating that a button has been depressed. When the button is released, the buffer is ready to be read into the computer. The keyboard read operation will be described in a subsequent paragraph.

AMTRAN II keyboard contains no protection against the simultaneous depression of two keys nor against pushing a key before the computer has read the previous code. With a single station on-line this is not a great problem because with an instantaneous response from the computer one can make immediate corrections. However, for remote phoneline operation of many terminals on a large computer system some protection is necessary and will be included into AMTRAN III.

Indicator Unit

AMTRAN II contains two indicator units. One is located on the keyboard and provides information concerning the status of the system in relation to the computer. The other indicator unit is located in the multiplexer interface box. It is used mainly for diagnostic purposes and it displays the state of the key flip-flops in the multiplexer interface. Details of the multiplexer monitor indicators are found in Appendix C XIII.

A schematic of the keyboard indicator unit is shown in Figure 7. Starting with the top row, left-hand corner we have the following indicators, some of which contain a switch to select a choice of two conditions.

STOP

A red light in the STOP indicator appears whenever a button is pressed and is switched off when the computer reads the code from the buffer.

The purpose of this indicator is to warn the user not to press another button before the previous one has been read.

It is activated by the KBRO signal which comes true as a button is pushed and goes off when the computer has read the last digit of the code.

GO

The indicator located below STOP is the inverse of the STOP signal in AMTRAN II. A green light in the GO indicator appears whenever a button may be pressed by the user. It is activated by the KBRO signal.

POWER READY

Both sides of this indicator should remain on for normal operation of the system.

This is a multiple indicator showing whether all power supplies in the system are working properly. Top left-hand light is lit when +6V supply is active, top right-hand for -12V and the bottom half for -48V. The lights are activated directly from the appropriate power supplies.

COMPUTER READY

This indicator should be on for normal operation of the system. It lights up whenever the computer is switched on.

It is activated by a +24V level sent by the computer indicating that all voltages inside the computer are in a working condition.

I/O CHECK STOP

This indicator should be normally off. It lights up red whenever a check stop occurs on the central processing unit of the 1620 computer.

It can only be reset from the computer console and it tells the AMTRAN user at the remote terminal that all is not well inside the computer and an operator familiar with the use of the 1620 may have to be consulted.

It may be, however, that the check stop was caused by the misreading of a character in an I/O operation, so first one should just push Reset followed by Insert at the 1620 console and type 4902402 RS to get the AMTRAN program going again. For simple read or write checks this will restart AMTRAN without reading in the whole deck again.

VERTICAL DOTTED LINE CONTINUED

This is an indicator containing a selector switch which adds or removes a parallel capacitor and series resistor to the input line of the vertical amplifier of the cathode ray scopes. Without the extra capacitance, the trace moves so quickly across the scope face that only the end points are stored and a dotted display results.

The capacitance slows the rate at which the beam moves from point to point and a continuous trace results.

The indicator light shows which case is selected and pushing of the indicator toggles the switch from one case to the other.

HORIZONTAL DOTTED LINE CONTINUED

This indicator operates exactly like the one described above except that it controls the horizontal amplifier of the scopes.

LEVEL SELECTOR

This indicator contains a switch which allows the user to select either the top or bottom level of interpretation of the keys on AMTRAN II. The screen has the same white top, yellow bottom split as the keys but the lights in the keyboard button indicators themselves show which interpretation is selected. The level is changed by pushing the indicator and the necessary four of hundreds digit is automatically added to the key codes whenever the upper level is selected.

TYPEWRITER SELECTED — This indicator lights up whenever AMTRAN is addressing the special typewriter of the terminal unit. It is mainly intended for quick trouble shooting of maintenance problems in the multiplexer interface and typewriter circuitry.

KEYBOARD SELECTED — This indicator lights up whenever AMTRAN is addressing the keyboard of this terminal unit. Again its main purpose is for diagnostic trouble shooting in multiplexer maintenance.

Two of the indicator lights of AMTRAN II are at present not used for any particular purpose.

Storage Scopes

A typical terminal contains two Tektronix Model 564 storage oscilloscopes. One is primarily intended for displaying messages and alphanumeric codes, the other for displaying curves. Their roles are completely interchangeable and both scopes may be used to display curves as in conformal mappings or to display two pages of a long message. This is possible because both scopes share a single input-output buffer (Appendix C VIII) and AMTRAN's set of alphanumeric and mathematical symbols is stored in core.

The computer can address either scope by using the appropriate selection code. A true signal on a scope select line removes a -20V level from the control grid of that scope and the unblanked beam writes the message.

The Digital to Analog converters of C VIII are arranged to provide three decimal digit accuracy on each axis. This provides an effective grid of 1000 x 1000 points over the usable portion of the scope face which is about 8 cm x 10 cm.

Each character in the alphanumeric and special symbol set shown in Figure 8 is first coded inside a basic rectangle of 18 x 30 units of the 1000 x 1000 point grid using on the average about 10 points to describe the character. These coordinates are stored in the computer and called by AMTRAN whenever necessary. The WRITE ON SCOPE operator automatically positions the characters one behind the other and into the next line after a predetermined line length has been reached. Furthermore, before it starts to write a word it checks to see whether it will fit into the space remaining on a line. If the word is too long, the computer automatically "carriage returns" the scope and begins a new line.

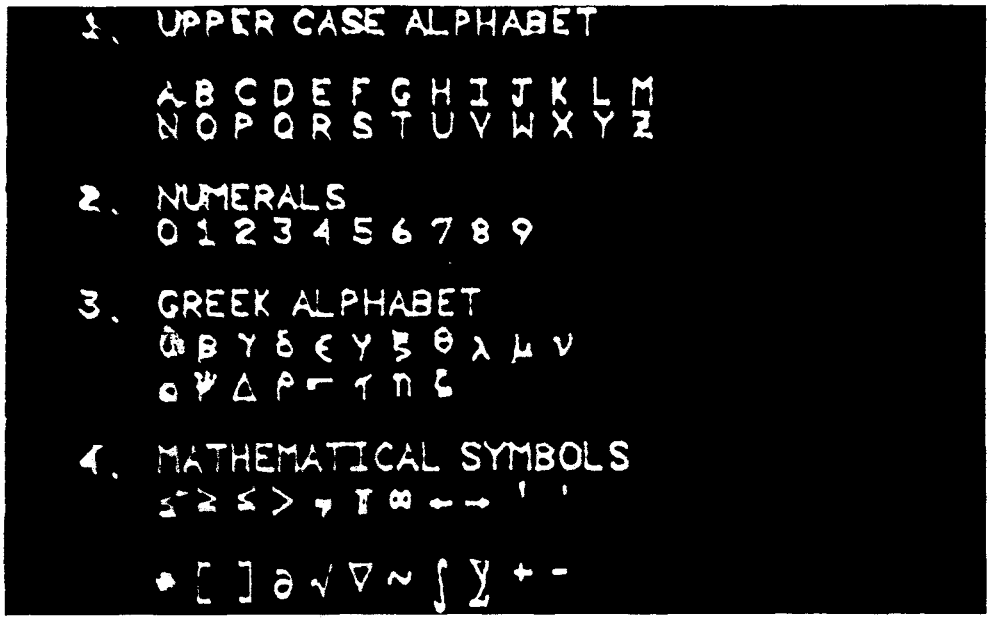


FIGURE 8. ALPHANUMERIC AND SPECIAL SYMBOL SET AVAILABLE IN AMTRAN

Although 20 lines of up to 40 characters long may be put on the scope face at one time, normally 14 lines with 34 characters are used for ease of reading and a more pleasant appearance.

The performance, resolution and other operating characteristics of the storage scopes have been entirely satisfactory. As seen from Figure 8, the quality and legibility of the lettering compares favorably with characters generated by special core rope devices in real time scope systems.

The most important advantage of a storage scope is that displays of arbitrary complexity may be constructed by computing and displaying each element of such a display just once. In television raster type displays the whole display has to be stored in a sufficiently large and fast buffer to permit a replenishment of the image at least several times per second. Unless one uses a very large buffer, the complexity is necessarily limited to a small number of points which may be displayed at any one time although the points may be positioned on a fine underlying grid of 1000 x 1000 over the scope face.

A storage scope with a 1000 x 1000 raster on the other hand requires only a six decimal digit buffer as used in C VIII, to hold the beam at a point on the scope face while the coordinates of the next point are being assembled.

The indicator panel on the keyboard allows us to select either a dotted or continuous display. The dotted display should not be used for alphanumeric display. In this mode the Digital to Analog converters are connected directly to the X and Y amplifiers so that between points the writing beam moves too fast to register a trace. Continuous mode introduces a series resistor and a parallel capacitor to the amplifier input and slows the beam between points so that a visible trace is produced.

A remote erase attachment supplied by Tektronix is installed in the scopes so that a display may be obliterated by calling the ERASE operator in AMTRAN or typing 34 00000 04000 in SPS.

Remote blanking (Z-axis control) is achieved by switching a -20V level directly onto the main control grid of the oscilloscope tube. The switch is controlled by AMTRAN software through the select register.

A standard Polaroid camera is provided on one of the scopes for a quick hard copy of any useful results.

Stylus

A mechanical stylus for direct input of graphical data is at present under construction. When completed, it will perform most of the functions of a light pen, the present favorite input device of regenerative displays. It is, however, not included in AMTRAN II at present.

Typewriter

The AMTRAN II terminal contains an IBM Model B Input-Output Writer with a specially selected symbol set. Because only 88 type positions are available, we do not have the freedom of the WRITE ON SCOPE display. The typewriter is necessary for hard copy, however, because there seems to be no low cost photographic or electrostatic copier on the market which could be used to make a fast permanent copy of the scope face. The Polaroid process is too slow and costly for a general copy of all programs although it is excellent for fast copies of a graphical result.

The main problem in this development was to achieve reliable solid state switching performance to activate the typewriter keys and to design the interface logic which will be described in a later section.

A special two level decode matrix had to be constructed (shown in Appendix A III and A IV).

No modifications have been made to the Model B I/O Writer of AMTRAN II. The selectric typewriters chosen for AMTRAN III will be equipped with forward and reverse half-line indexing capability. This will provide a more flexible typewriter for writing mathematical expressions.

AMTRAN II uses the typewriter for output only. The keyboard contains all the symbols available on the typewriter, hence, only the output interface was built for the Model B Input-Output Writer.

Multiplexer Terminal Interface

The electronic multiplexer terminal interface represents the major developmental effort of the AMTRAN terminal. A block diagram of AMTRAN II multiplexer is shown in Figure 9. It maps out the main parts of the design which can be found in the appendices indicated. It also indicates the flow of data and control signals coming and going between the terminal and the computer.

The interface logic was designed using standard Raytheon Computer 200 kc germanium digital circuit modules, except for some decode cards which were designed by the authors.

The logic levels used are Raytheon S-levels with

$$\begin{array}{rcccccc} 0V & \equiv & \text{logic } 0 & \equiv & \text{logic FALSE} & \equiv & +S \text{ level} \\ -12V & \equiv & \text{logic } 1 & \equiv & \text{logic TRUE} & \equiv & -S \text{ level} \end{array}$$

The interface performs two basic functions. First, it has to establish communications between the terminal and the computer and second it has to synchronize and switch the ensuing data flow to operate all the terminal devices at their specific rates. In the case of the keyboard and typewriter, contact bounce of mechanical switches has to be eliminated. Soft action switches proved to be especially notorious in regard to contact bounce and conservatively long period tandem one-shots are used to overcome this problem.

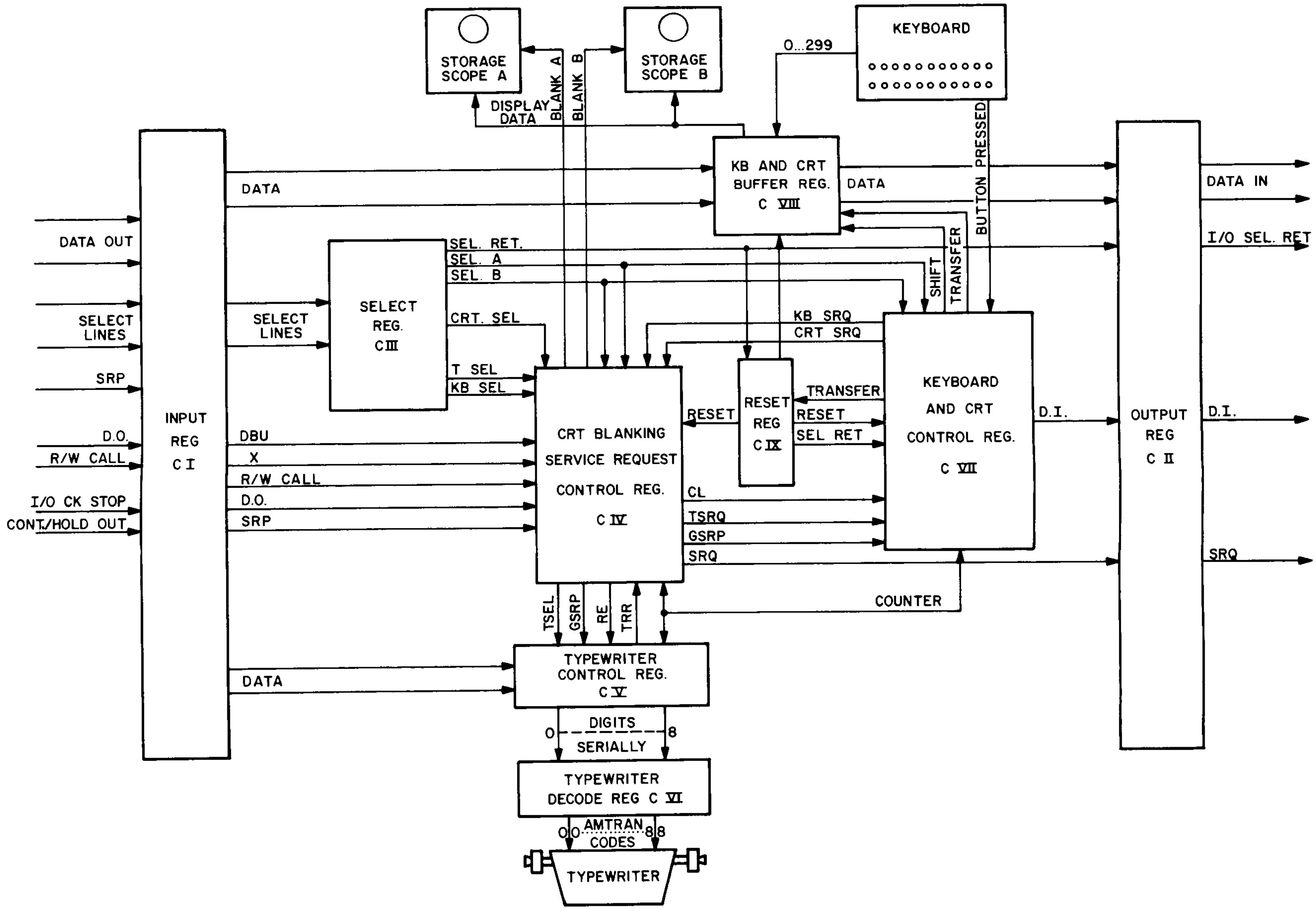


FIGURE 9. A BLOCK DIAGRAM OF THE ELECTRONIC MULTIPLEXER INTERFACE

INPUT-OUTPUT OPERATIONS ON THE IBM 1620 COMPUTER

The IBM 1620 II Computer is a solid state data processing system composed of several units: the 1620 Computer Unit, the 1625 Memory Unit, the 1622 Card Reader Punch, the 1311 Disk Storage. Special non - IBM devices can be connected to the Computer Unit through a Special I/O Adapter RPQ M10376.

Information in the 1620 is carried as binary coded decimal digits. The basic digit has six binary bits composed of four numerical bits, one flag bit and a parity check bit. Characters are represented by one or two digits as required by the numerical or alphanumerical mode of operation.

The basic word length is not fixed and character strings of arbitrary length may be manipulated by the computer. Computer instructions, however, do have a fixed word length of twelve digits, arranged as:

$$0_0\ 0_1\ P_2\ P_3\ P_4\ P_5\ P_6\ Q_7\ Q_8\ Q_9\ Q_{10}\ Q_{11}$$

The first two numerical digits 0_0 and 0_1 denote the operation to be performed using the list of operation codes given in any 1620 manual. The next five digits P_3 P_4 P_5 P_6 P_7 and the last five digits Q_8 Q_9 Q_{10} Q_{11} represent what is loosely termed the P-address and the Q-address section. Their exact function depends upon the operation which is to be performed.

Data flow through the machine is accomplished by a series of machine cycles. In each machine cycle the computer addresses a memory position, reads a character from that position, and writes a word back into that position. The machine cycle is 10 microseconds long. When a read, write, or control operation is called, the 1620 will establish communications with its various input-output devices according to the selection code placed in Q_8 Q_9 position of the instruction. P-address contains the address of the first core location that is to be read or will receive information according to the operation code called. The values of the other Q digits are ignored by the computer. A list of the available selection codes is given in Appendix B II. A detailed description of each type of operation will be given in the next section. Here the discussion will be confined to a quick general description applicable to all I/O operations.

Although the internal logic uses "S" levels in the 1620, they are converted to the IBM "C" levels for more reliable cable transmission to the external device. The output lines from the 1620 are on when they are at "+C" level. The input lines into the 1620 are on when they are at the "-C" level.

When the 1620 comes to a read, write or control instruction, it first of all presents the selection code of Q_8 Q_9 to all I/O devices. Each I/O device has to decode the incoming selection code and prevent the activation of any of the communication lines if the device is not selected.

The device which is selected returns a signal to the computer on the I/O Select Line indicating that it knows that it is being addressed. I/O Select gates all other communication lines going through the special I/O adapter except, of course, the selection codes themselves. Therefore, the selected device has to turn this line on to establish any communication at all.

On receipt of the I/O Select return signal the computer presents a Service Response signal to the device indicating that it is ready to read or write, as the case may be. The I/O device now completes its share of the tasks specified by the operation code and sends a Service Request pulse to the 1620 indicating that it is ready for or with the next piece of information.

An operation is terminated either by the 1620 when it senses a record mark in the memory on a write instruction or by the external device by sending a Disconnect In signal.

OPERATION OF THE AMTRAN II TERMINAL

General

The remote terminal draws AC power from an axiliary power plug inside the Special Adapter. In this way, it is switched on and off with the rest of the 1620 system.

A manual switch is available to switch off the terminal, when not in use for prolonged periods, but it should be used with caution making sure the 1620 is in a reset condition as it may cause a check stop of the 1620 system if the terminal is switched on or off during an I/O operation to another device. Future terminals will include an independent automatic switch-off device which will switch off any terminal dormant for a certain length of time at a moment at which a check stop cannot occur on the computer.

Depressing the Reset switch on the 1620 console will restore the KB-CRT buffer and all important control flip-flops to their initial condition. A manual reset button is provided at the terminal for the same purpose, however, it is not possible to reset and restart the computer from the terminal. This can only be done at the 1620 console.

At present, AMTRAN II contains no protection against illegal or incorrect codes generated by accidental depression of a second button before the code of the previous one is read by the computer, therefore, caution has to be exercised in this direction.

The gain and position controls of the horizontal and vertical amplifier should not be manipulated once they are properly adjusted. If a new scope or amplifier has to be installed, proper adjustment is most easily achieved by switching the scope to non-store and writing a geometric square over the maximum limits of the available scope area in a tight loop using a program somewhat like this (from 1620 console typewriter):

```
36 00050 00100 RS

000 000 000 000 000 999 000 999 999 999 999 999 999 000 999 000 ≠
```

Writing each corner twice allows more time for the beam to reach the point concerned before it is dispatched to the next one. The loop, to send the square to the scope, selected by 40, is (after hitting Reset, Insert):

```
38 00050 04000

49 00000 RS
```

The gain and position can now be adjusted to center the square on the scope face and adjust its size to cover all of the available scope area. The focus and astigmatism controls should also be adjusted at this stage to produce optimum sharpness of the writing beam. Subsequently, only the intensity control should be adjusted, otherwise, the whole procedure may have to be repeated because it is difficult to adjust the gain and position accurately when writing with a single trace in the storage mode.

Read Keyboard Operation

In its normal mode of operation, AMTRAN will use a tight read-in loop to interrogate the terminal repeatedly. The loop makes provisions for several terminals which may be interrogated in sequence. At present, AMTRAN II employs only one terminal. If no button has been pushed the enquiry generates a Disconnect In signal (C VII) and the computer proceeds to the next instruction. The loop goes on until a button is pushed. The code is set by collector hold down in the KB-CRT buffer C VIII. The signal KBRO prevents the generation of a Disconnect In and the whole system is held up until the button is released and contact bounce has died down.

For a single console operation on the 1620, it may be permissible to "hang up" the whole system until a button is released, but for multiterminal, multiprocessor computer systems, it would be intolerably wasteful, hence, we are making provisions in AMTRAN III to interrupt the read loop only when a code is ready for readout in the KB-CRT buffer.

The actual readout process is best described by reference to the timing diagram of Figure 10. A keyboard button is pressed (6th line from top) and causes KBRO to come true and it also sets off the (B9-16) one shot. The read keyboard loop comes to a read numeric keyboard instruction and sends a 10 on the select lines. This is decoded in the selection register C III and is sent back on the I/O Select Return line.

The 1620 now sends a Service Response signal to indicate that it is ready to read, and waits for our response. Service Response goes through some protective gating and emerges as the GSRP signal. The GSRP enables the clock to toggle a flip-flop generating the RE pulse.

Returning to our (B9-16) one shot we find it will switch off after 40 ms switching on the (B16-31) one shot. Any prolonged contact bounce with a period of 80 milliseconds or less will in this way trigger the one shots continuously until firm contact is actually made. The signal which will permit us to proceed is BD and either one shot or the depressed button will hold it up.

When the button is released, one shot (B9-31) fires through a Schmidt trigger and holds BD for a further 20 milliseconds.

Finally, BD comes true and enables RE to toggle a flip-flop to generate RE II. The inverse signal $\overline{\text{RE II}}$ is used to trigger a short pulse one shot and generate a SHIFT pulse.

The SHIFT pulse jamb transfers the contents of the KB-CRT buffer C VIII one character to the right so that the hundreds digit of the keyboard code is presented to the output register ready to be read by the computer. A parity decoder automatically provides a check bit whenever it is required because the 1620 requires incoming characters to have odd bit count.

The RE II pulse is returned to the computer on the Service Request (KB SRQ) line. This pulse also increments an internal counter to one. The rising edge of the Service Request pulse restarts the clock of the 1620 and allows the computer to switch off the Service Response signal and to proceed to read the first digit into memory. Then the 1620 returns with the Service Response signal indicating that it is ready to read another character.

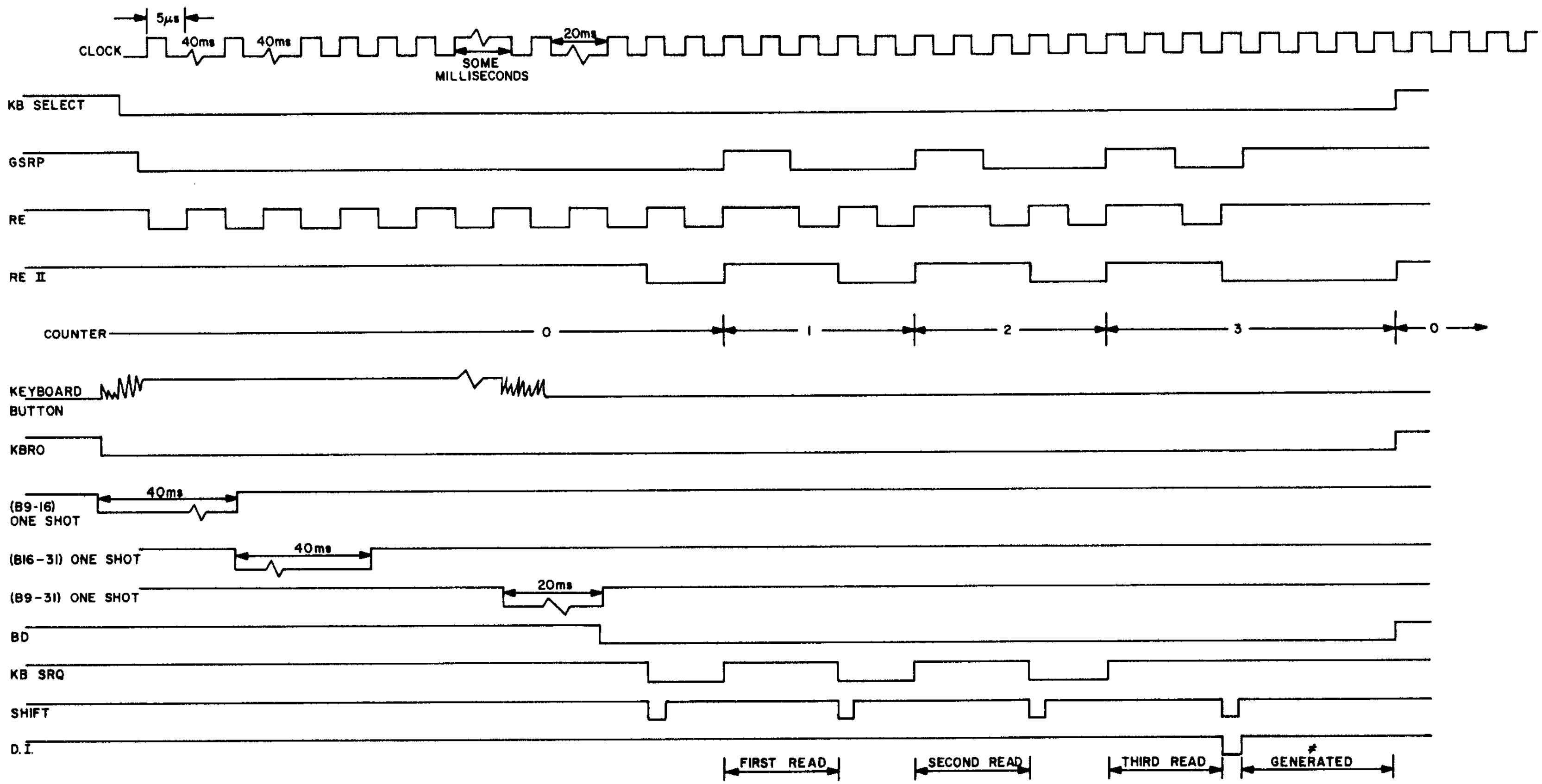


FIGURE 10. READ KEYBOARD OPERATION - TIMING DIAGRAM

Since BD is true, RE can immediately generate RE II and shift the tens digit into the output register. The computer then reads the second digit and the third digit similarly. When the internal counter reaches three, however, KB SRQ is blocked and RE is channeled to fire a short pulse one shot which is returned on the Disconnect In line.

The 1620 generates a record mark, places it in the next core location and proceeds to the next instruction. The DI generates another SHIFT pulse because all data lines have to be off during the generation of the record mark. Otherwise, an illegal character may be generated.

Write Scope Operation

The Digital to Analog converters of C VIII are arranged to position the writing beam according to a three digit decimal number for each axis. Thus, the useful writing area of the scope face is effectively covered by a 1000 x 1000 point grid. The six digits of the coordinates of a point are received serially into the buffer C VIII.

The numbers representing the X and Y coordinates of the points to be displayed have to be scaled to lie between 0≤ coordinate ≤999 and inverted with respect to (999 999) because the origin (000, 000) of the coordinate axes appears in the top right-hand corner of the scope face instead of the usual bottom left-hand corner. The software also must arrange the display in the sequence:

$$X_0^2\ X_0^1\ X_0^0\ Y_0^2\ Y_0^1\ Y_0^0\ X_1^2\ X_1^1\ X_1^0\ Y_1^2\ Y_1^1\ Y_1^0 \text{ etc.}$$

where the superscript denotes the power of ten in the number:

X_i^2	hundreds X_i
X_i^1	tens X_i
X_i^0	units X_i

and the subscript denotes the points of the sequence. The display can then proceed without interruption until the end of the record is reached.

The writing beam may be blanked by placing a flag over the third digit:

$$X_i^2\ X_i^1\ \overline{X_i^0}\ Y_i^2\ Y_i^1\ Y_i^0$$

and the beam is unblanked by a flag over the sixth digit:

$$X_i^2 \; X_i^1 \; X_i^0 \; Y_i^2 \; Y_i^1 \; \overline{Y_i^0}$$

Blanking is removed on entry into a write scope operation, hence, it has to be explicitly set whenever required.

The CRT part of C VIII contains a transfer buffer, which holds the previous point until the next point is assembled. Thus, the writing beam travels from point to point, always remaining at the last point sent, because the transfer buffer is not reset—its contents can only be changed by jamb transfer of another point.

This is useful for many applications, for example, if the computer computes a curve segment by segment, a continuous curve can be drawn because the transfer buffer is not reset between writing the segments.

The write on scope operation is best described by following the timing diagram of Figure 11.

When the computer comes to a write on scope instruction, it sends the appropriate selection code to the terminal. It is decoded and returned to the computer along the I/O Select Return line. This releases all communication lines between the Special I/O Adapter and the terminal and the 1620 proceeds by placing the first digit (hundreds of the X coordinate) on the data lines and sending Service Response signal which in this case indicates that the first digit may be read by the terminal.

The Service Response signal enables the clock to toggle a flip-flop to generate RE pulse. The RE pulse is used to shift by jamb transfer all digits of the C VIII buffer one unit to the right. It also toggles the internal counter to one and goes to the computer on the Service Request line to indicate that the first character has been read.

This switches off the Service Response in the computer. The 1620 places the next character into the Input Register and presents Service Response, repeating the cycle for the next digit. Five digits are placed into the buffer in this way.

When the internal counter reaches five and the sixth digit is on the input lines, the shift pulse is blocked and the RE pulse is released as the TRANSFER pulse which jamb transfers all six digits into the transfer buffer

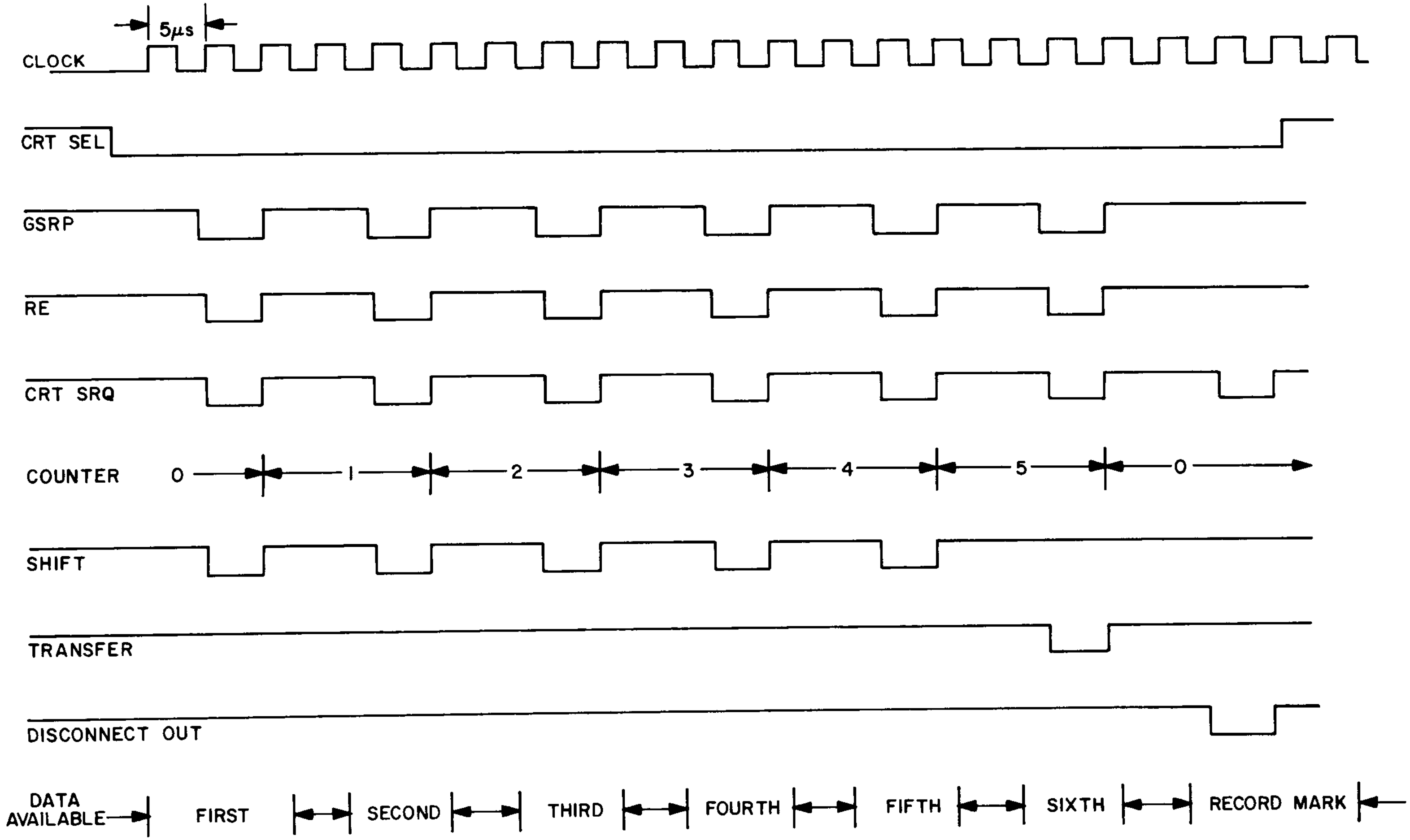


FIGURE 11. WRITE SCOPE OPERATION - TIMING DIAGRAM

which repositions the writing beam through the D/A converters. The transfer pulse resets the counter and the terminal is ready for the first digit of the next number.

When the 1620 senses a record mark in memory indicating that all digits have been sent, it presents the Disconnect Out signal instead of the Service Response. The Disconnect Out signal enables the clock to toggle a flip-flop and the ensuing pulse is returned directly along the Service Request line. The 1620 then proceeds to the next instruction.

Write Typewriter

To write on the typewriter, AMTRAN software arranges a sequence of typewriter codes followed by a record mark and presents a selection code to the terminal.

As seen from the timing diagram of Figure 12, the Typewriter Selection Code is returned via the Select Return line and Service Response is sent by the computer indicating that the first character is available on the data lines.

Service Response enables the RE pulse to be generated from the clock pulse. When the counter is at zero, RE is gated into the pulse called "A". "A" jamb transfers the first digit of the incoming code into a set of flip-flops. The flip-flops present the digit to a double decode matrix which is directly connected to the driving coils of the typewriter through solid state power transistor switches. Typewriter Select switches on the signal TRR (typewriter ready). It also enables RE to toggle a flip-flop and generate the TSRQ pulse which is returned to the computer on the Service Request line to indicate that the digit has been read.

TSRQ toggles the internal counter to one and "A" is blocked. The 1620 switches off, Service Response places the second digit on the data lines and returns with the Service Response signal.

Service Response triggers one shot (B16-7) called "B" and switches off TRR. This blocks TSRQ until the typewriter has completed its operation.

The data lines are gated with "B" and connected to the decode matrix. Thus for 30 milliseconds while "B" is on, the decode matrix receives and decodes an AMTRAN typewriter code and activates a response in the typewriter. The mechanical contacts on the typewriter are so slow, however, that "B" is used to trigger another one shot (A2-31) before the Interlock

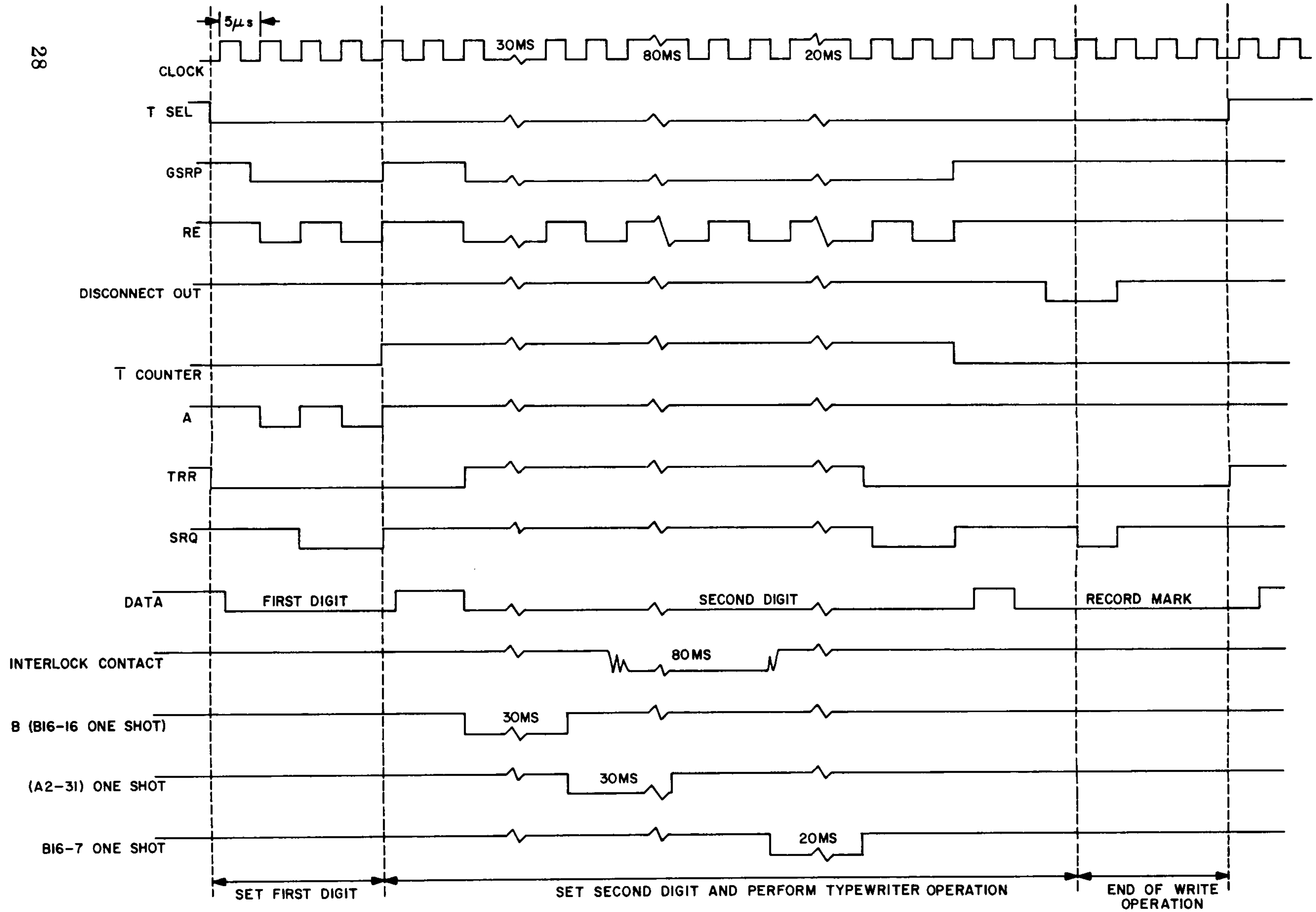


FIGURE 12. WRITE ON TYPEWRITER OPERATION - TIMING DIAGRAM

Contact takes over and holds TRR until the required operation is completed. On opening, the Interlock Contact triggers one shot (B16-7) through a Schmidt trigger and this carries the process over any contact bounce and mechanical settling time of the typewriter before the next operation may be initiated. When one shot (B16-7) goes off, TRR comes true again and enables RE to generate TSRQ. The 1620 then switches off Service Response and gets ready to repeat the cycle by sending another code.

When the message is completed and the 1620 senses a record mark in core, it sends a Disconnect Out level which enables a pulse returned on the Service Request line. This releases the 1620 to proceed to the next instruction. The record mark which terminates the write operation is presented to the terminal on the data lines, but it is not read into the flip-flops because Disconnect Out by-passes the generation of "A".

Control Operation

Besides the read and write operations another mode of communication with the computer is available to the system. A control operation (code 34) will select any output device according to the digits placed in Q_8 Q_9 and when selection is confirmed by the terminal the digit in Q_{11} is available on the data lines from the computer to perform whatever control function is chosen for that digit.

AMTRAN II uses the control operation solely for the remote erasure of the storage scopes. Therefore it does not decode nor use the Q_{11} digit. In a control operation the control and Hold Out signal is sent by the 1620 instead of the Service Response signal. AMTRAN II uses the Control/Hold Out to fire off a short pulse one shot. This pulse goes to two "and" gates where it is gated with Select Scope A and Select Scope B, respectively. The gating ensures that the proper scope is erased. Since the Control/Hold pulse is used by all control operations such gating is essential to avoid undesired erasure of the scopes whenever a tab is called on the console typewriter.

As shown in the timing diagram of Figure 13, the operation is completed by returning the erasing pulse on the Disconnect In line.

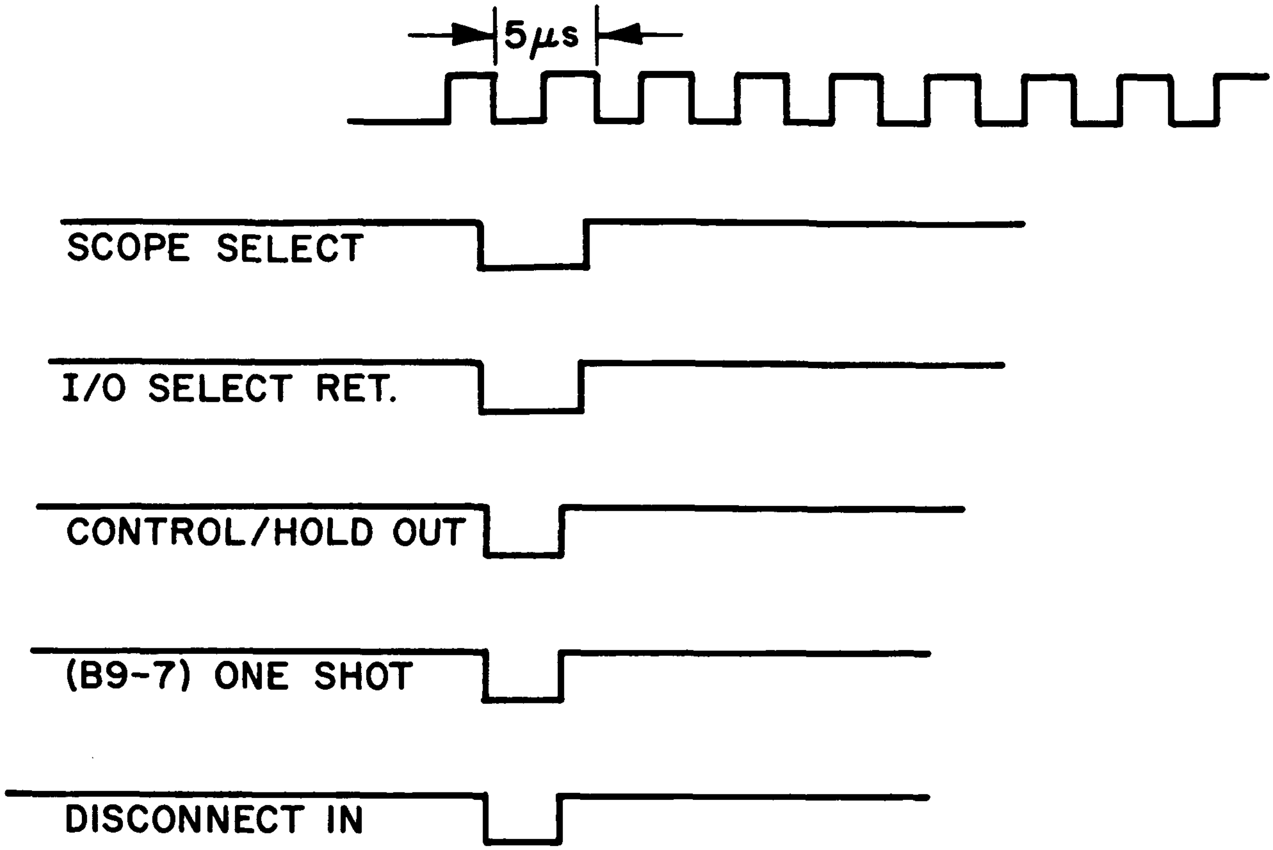


FIGURE 13. REMOTE ERASE OPERATION - TIMING DIAGRAM

INDEX AND A DESCRIPTION OF SIGNALS

A — Generated on C V. Used to distinguish between the first and second digit of the typewriter code. Pulsing A for the first digit allows the digit to be set into the typewriter buffer flip-flops. Cannot be activated when counter is at one, hence first digit is saved while second one arrives on the input lines.

B — Generated on C V. Uses the pulse from the (B16-16) one shot to release the second digit of the typewriter code to the typewriter decode matrix for the duration of the pulse. The pulse is long enough to commence the activation of the selected key.

BD — Button Down. Generated on C VII. Used to enable RE to generate RE II after a button has been pushed and all contact bounce has ceased.

BN STOP — Bigger than Nine Stop. Generated on C II this signal comes true whenever a digit is greater than nine is presented to the output lines of the terminal. The signal was an experimental attempt to block incorrect codes. At the moment it is redundant because it just blocks all output lines when a BCD digit with a bit configuration in excess of nine appears so that the computer check stops anyway.

C/H OUT — Control and Hold Out. Generated by the 1620 in a control operation and sent instead of the Service Response signal. Used for remote erase.

CL — Clock. Generated on C VI from a standard Raytheon 200 kc free running multivibrator. Used to provide the internal clock pulses for AMTRAN II.

CNTR — Counter. Located on C VII. Three flip-flops arranged as a three stage binary counter. Used by the system to keep track of repetitive events in sending or receiving multidigit codes.

CR — Computer Ready. Generated on C IV. Used to gate all selection decodes so that selection of a special I/O device can occur only in execution cycles and with an instruction having a zero in the Q_9 position.

CRT A SEL — Cathode Ray Tube A Select. Generated by an instruction with Q_8 Q_9 = 40, otherwise like CRT SEL for one scope.

CRT B SEL — Cathode Ray Tube B Select. Generated by an instruction with Q_8 Q_9 = 50, otherwise like CRT SEL.

CRT SEL — Cathode Ray Tube Select. Generated on C III by decoding the selection code from the 1620 and combining the selection signals of both scopes. The selection codes are presented to the terminal from the Digit and Branch register along special selection lines with Q_8 presented in full and Q_9 decoded for zero in DBU. Used to enable circuits concerned with both CRT's.

CRT SRQ — Cathode Ray Tube Service Request. The Service Request pulse generated in a write scope operation on C VII.

D/A — Digital to Analog conversion, accomplished by using standard Raytheon D/A card.

DBU — Digit and Branch register units. Generated by the 1620 whenever there is a zero in the Digit and Branch register—where the selection codes of I/O equipment are placed during operation set up time. Used to ensure the terminal does not respond to the selection codes of the IBM devices which always have a non-zero Q_9.

D.I. — Disconnect In. Generated by the terminal on C VII to indicate to the 1620 that a read operation has been completed, and the terminal has no more information available. Also used to terminate a control operation.

D.O. — Disconnect Out. Generated by the 1620 to indicate that the end of a record has been reached in a write operation. When D.O. appears a pulse has to be returned to the 1620 to conclude the operation and permit entry into the next one.

ER CRT — Erase Cathode Ray Tube. Generated on CI. A temporary signal used to trigger the erase one shot while AMTRAN II uses just one scope.

GSRP. — Gated Service Response. The Service Response signal gated with R/W call and DBU so that it can only be activated during execution cycles and when the 1620 addresses a special terminal using a code with a zero in Q_9 position. Generated on C IV.

I/O CHECK STOP	Input-Output Check Stop. A signal generated whenever a Read or Write check stops the 1620 computer. It is used to light a warning light on the indicator panel.
I/O SEL or SEL RET	Input-Output Select Return. See SEL RET.
KBRO	Keyboard Requires Entry. Generated on C VII by a button push on the keyboard. Reset by the rising edge on the Select Return line which is normally the end of the read keyboard operation. Used to light a stop light on the indicator panel to warn the user not to push another button before the previous button has been read.
KB SEL	Keyboard Select. Generated by an instruction with Q_8 Q_9 = 10, otherwise like CRT SEL.
KB SRQ	Keyboard Service Request. The Service Request pulse generated by a read keyboard operation on C VII.
MR	Manual Reset. A ground signal generated by pushing a button at the terminal. Used to reset all significant flip-flops of the system to their initial state.
P5	Plug five. A designation of the plugs used by the terminal. A list of the plugs is found on BI.
R	Reset. A signal generated by the 1620 whenever the reset button on the computer console is pressed. Used to generate a ground signal on the manual reset line to reset all significant flip-flops of the system to their initial state.
RE	Request Enable. Generated on C VII as a pulse to be used by the control circuits of the terminal, especially in the generation of the Service Request pulse.
RE II	Request Enable II. A pulse generated from RE by toggling a flip-flop on C VII. Used in the generation of KB SRQ.

R/W CALL — Read and Write call. A signal, generated by the 1620 just before entering execution cycles on a read or write operation. Used to generate GSRP.

S — Shift pulse. Generated on C VII and used to shift BCD data in the main buffer C VIII by one position toward the right.

SEL RET — I/O Select Return. A signal generated by the terminal on C III in response to a selection code presented by the 1620. When a code concerning a terminal is detected in Q_8 Q_9 in execution time, the terminal sends this signal to the computer.

Select Return gates all other communication lines inside the special adapter hence it is essential to turn it on and maintain it until the end of the communication.

SRP — Service Response. Generated by the 1620 to indicate that it is ready either to read data from the terminal in a read operation or data from the 1620 is waiting on the data lines to be read by the terminal in a write operation. Turned off by the rising edge of the Service Request or D.I. pulse.

SRQ — Service Request. A pulse generated by the terminal on C IV to indicate to the 1620 that it has completed the storing of a digit sent in a write operation or that a digit is on the output lines of the buffer C VIII ready to be read by the 1620. The Service Request pulse is used by the 1620 to switch off the SRP or D. O. signals.

T — Transfer pulse. Generated on C VII. Used to transfer a complete point ($X_i Y_i$) to the input buffer of the D/A converters for a write scope display.

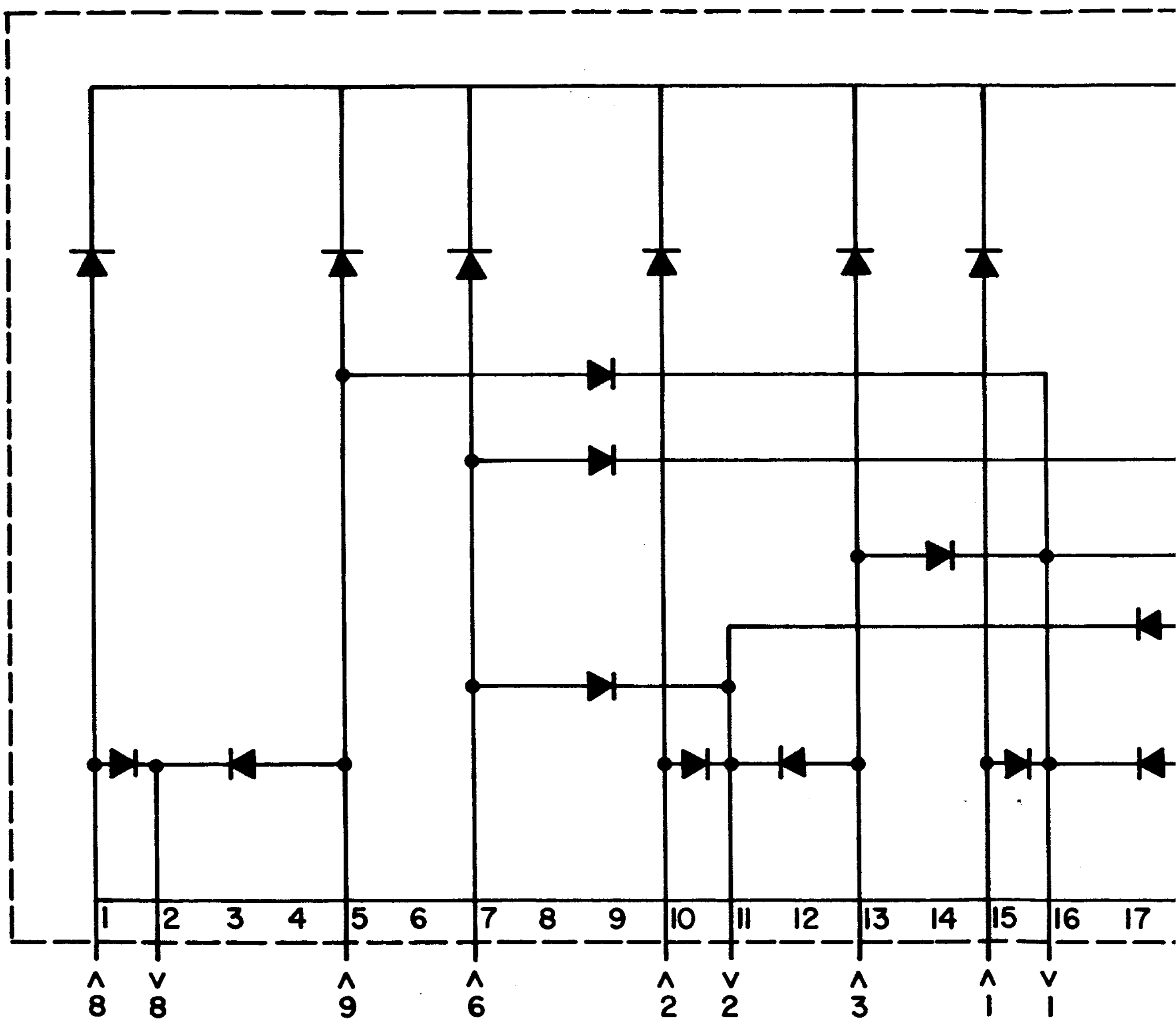
T SEL — Typewriter Select. Generated by an instruction with Q_8 Q_9 = 80, otherwise like CRT SEL.

TSRQ — Typewriter Service Request. The Service Request pulse generated in the read typewriter operation on C IV.

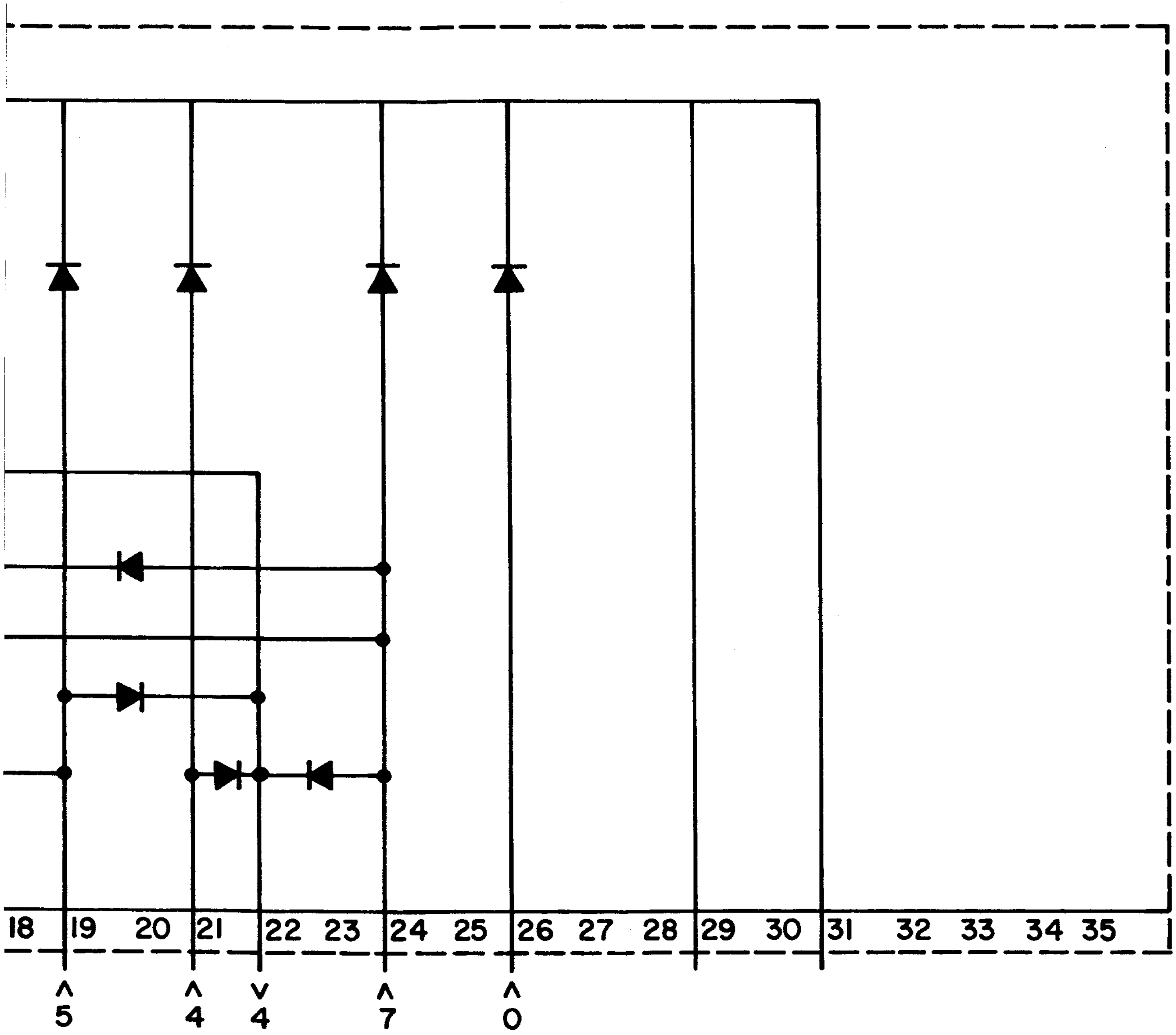
X OUT — X coordinate out. The analog voltage corresponding to the X coordinate to be displayed on the scope.

Y OUT — Y coordinate out. The analog voltage corresponding to the Y coordinate to be displayed on the scope.

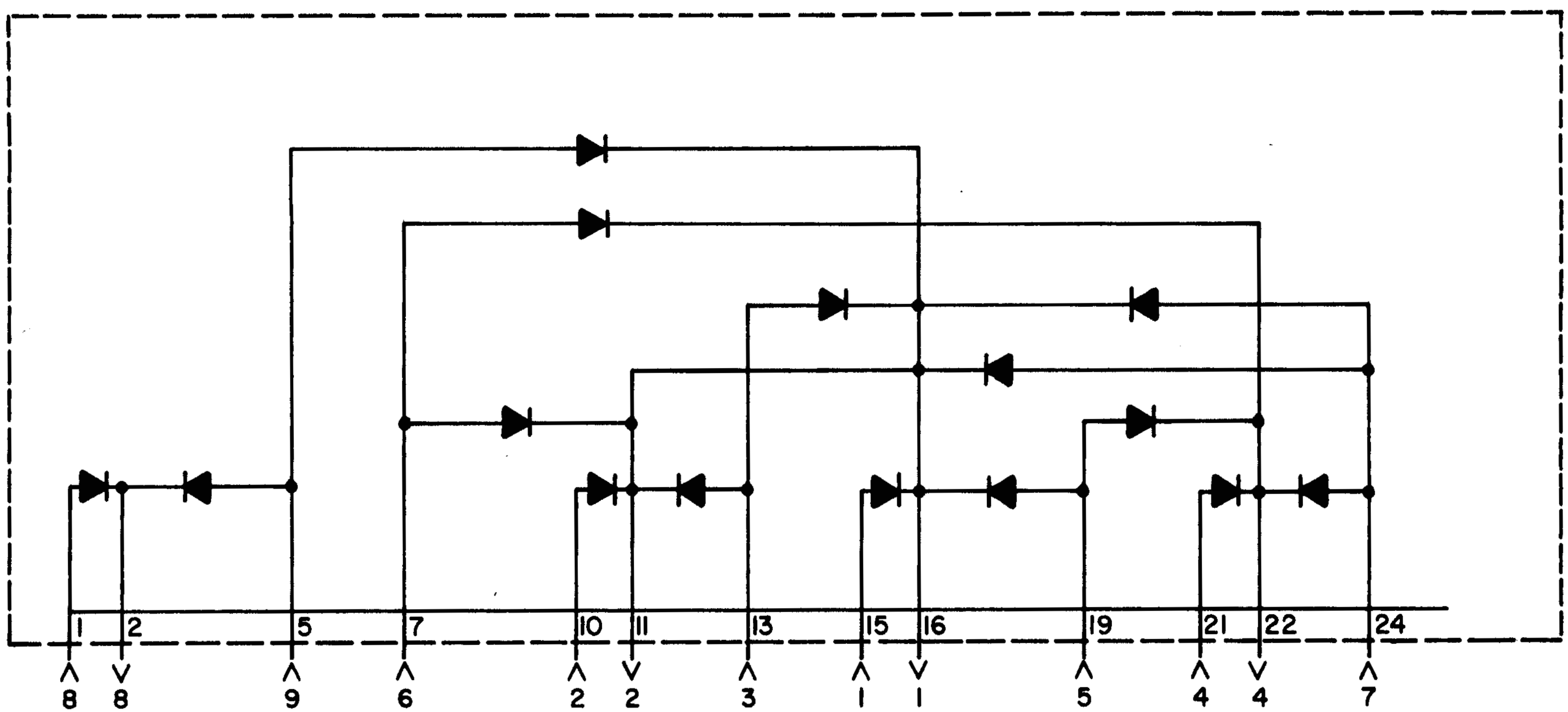
APPENDIX A



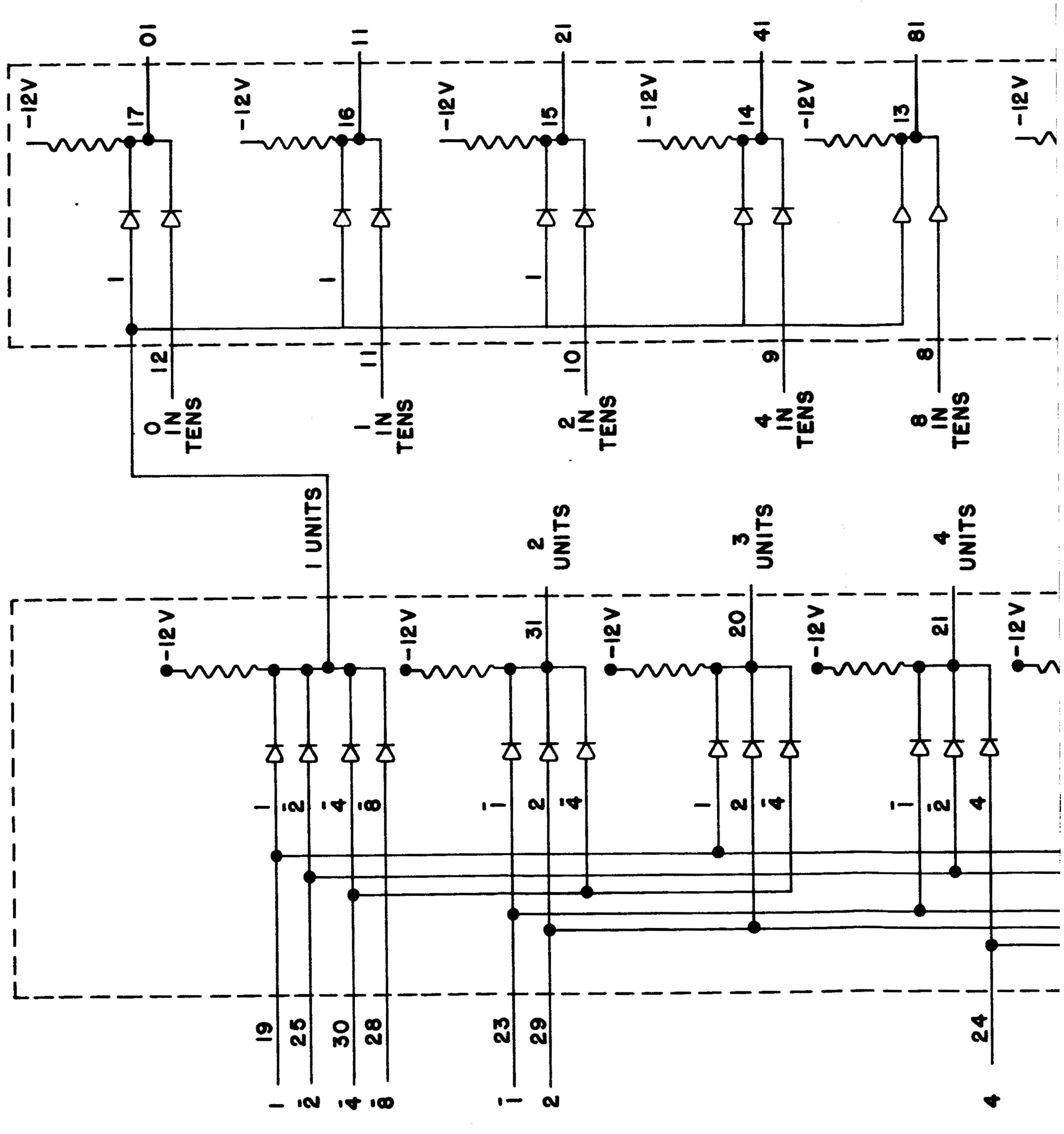
A1. KEYBOARD DECODI



CARD (UNITS)



A2. KEYBOARD DECODE CARD (TENS)



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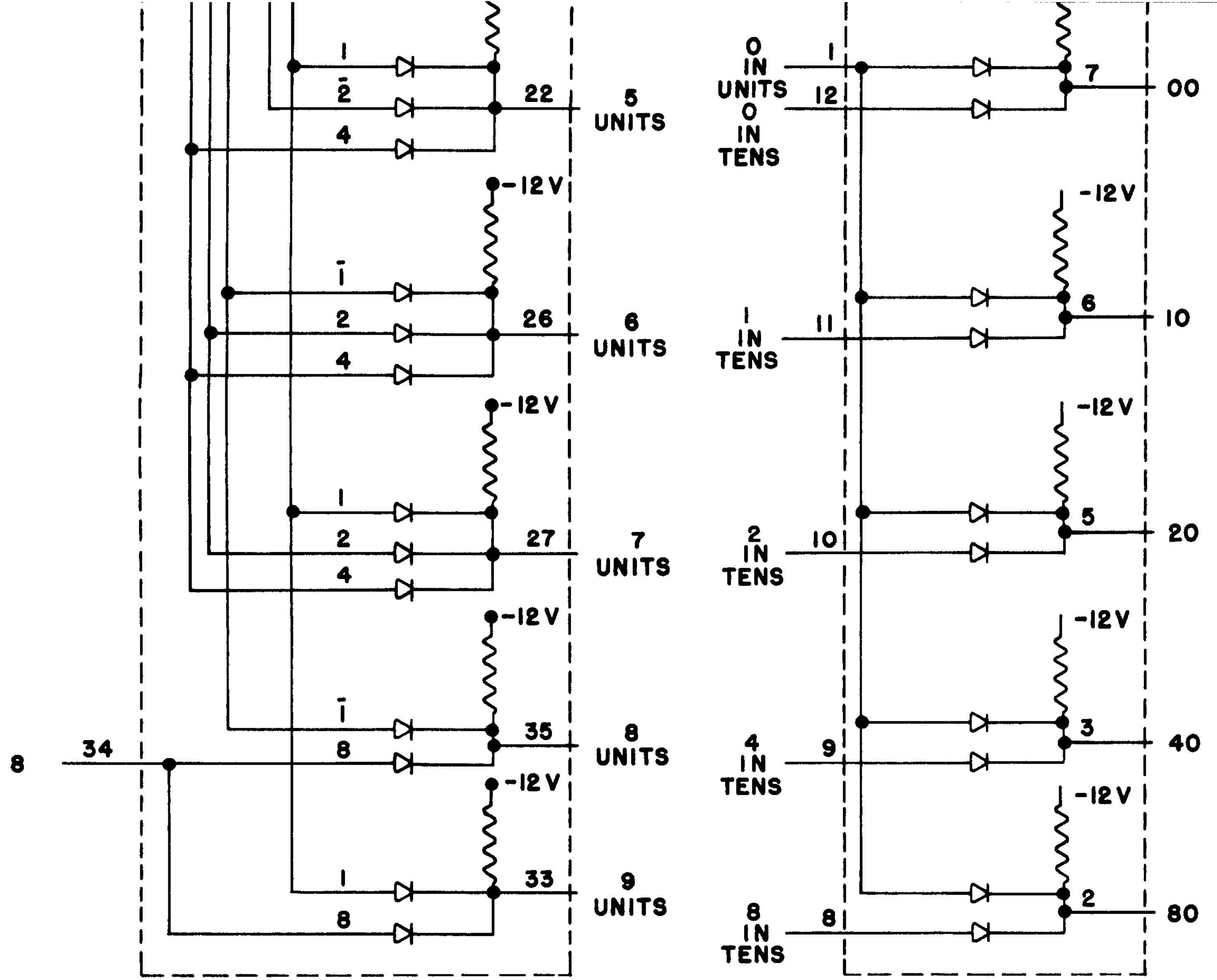
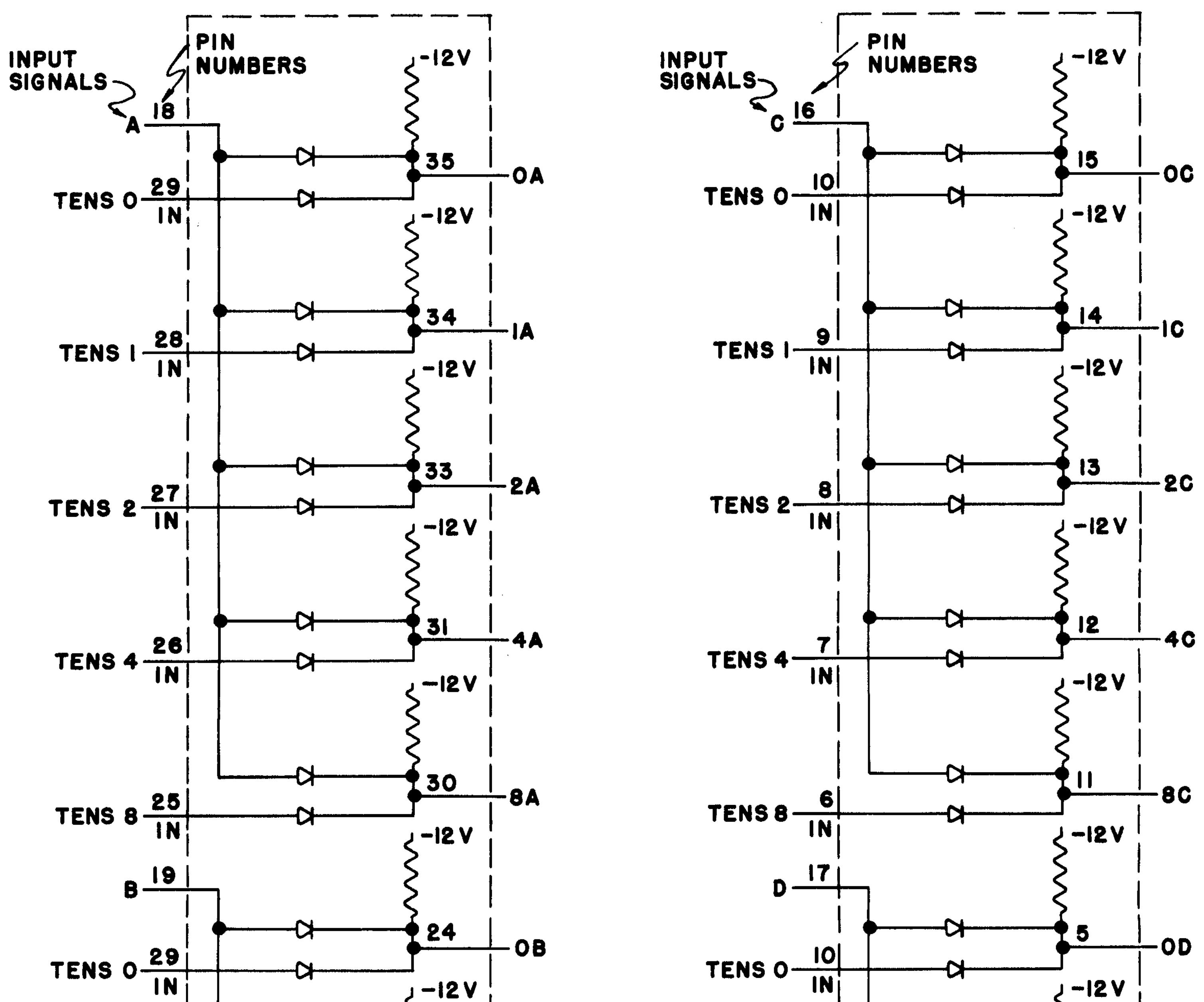
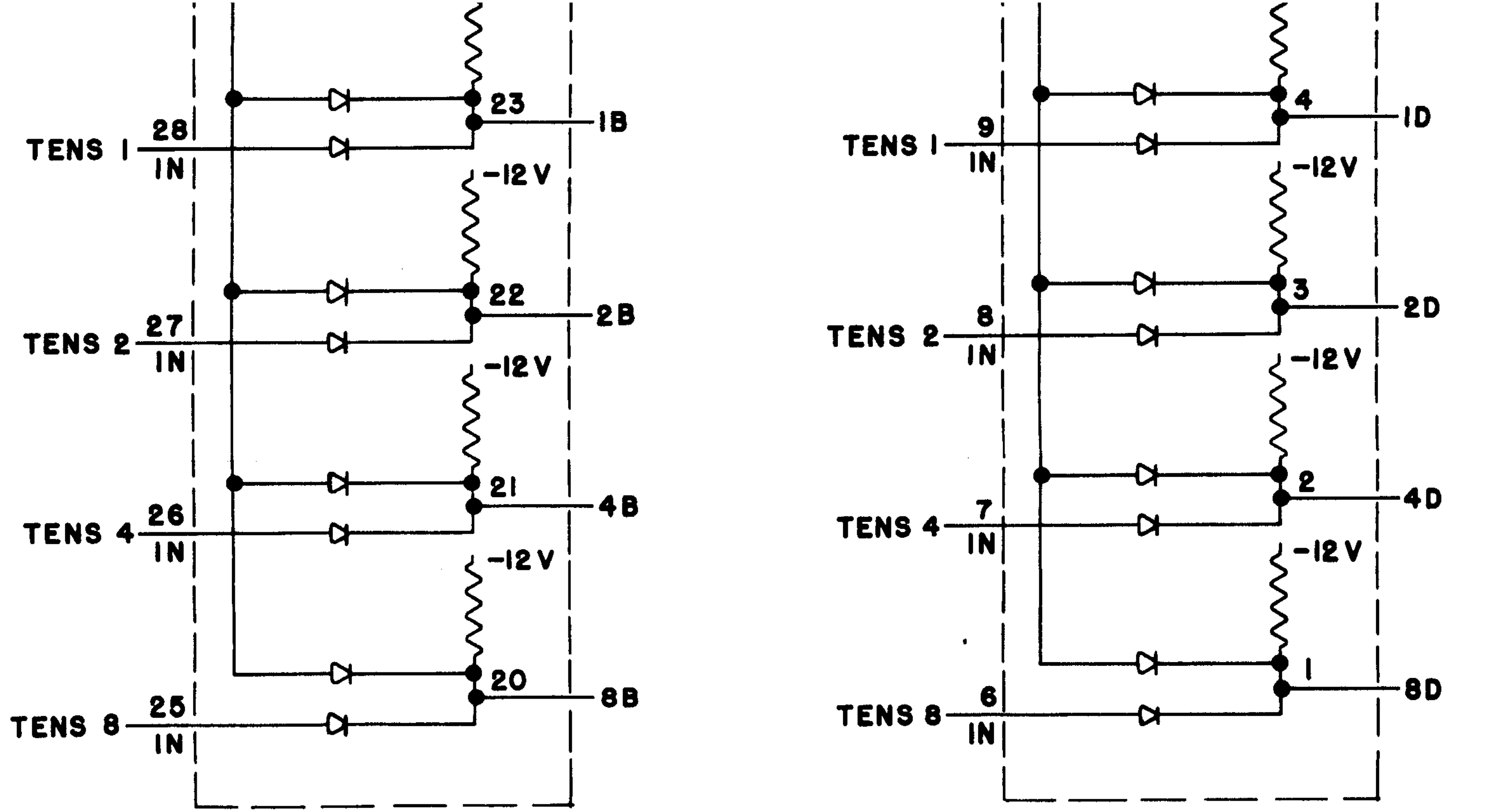


A3. TYPEWRITER DECODE CIRCUIT (UNITS)


INPUT SIGNALS
PIN NUMBERS
A
18
TENS 0
29
IN
TENS 1
28
TENS 2
27
TENS 4
26
TENS 8
25
B
19
-12V
35
34
33
31
30
24
0A
1A
2A
4A
8A
0B
C
16
10
9
8
7
6
D
17
15
14
13
12
11
5
0C
1C
2C
4C
8C
0D

13

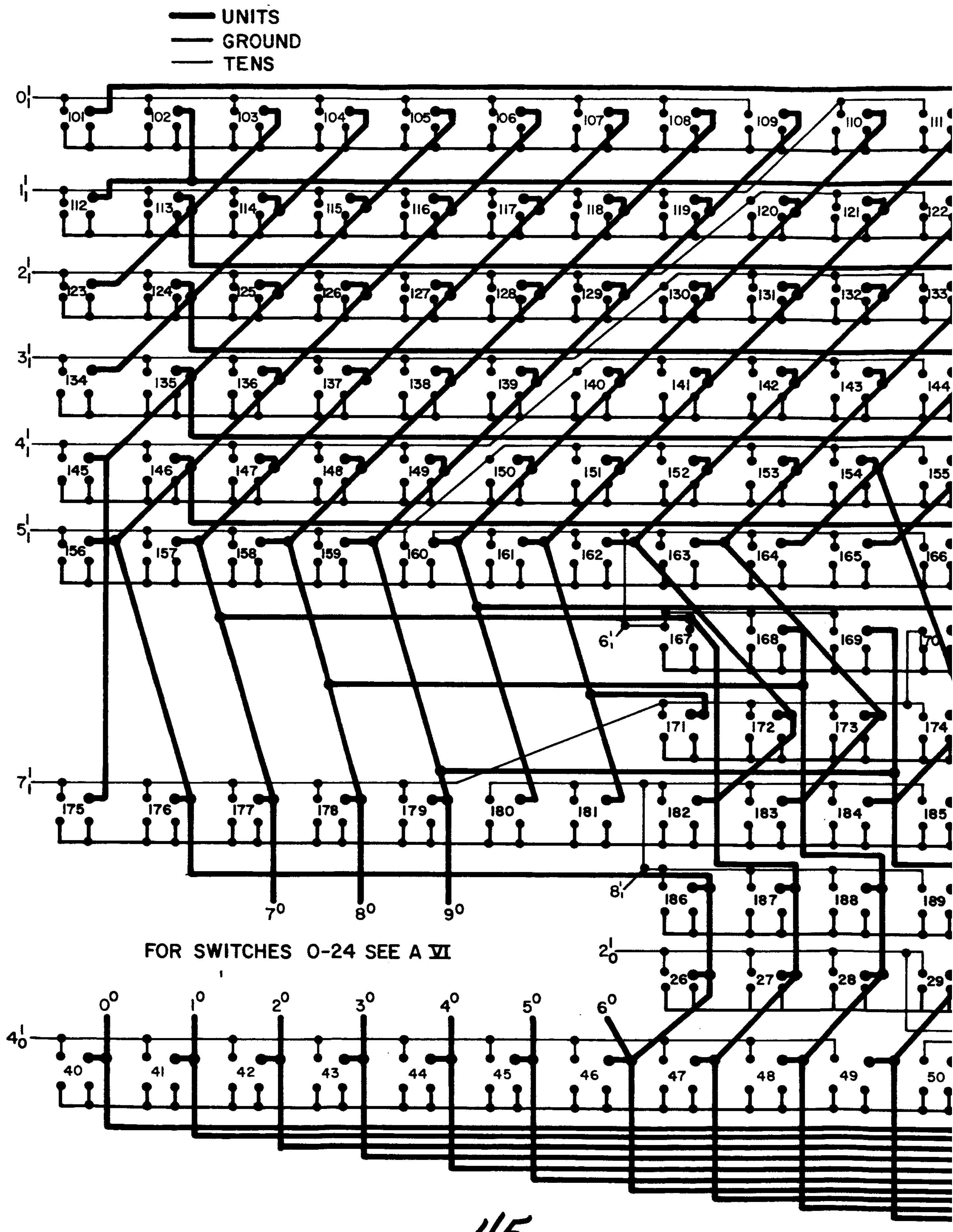


NOTE:

(1) THE UNITS SIGNALS FROM FIGURE 3 ARE USED AS INPUTS A,B,C,D
(2) ON CARD C19, A=2, B=3, C=4, D=5
(3) ON CARD C17, A=6, B=7, C=8, D=9

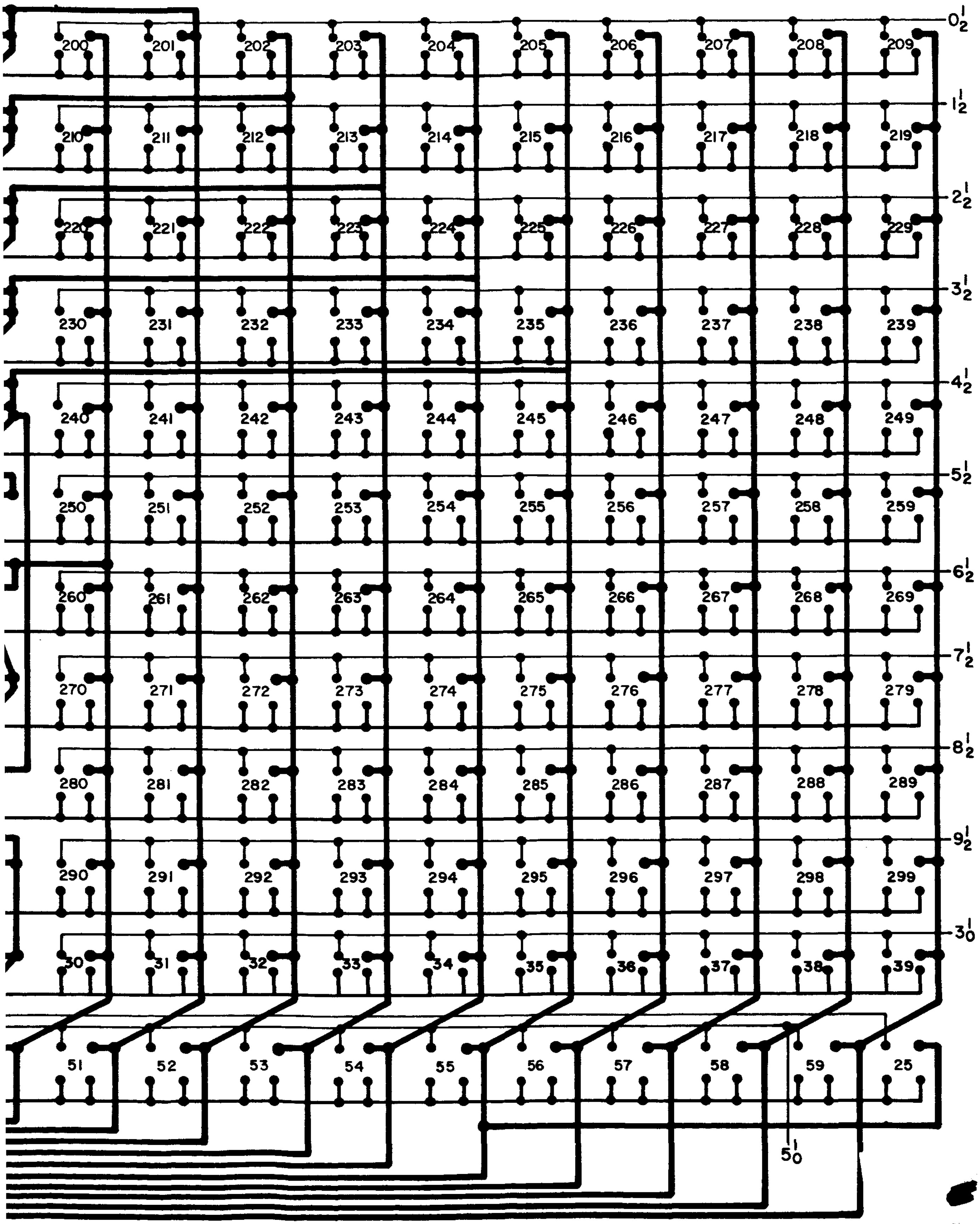
A4. TYPEWRITER DECODE CIRCUIT

44

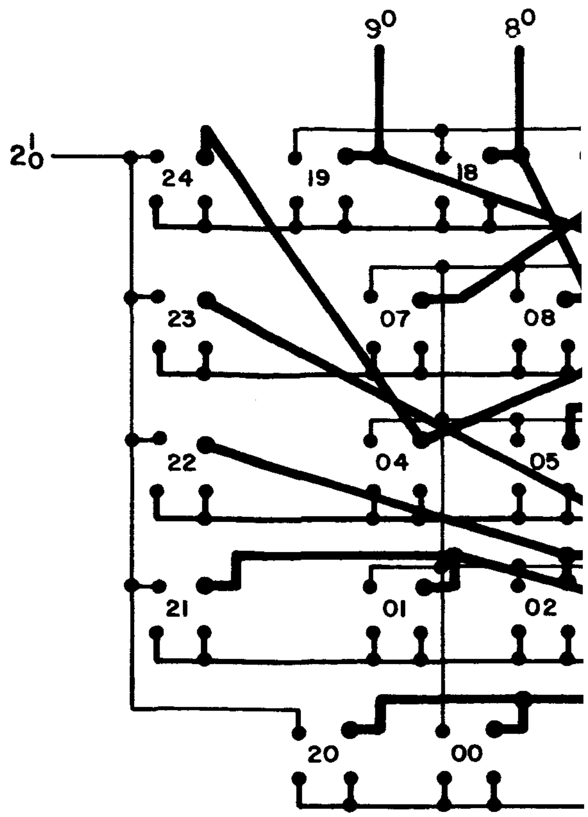


45

A5. KEYBOARD SWI



'CH WIRING DIAGRAM



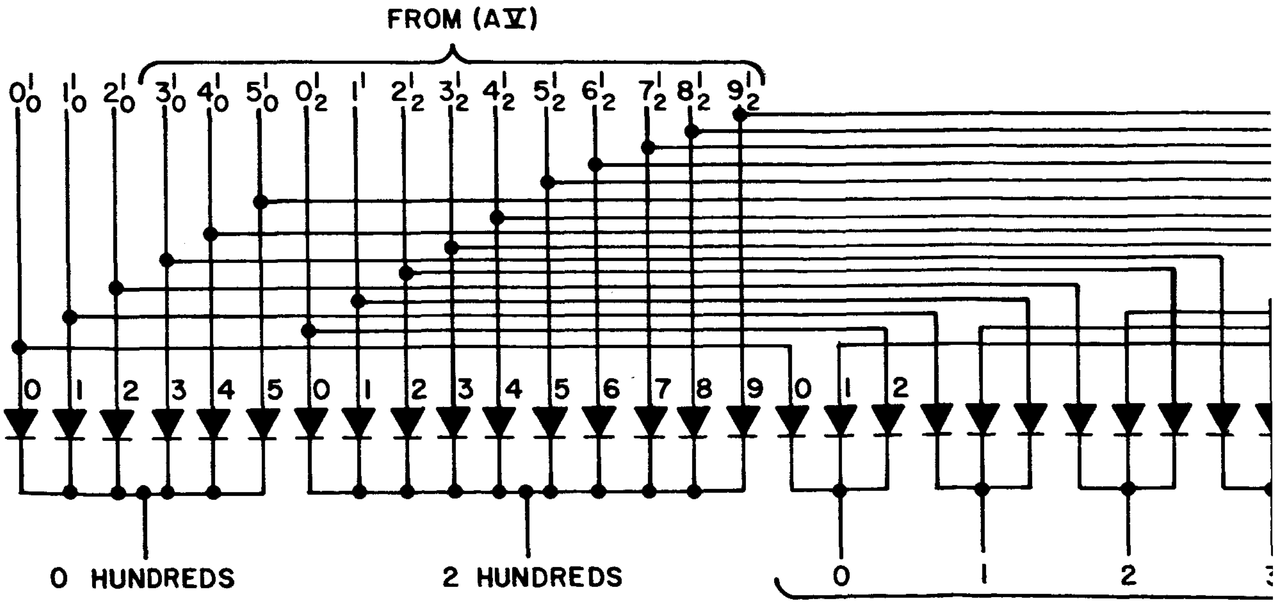
KEY:

d UNITS DIGIT d

d'_0 TENS DIGIT d FOR 0 HUNDREDS

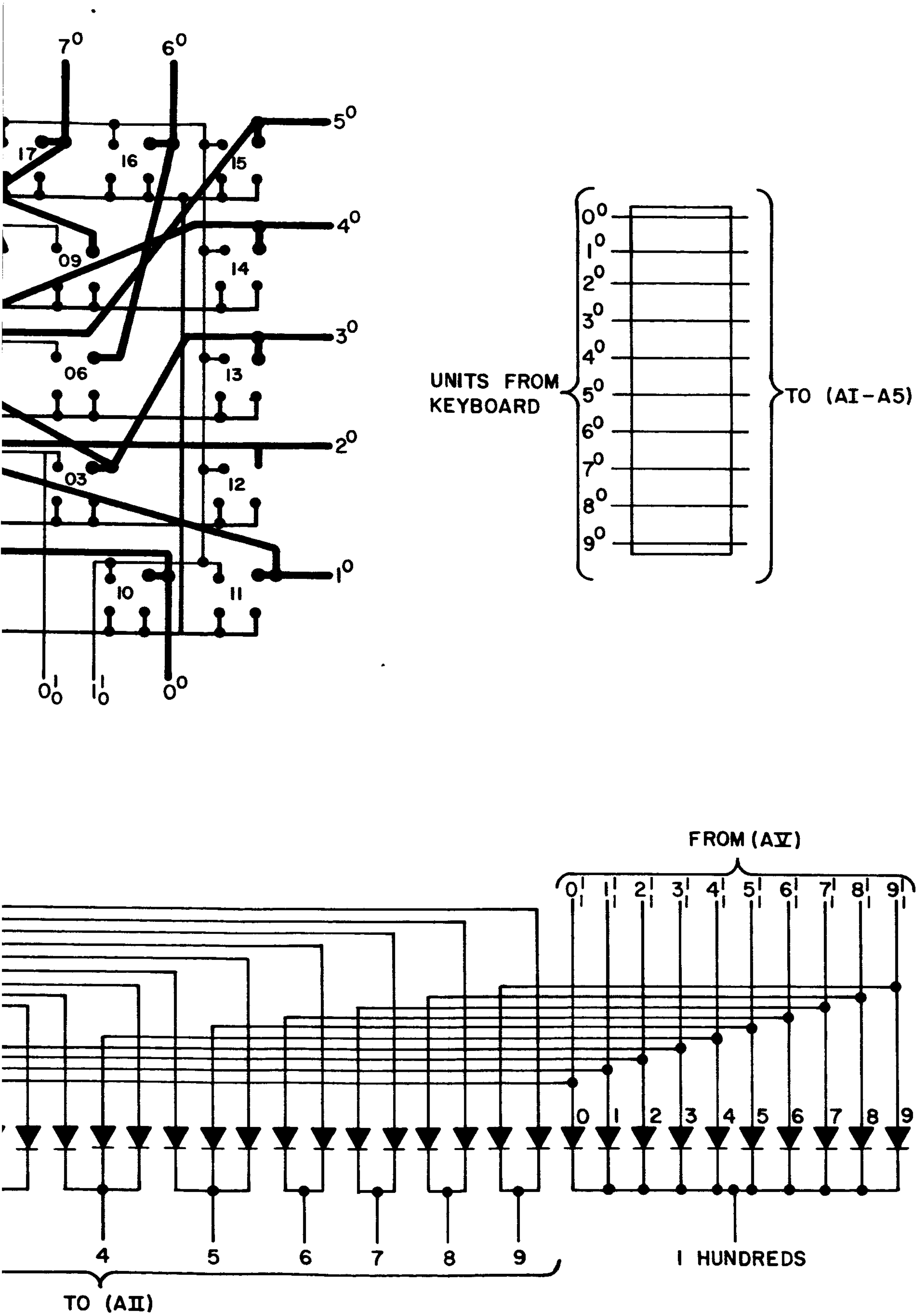
d'_1 " " " " 1 "

d'_2 " " " " 2 "



A6. KEYBOARD SWITCH WIRIN

47-1



DIAGRAM

APPENDIX B

PLUG NUMBER	FUNCTION
P1	TYPEWRITER INPUT CVI
P2	TYPEWRITER INPUT CVI
P3	INDICATOR LIGHTS CXII
P4	KEYBOARD PLUG CXI
P5	COMPUTER PLUG CXI
P6	POWER SUPPLY CXI
P7	CRT PLUG CXI

B1. PLUG LIST

AMTRAN II SELECTION CODES

Q_8 Q_9	DEVICE SELECTED
10	KEYBOARD
40	SCOPE A
50	SCOPE B
80	TYPEWRITER

IBM 1620 I/O SELECTION CODES

Q_8 Q_9	DEVICE SELECTED
01	TYPEWRITER
02	PAPER TAPE PUNCH
03	PLOTTER
04	CARD PUNCH
05	CARD READER
07	DISC STORAGE
09	PRINTER

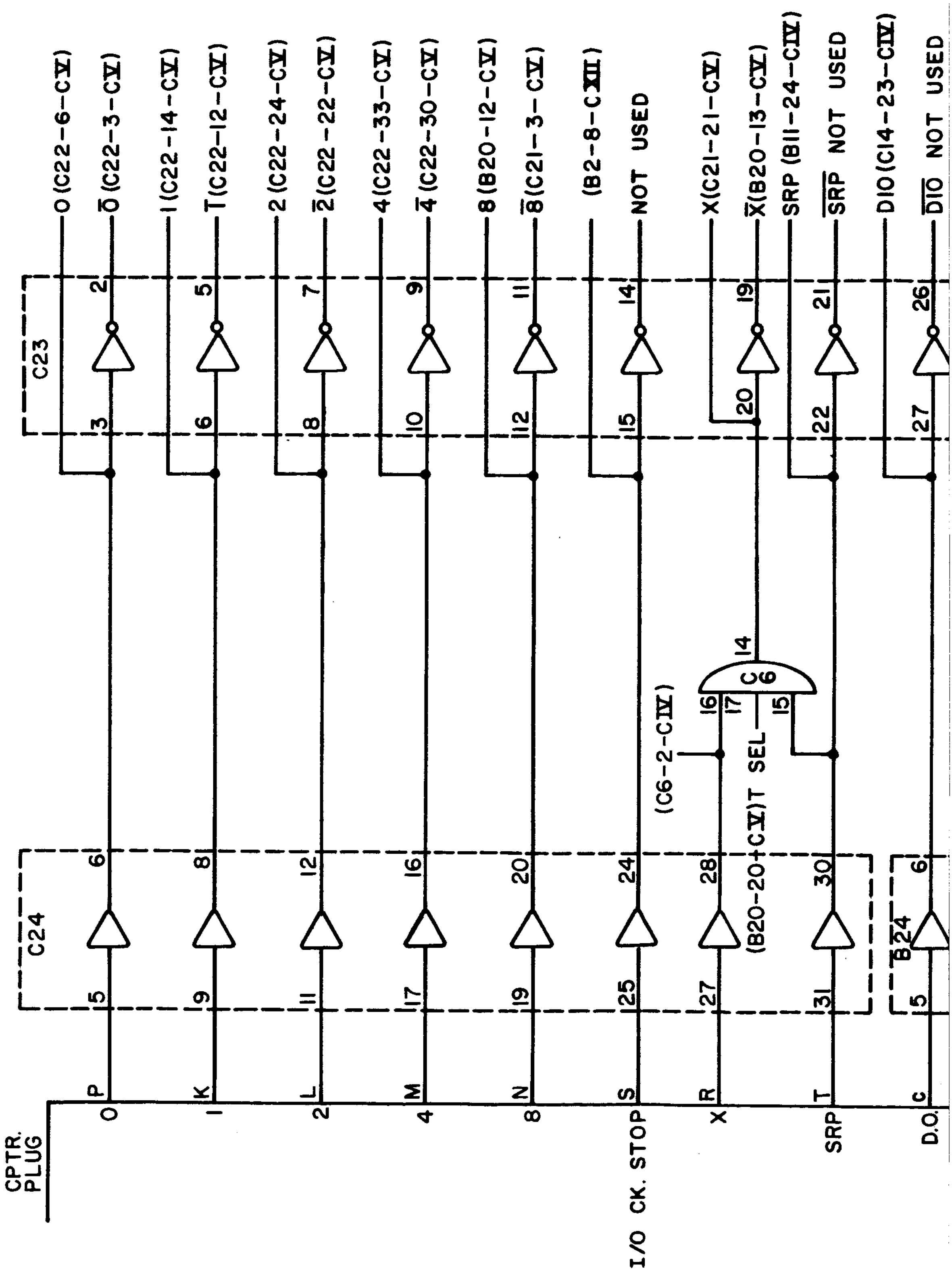
B2. INPUT-OUTPUT SELECTION CODES

PLUGS

	C	B	A
25	BLANK	BLANK	GLC8 (LC302) C→S LEVEL CONV.
24	GLC8 (LC302) C→S LEVEL CONV.	GLC8 (LC302) C→S LEVEL CONV.	GLC7 (LC301) S→C LEVEL CONV.
23	GAI12 INPUT REGISTER	GAI12 INPUT REGISTER	GDG3 OR GATE
22	GFFI TYPEWRITER CONTROL	GPAI TYPEWRITER DECODE REG	GAI2 OUTPUT REGISTER
21	GFFI TYPEWRITER CONTROL	GPAI TYPEWRITER DECODE REG	GLC7 (LC301) S→C LEVEL CONV.
20	DEC-I TYPEWRITER DECODE (UNITS)	GDG2 TYPEWRITER CONTROL	GDG2 CHECK BIT DECODE
19	DEC-2 TYPEWRITER DECODE (TENS)	GPAI TYPEWRITER DECODE REG	GFFI CRT BUFFER
18	GPAI TYPEWRITER DECODE REG	GPAI TYPEWRITER DECODE REG	GFFI CRT BUFFER
17	DEC-2 TYPEWRITER DECODE (TENS)	GPAI TYPEWRITER DECODE REG	GFFI KB BUFFER
16	GPAI TYPEWRITER DECODE REG	GOS3 ONE SHOT	GFFI CRT BUFFER
15	ISOLATION	GDG2 AND GATE	GFFI KB BUFFER
14	GFFI FLIP FLOP	GRGI RESET GATE	GFFI MAIN CONTROL
13	GMVI CLOCK PULSE GEN	GFFI COUNTER	GFFI KB BUFFER
12	GDG3 OR GATE	GDG2 AND GATE	GFFI CRT BUFFER
11	GAI2 INVERTER	GDG2 AND GATE	GFFI KB BUFFER
10	GAI2 INVERTER	GDG3 OR GATE	GFFI CRT BUFFER
9	GDG3 OR GATE	GOS3 ONE SHOT	GFFI KB BUFFER
8	GAI2 INVERTER	GDAI D/A CONVERTER	GFFI CRT BUFFER
7	GST2 SCHMITT TRIGGER	GDAI D/A CONVERTER	GDAI D/A CONVERTER
6	GDG2 AND GATE	GRSI REF SUPPLY	GDG2 AND GATE
5	BLANK	GDG3 OR GATE	KB DECODE UNITS
4	UTILITY BOARD	GDG2 AND GATE	KB DECODE TENS & HUNDS
3	BLANK	GFFI FLIP FLOP	GAI2 INVERTER
2	UTILITY BOARD	GPAI LIGHT POWER	GOS3 ONE SHOT
1	BLANK	BLANK	BLANK

B3. MULTIPLEXER INTER-FACE CARD LAYOUT

APPENDIX C



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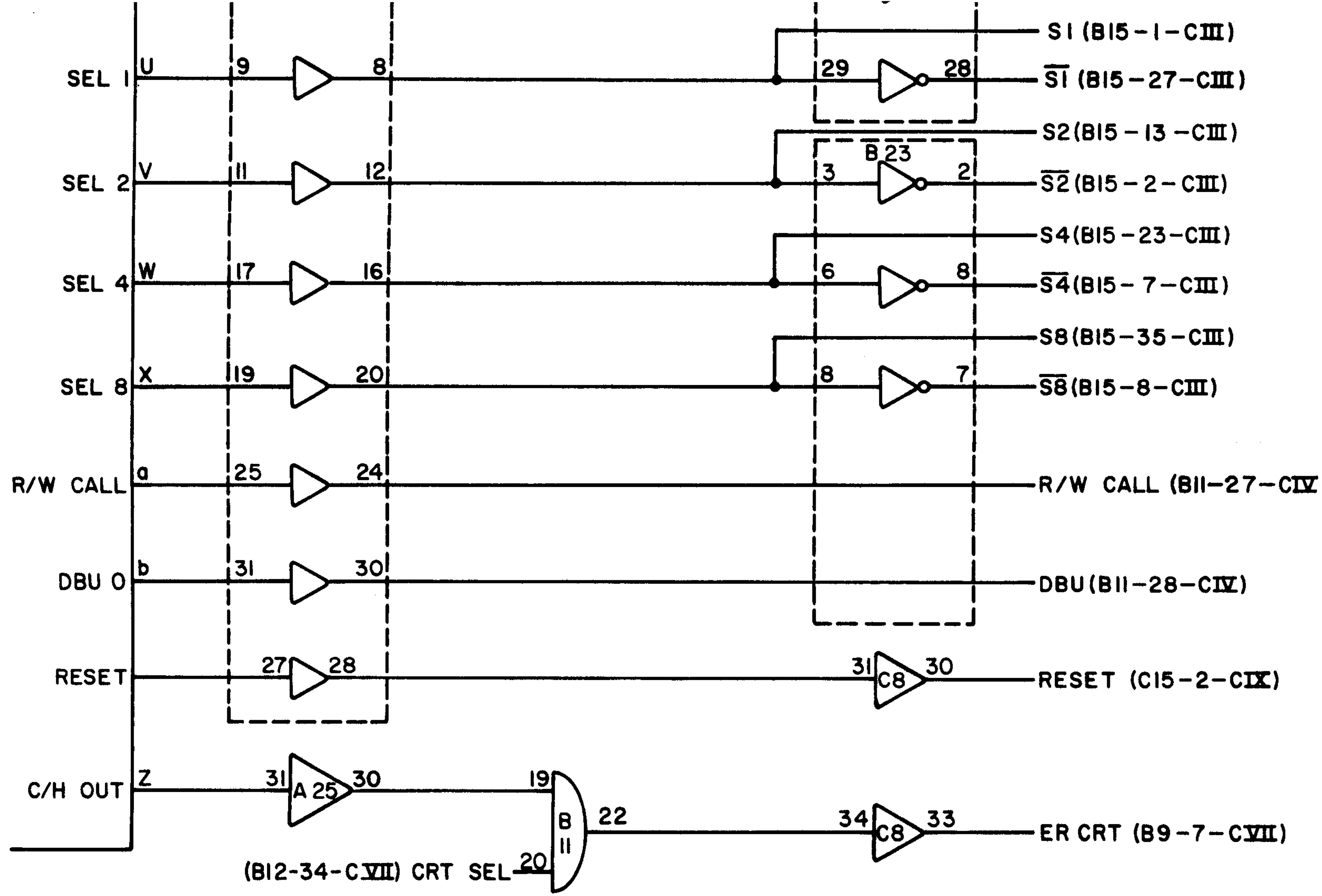
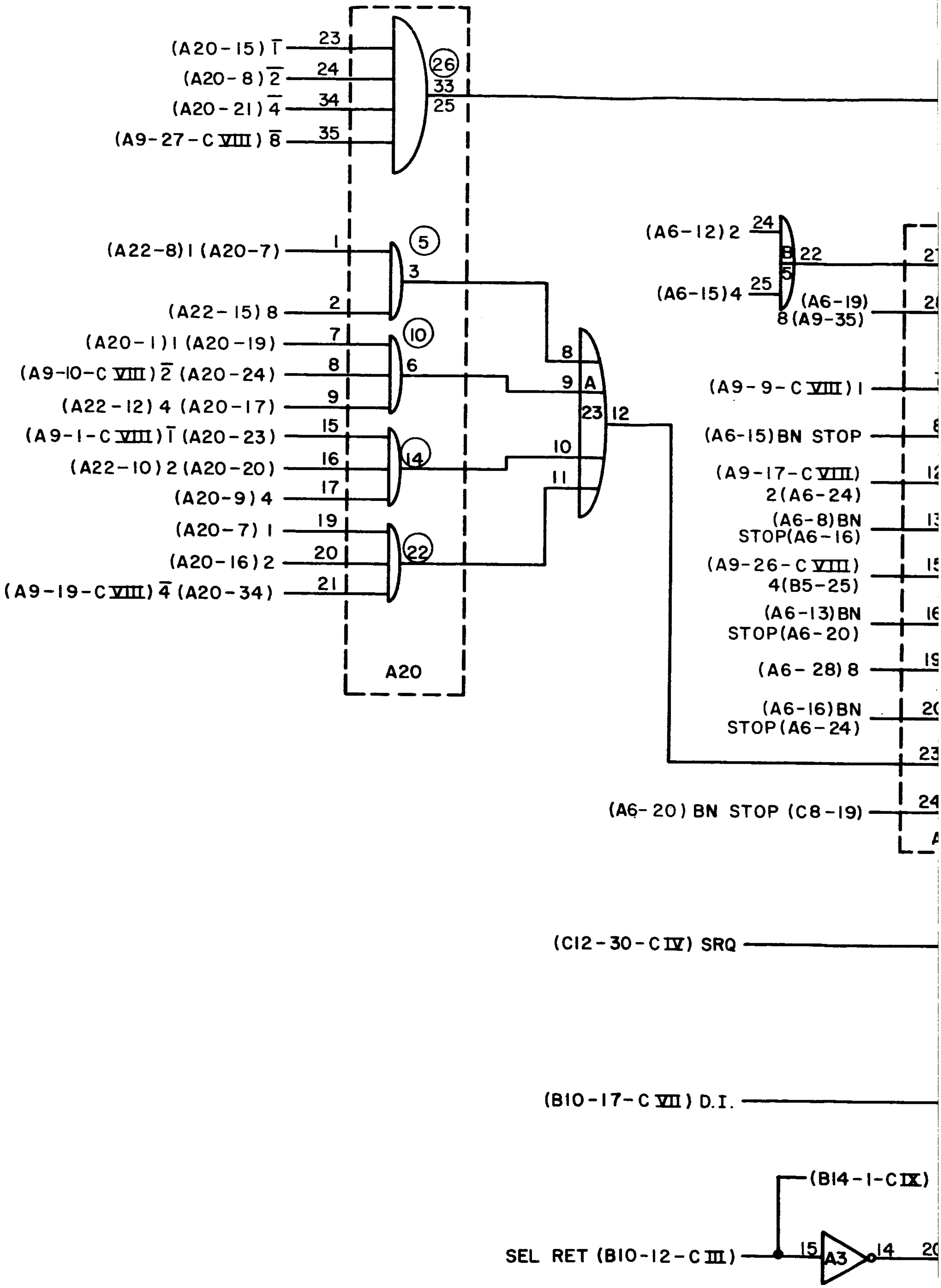
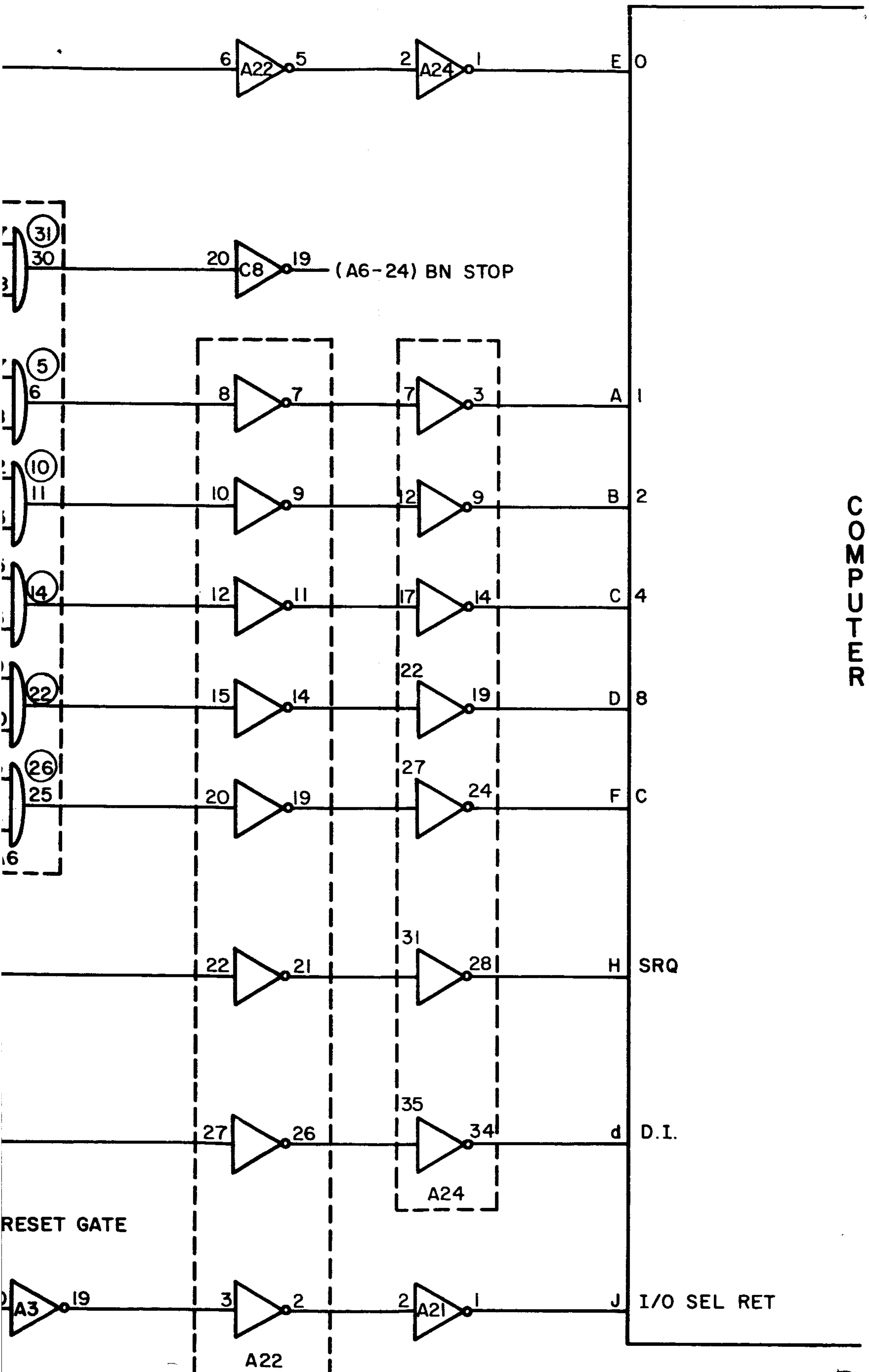


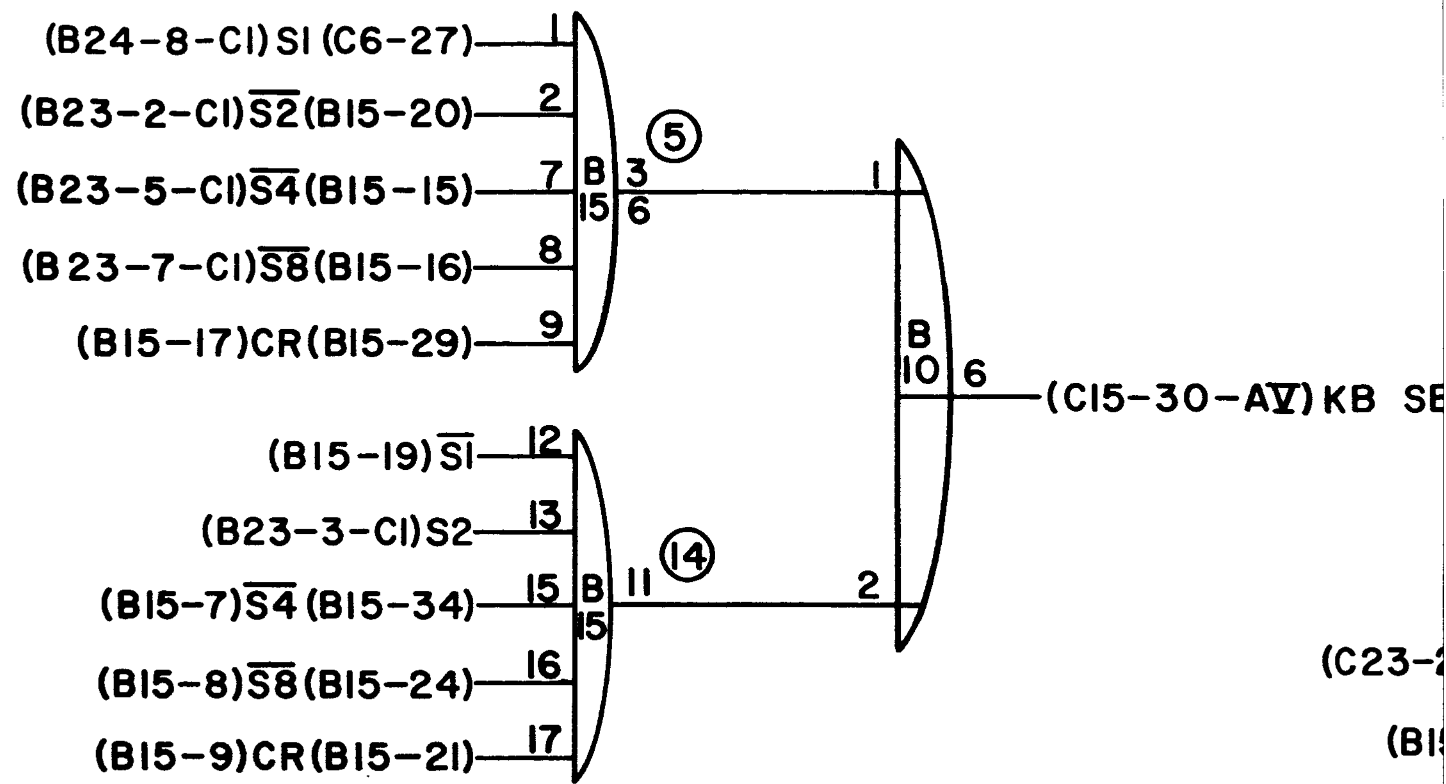
C1. INPUT REGISTER



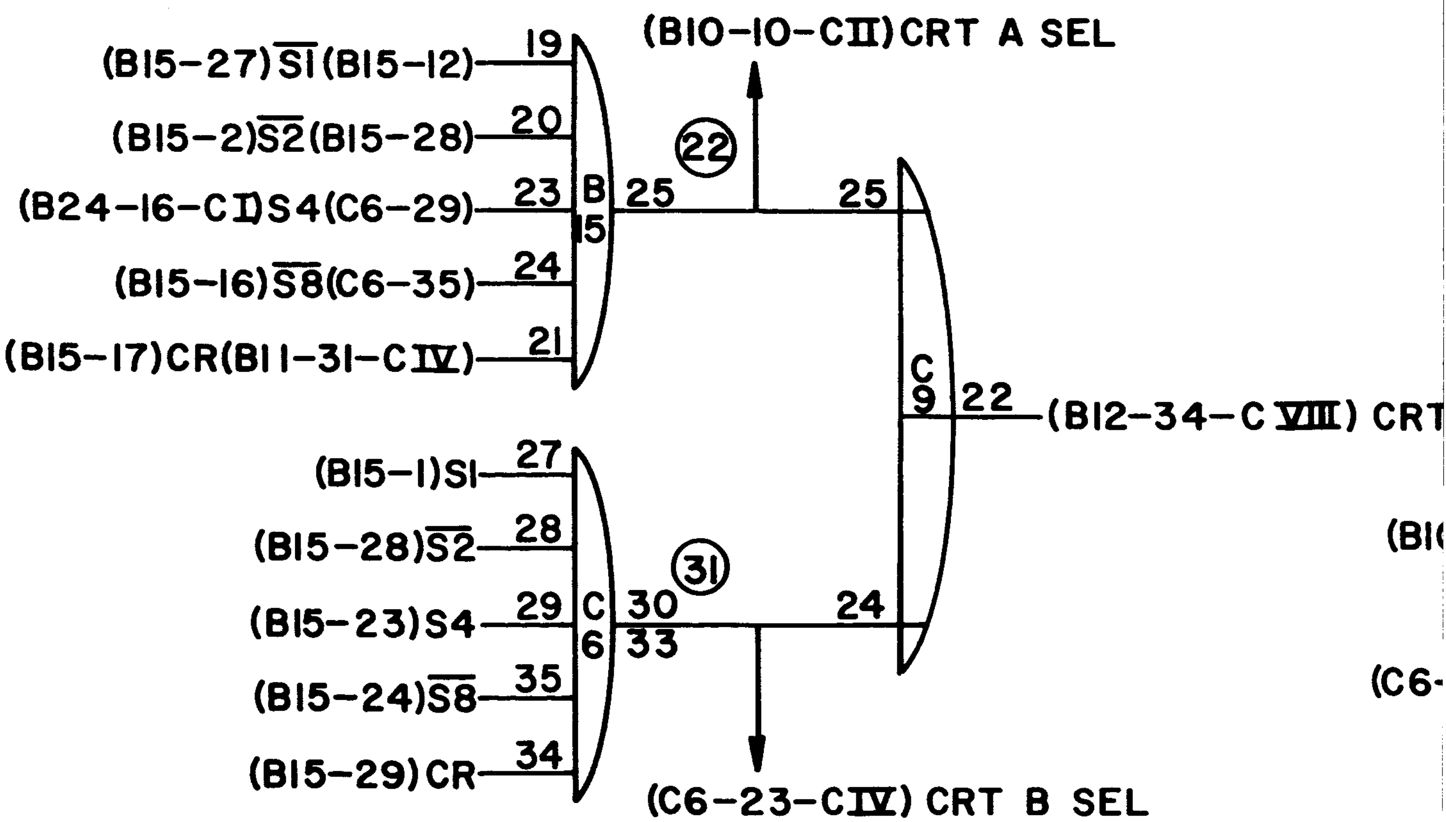
C2. OUTPUT REGISTER


A22
A24
(A6-24) BN STOP
C8
A3
RESET GATE
A22
A24
A21
E 0
A 1
B 2
C 4
D 8
F C
H SRQ
d D.I.
J I/O SEL RET
COMPUTER

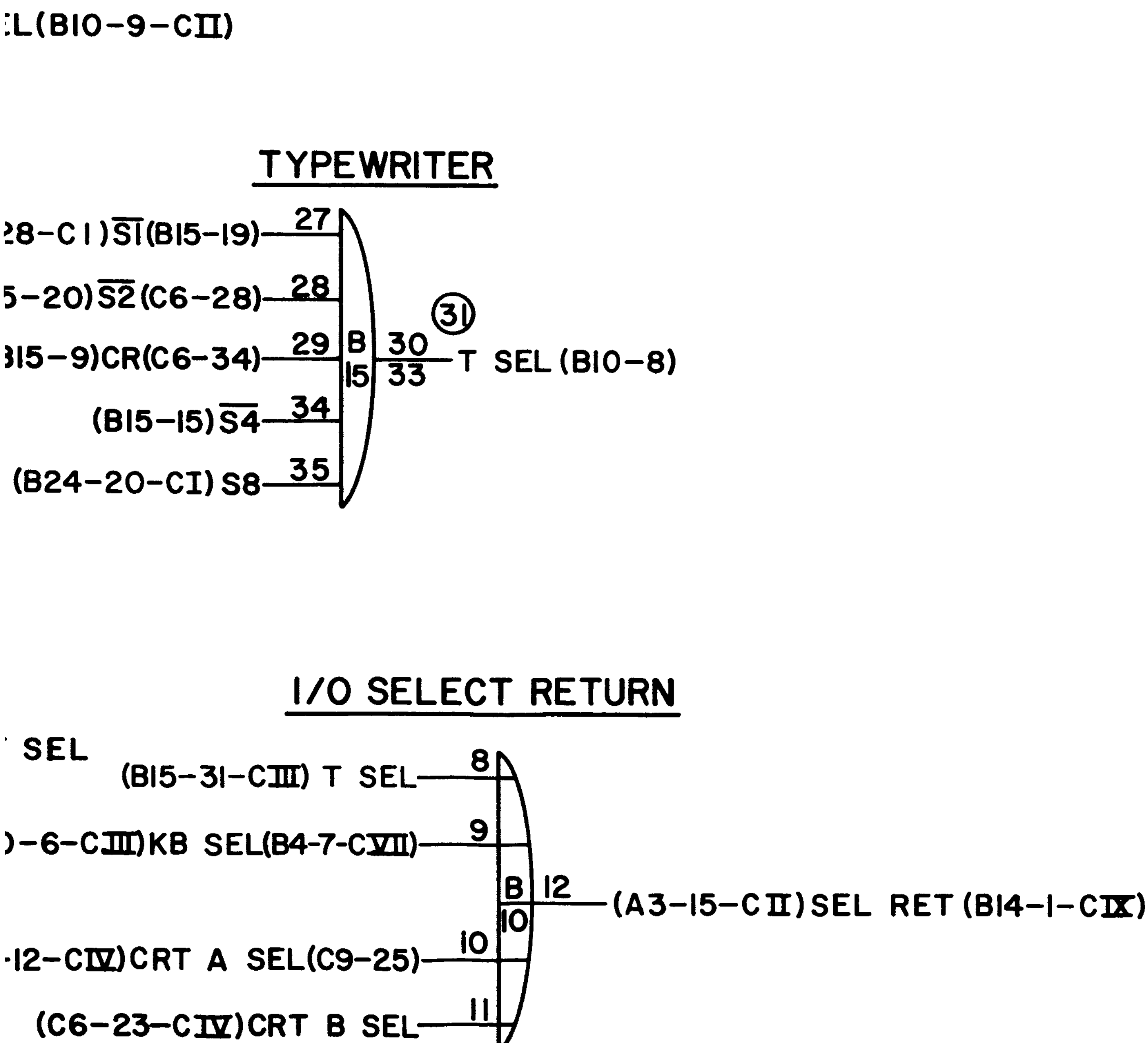
KEYBOARD



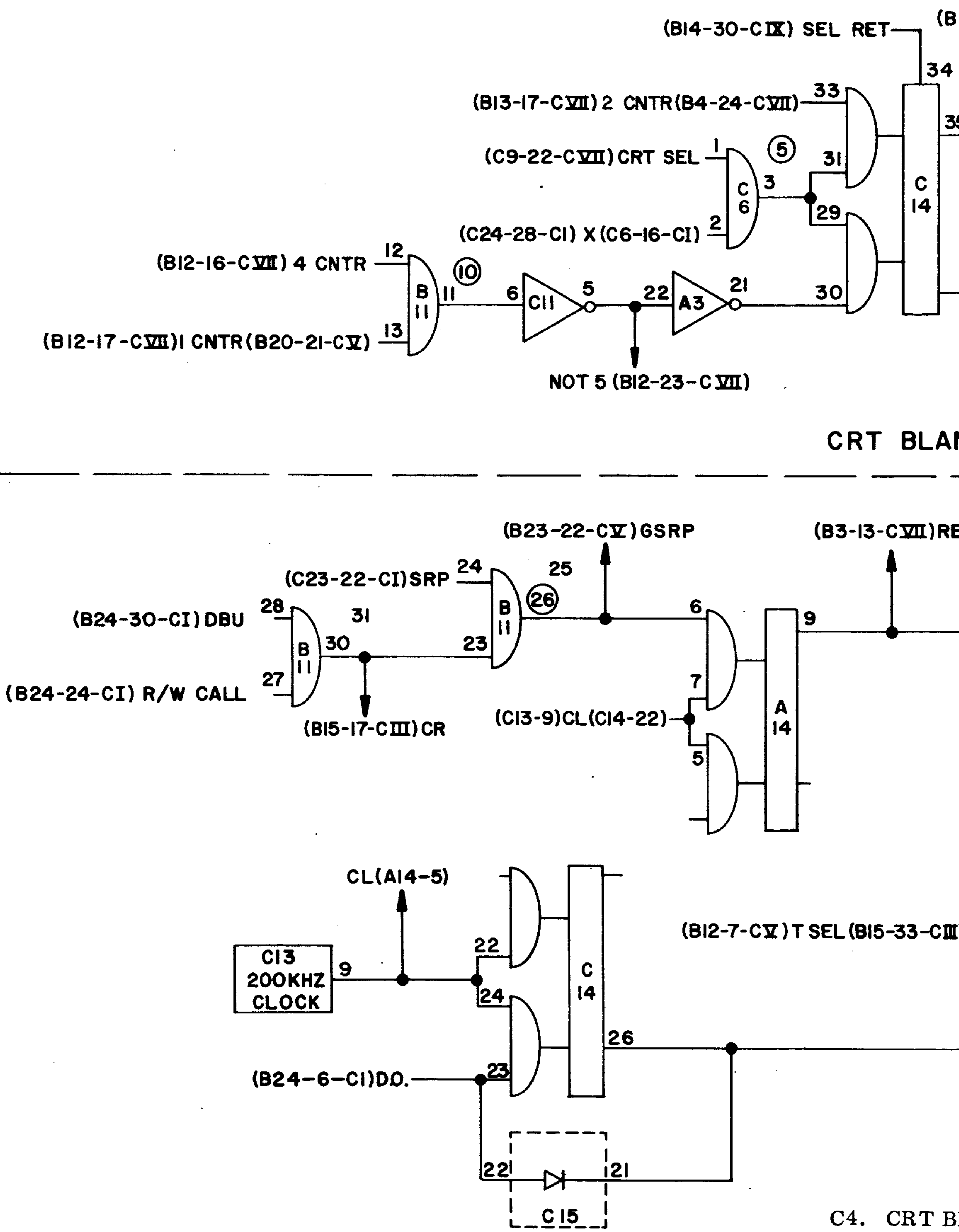
CATHODE RAY SCOPE



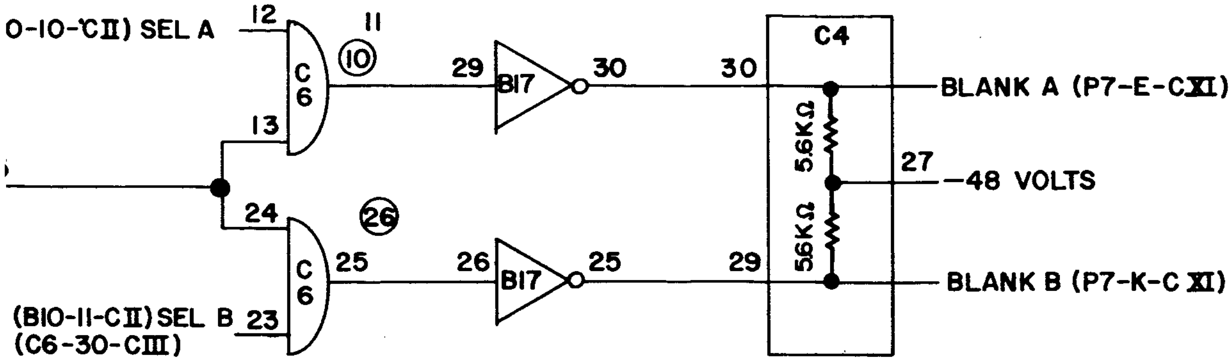
C3.



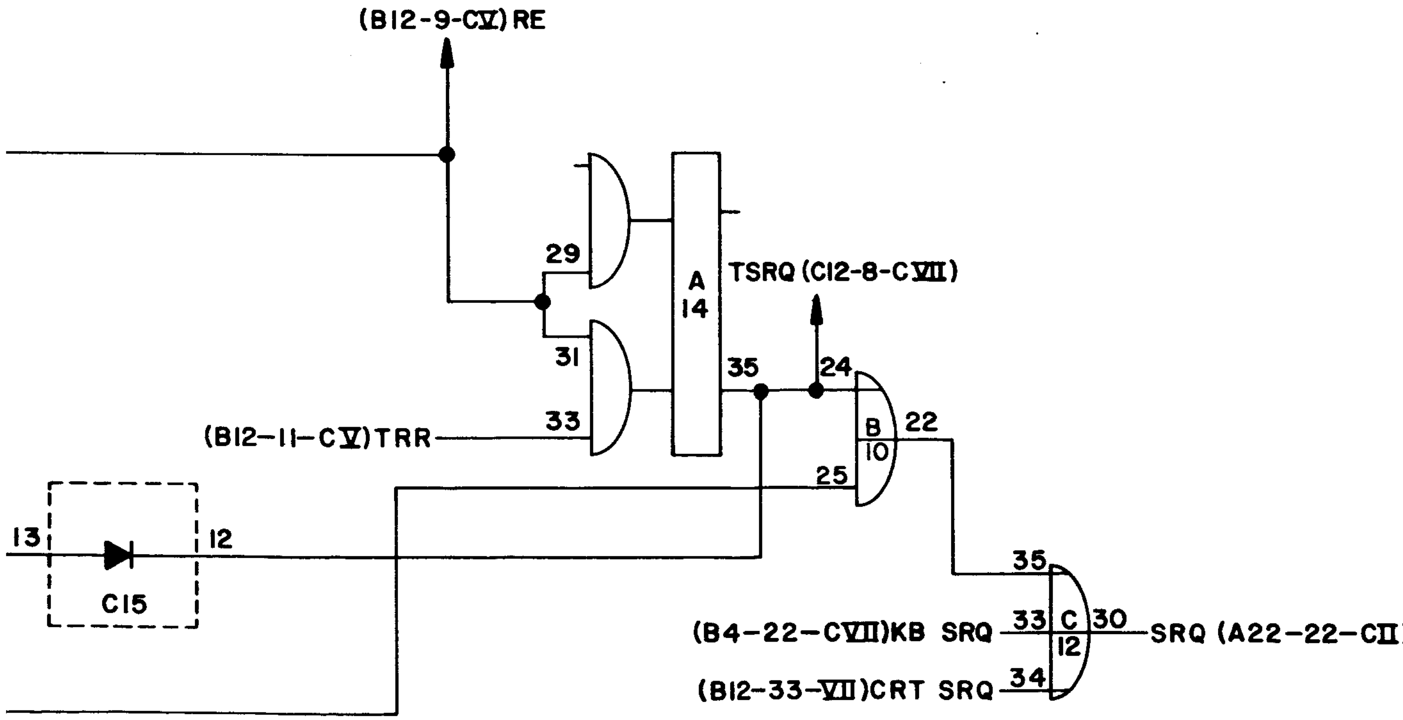
SELECT REGISTER


(B14-30-CIX) SEL RET
(B13-17-CVII) 2 CNTR (B4-24-CVII)
(C9-22-CVII) CRT SEL
(C24-28-CI) X (C6-16-CI)
(B12-16-CVII) 4 CNTR
(B12-17-CVII) I CNTR (B20-21-CV)
NOT 5 (B12-23-CVII)
CRT BLAN
(B23-22-CV) GSRP
(B3-13-CVII) RE
(C23-22-CI) SRP
(B24-30-CI) DBU
(B24-24-CI) R/W CALL
(B15-17-CIII) CR
(C13-9) CL (C14-22)
CL (A14-5)
C13 200KHZ CLOCK
(B12-7-CV) T SEL (B15-33-CIII
(B24-6-CI) D.O.
C15

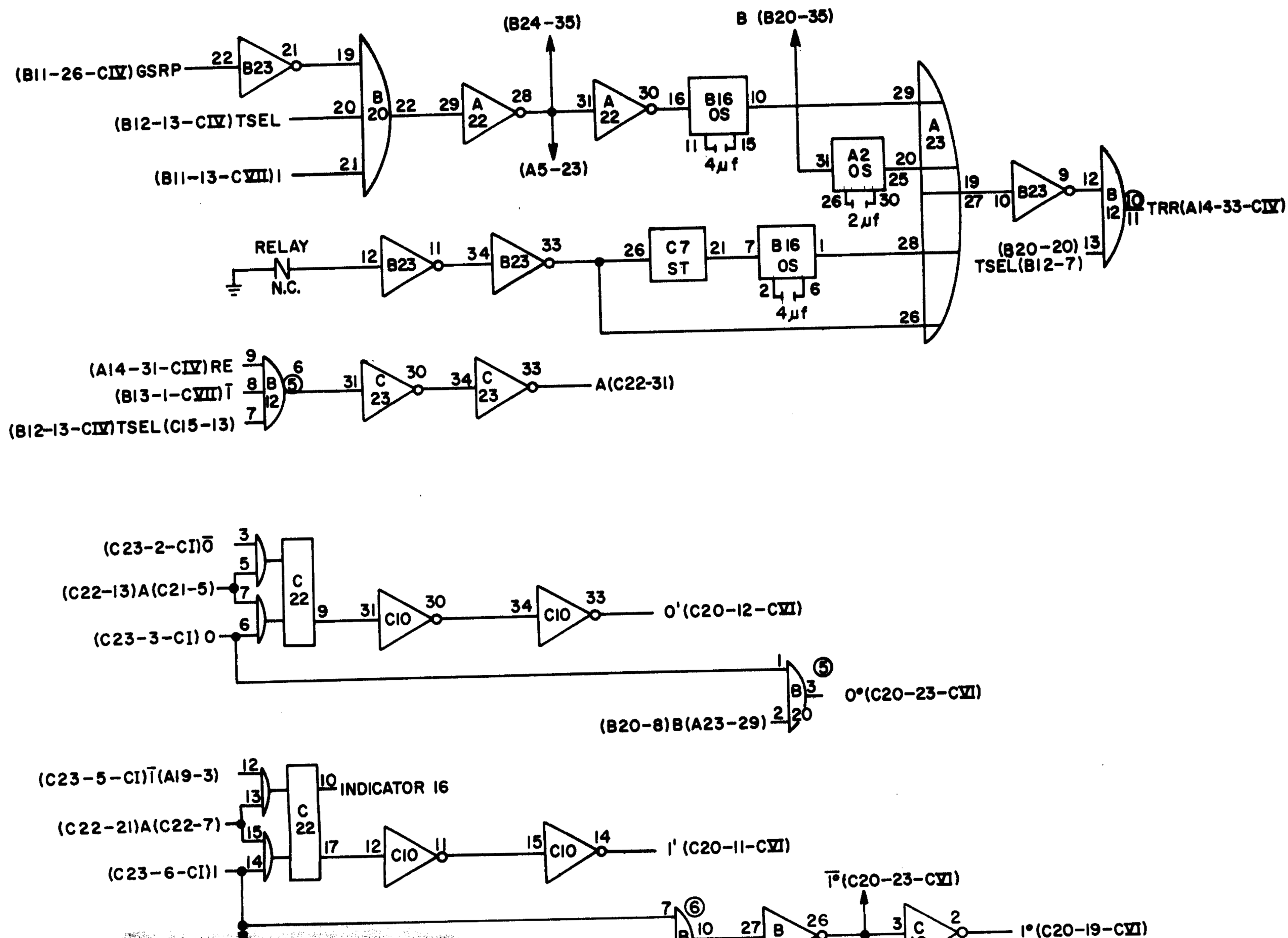
C4. CRT B



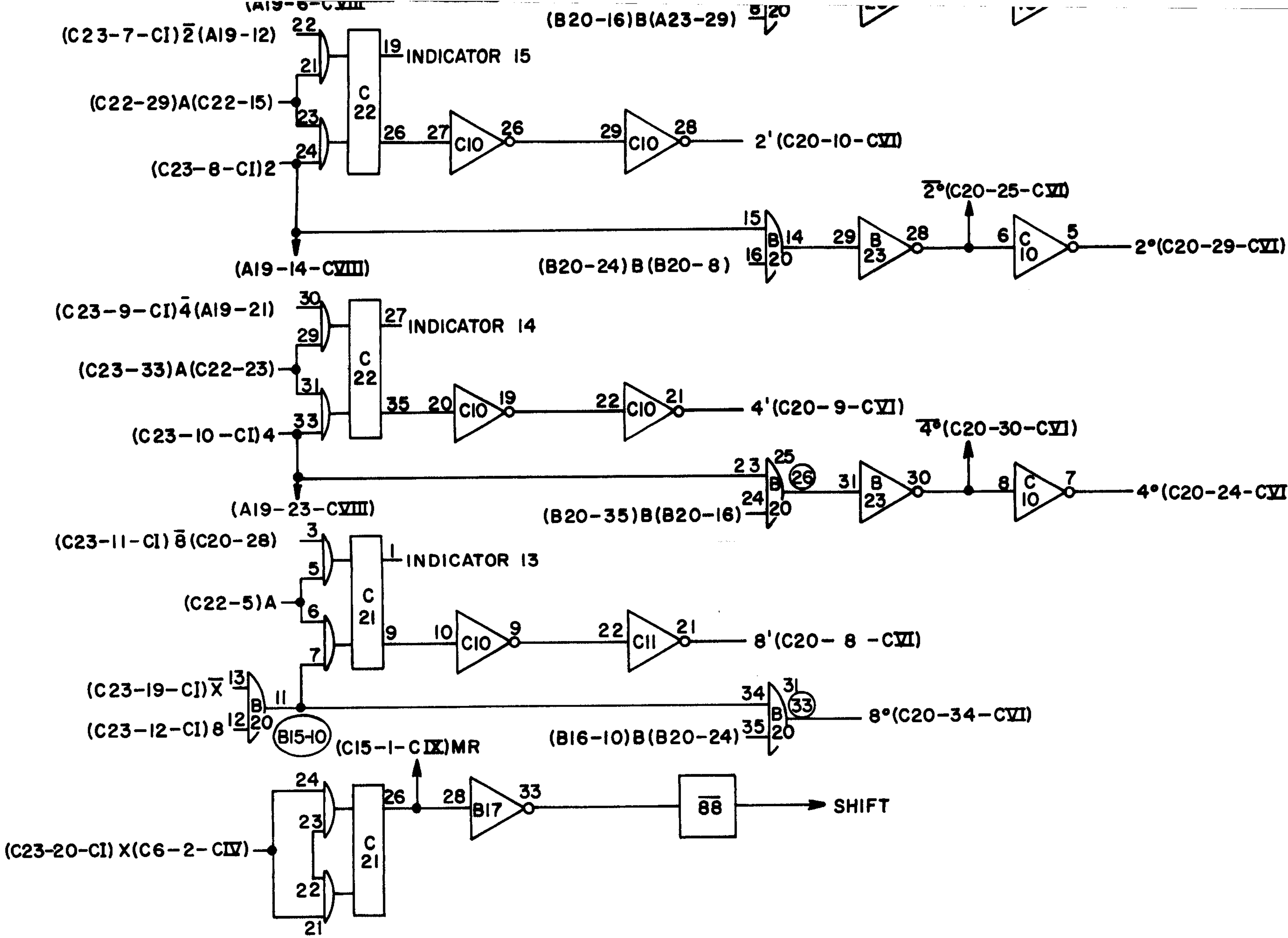
IKING



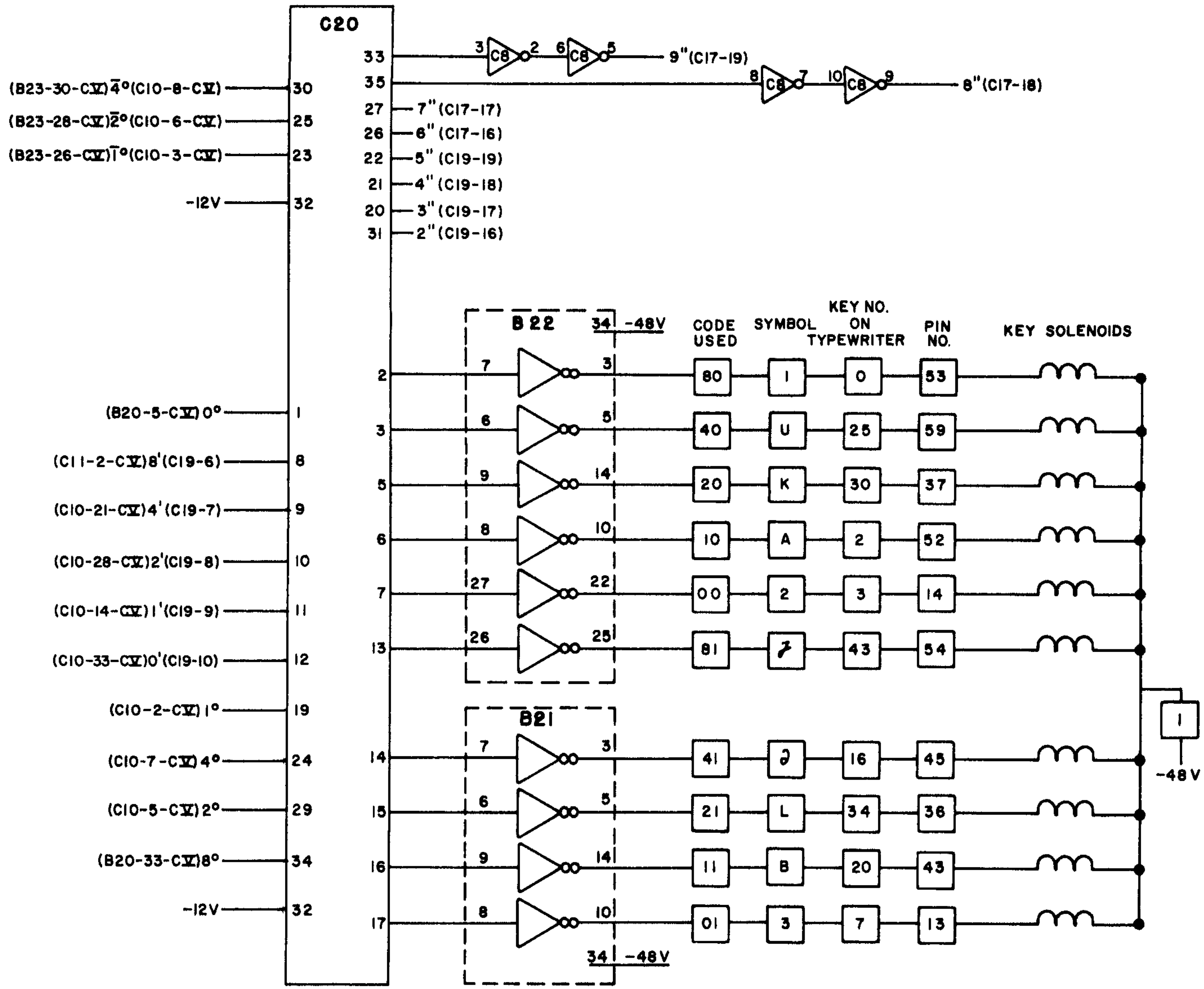
.ANKING AND SERVICE REQUEST CONTROL



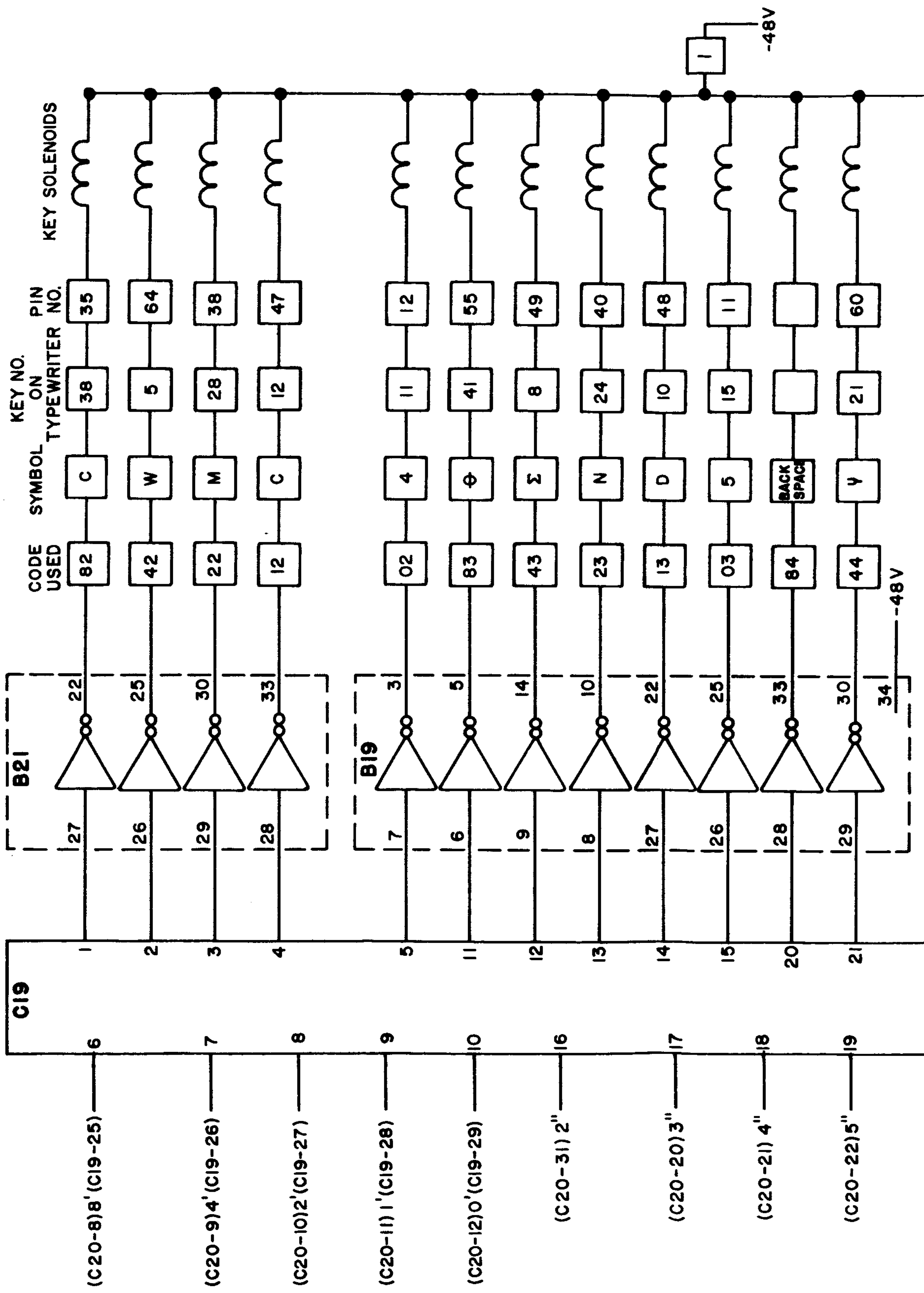
(B11-26-CIV) GSRP
(B12-13-CIV) TSEL
(B11-13-CVII) I
B23
B 20
A 22
(B24-35)
(A5-23)
B16 OS
4μf
B (B20-35)
A2 OS
2μf
A 23
TRR(A14-33-CIV)
(B20-20)
TSEL(B12-7)
RELAY
N.C.
C7 ST
(A14-31-CIV) RE
(B13-1-CVII) $\bar{T}$
(B12-13-CIV) TSEL (C15-13)
C 23
A(C22-31)
(C23-2-CI) $\bar{O}$
(C22-13) A (C21-5)
(C23-3-CI) O
C 22
C10
O'(C20-12-CVI)
O°(C20-23-CVI)
(B20-8) B (A23-29)
(C23-5-CI) $\bar{I}$ (A19-3)
(C22-21) A (C22-7)
(C23-6-CI) I
INDICATOR 16
I' (C20-11-CVI)
$\bar{I}$°(C20-23-CVI)
I°(C20-19-CVI)



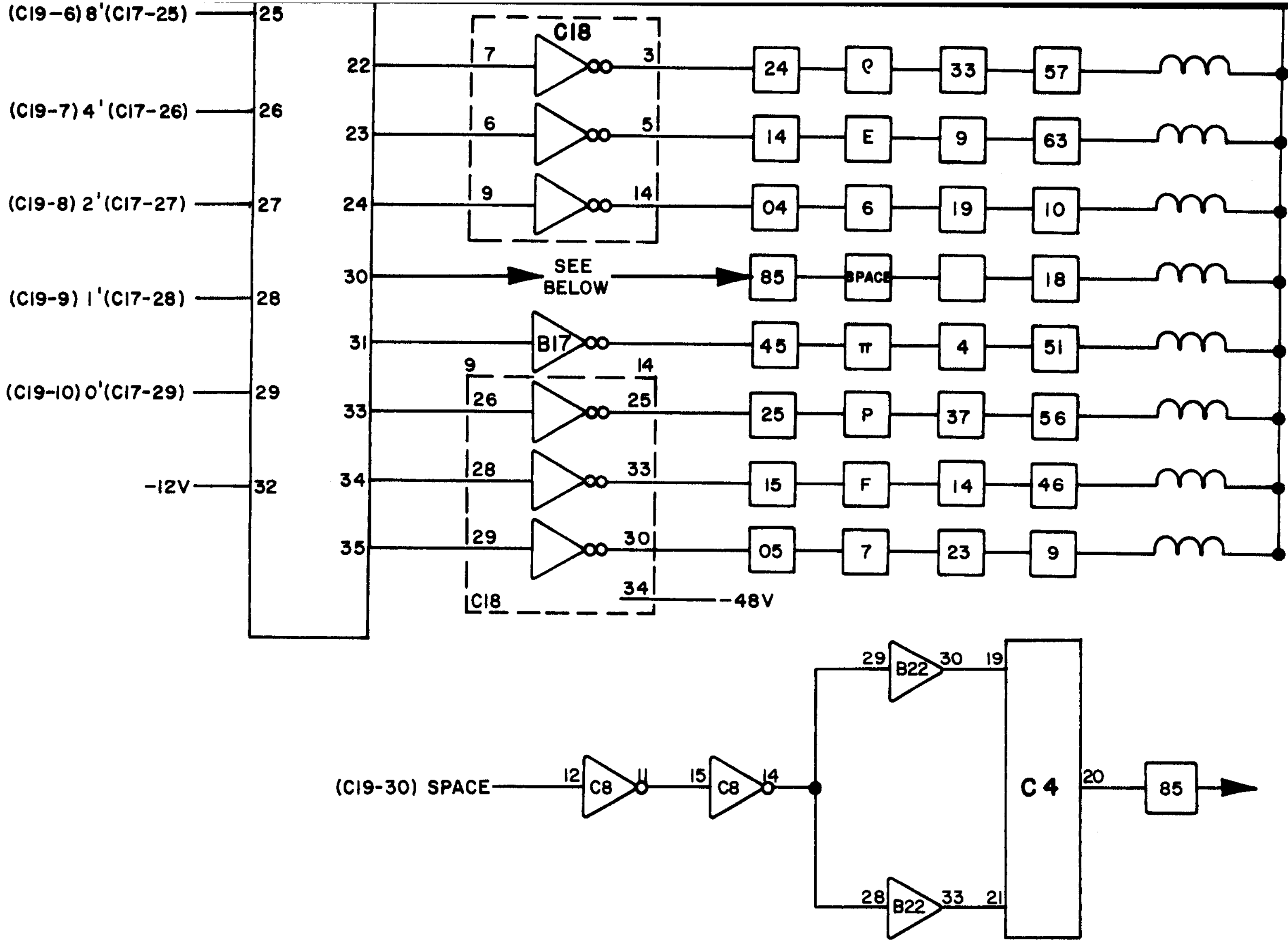
C5. TYPEWRITER CONTROL REGISTER



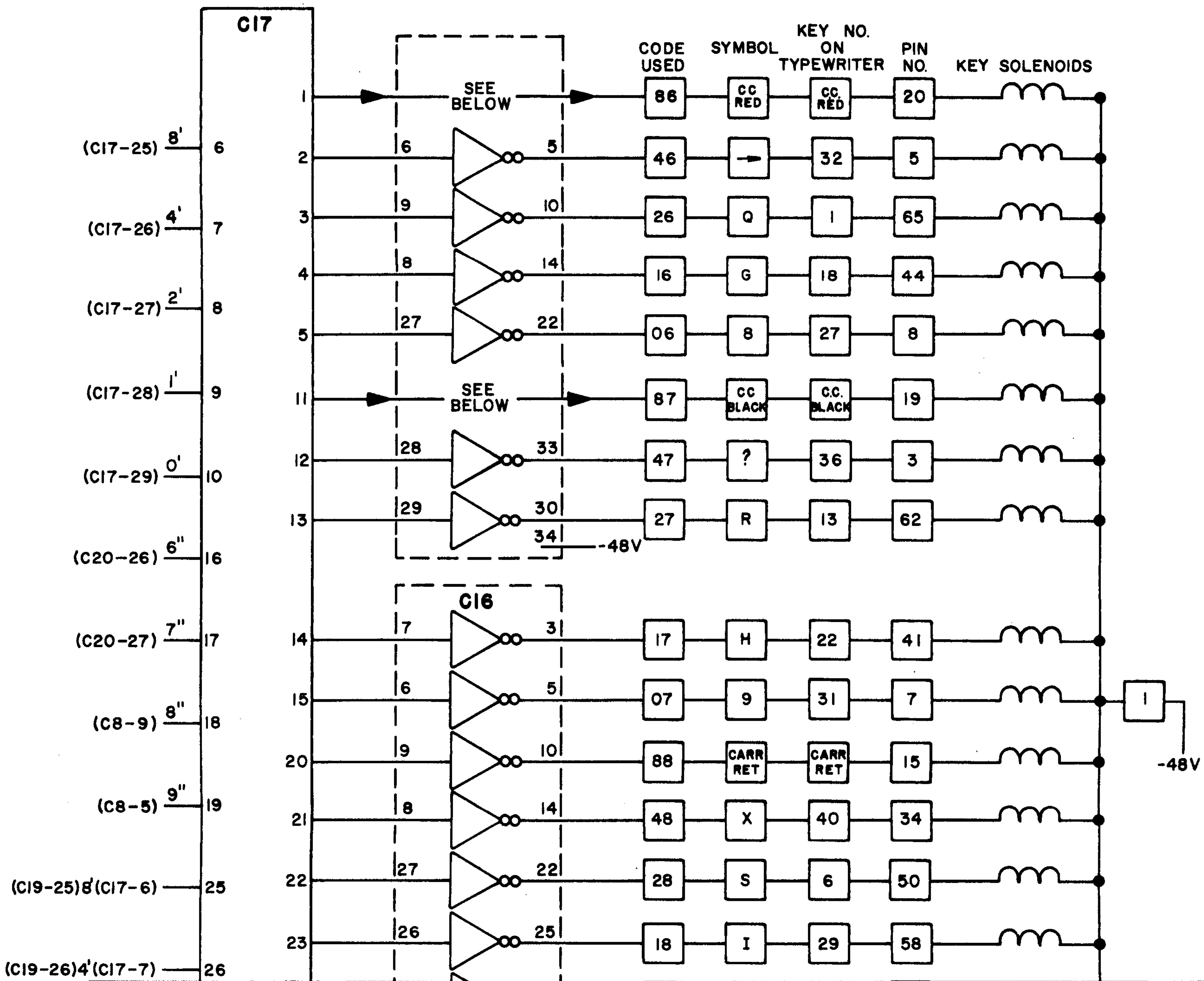
C6(PART 1). TYPEWRITER DECODING REGISTER

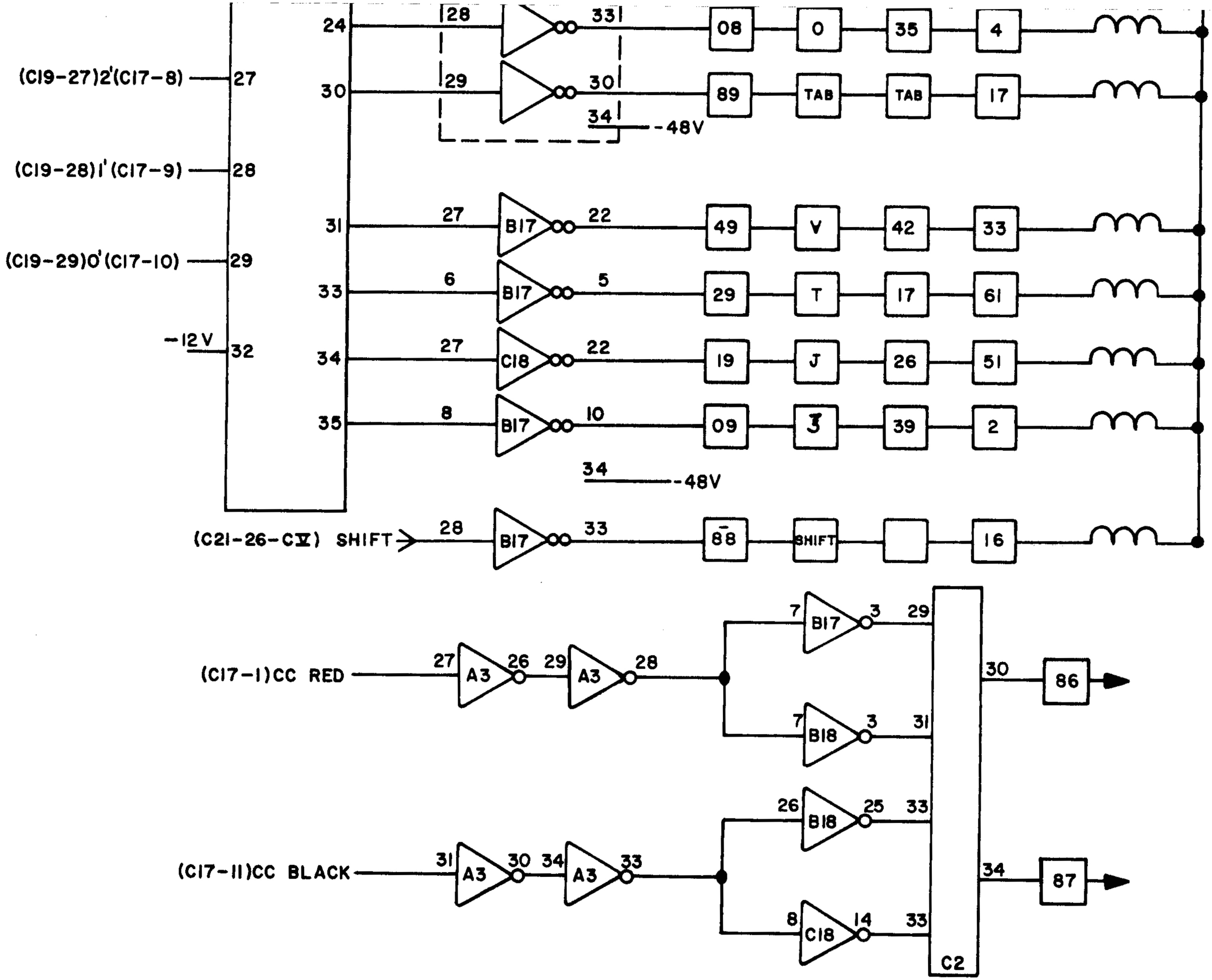


PRECEDING PAGE BLANK NOT FILMED.

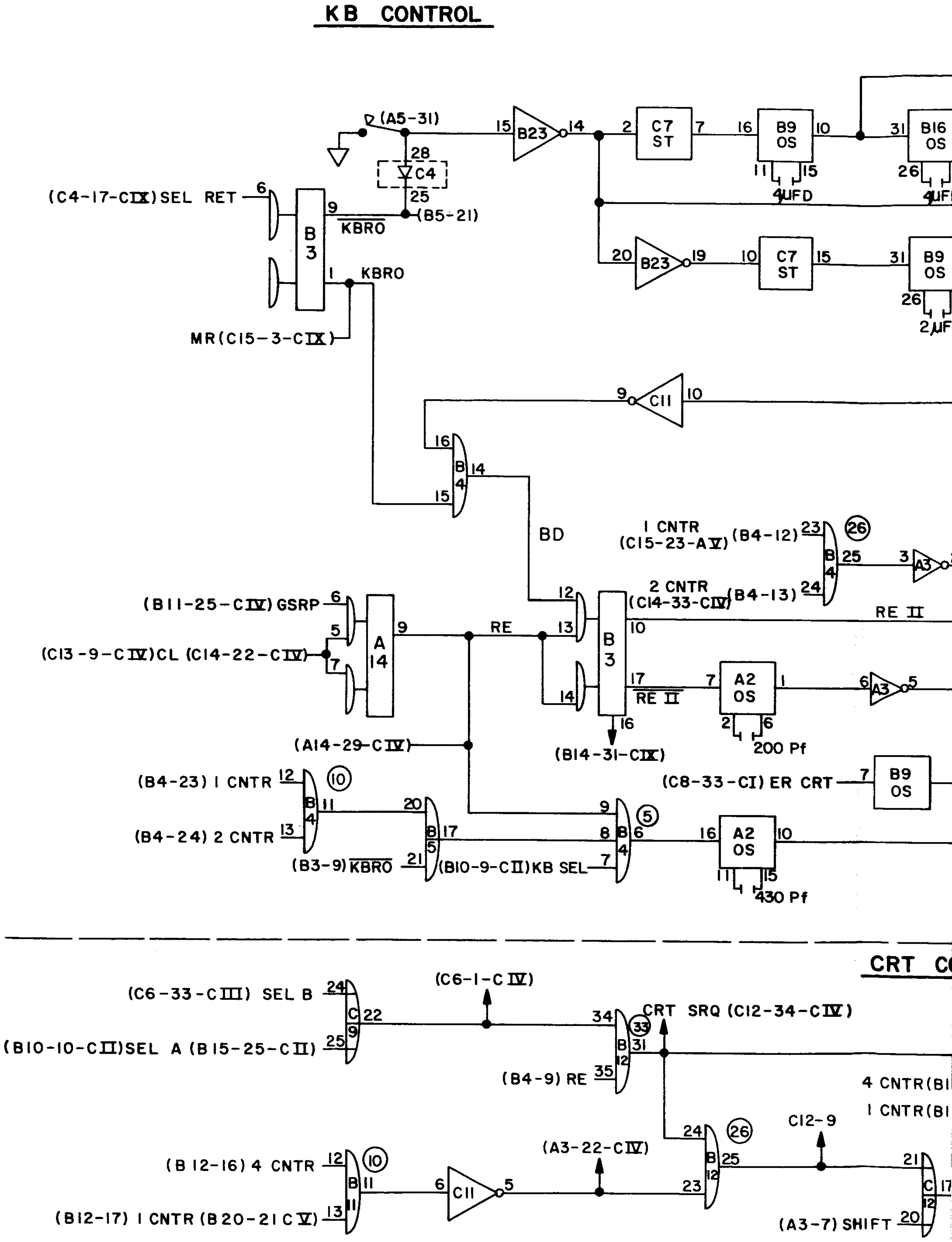


C6(PART 2). TYPEWRITER DECODING REGISTER

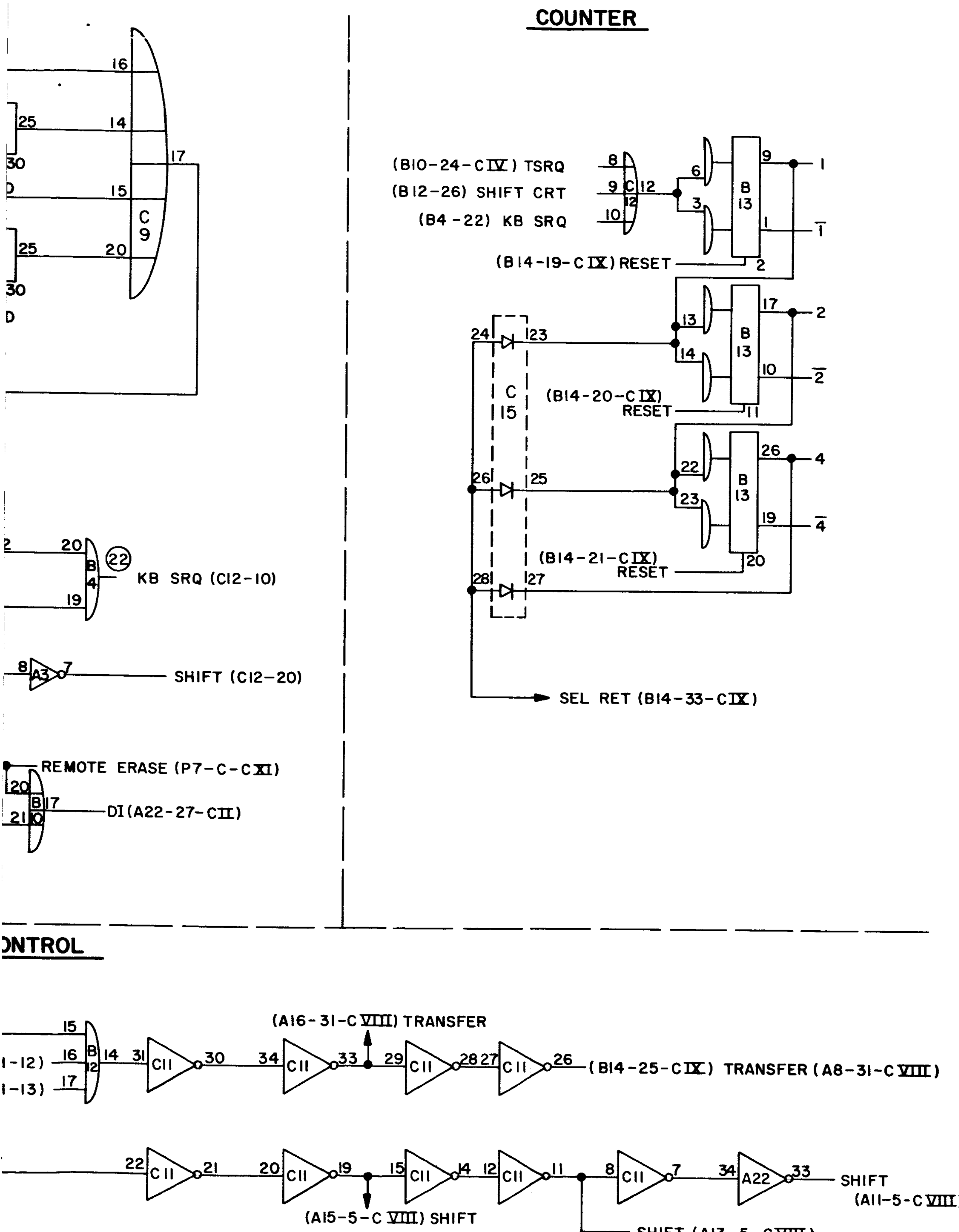

C17
C16
CODE USED
SYMBOL
KEY NO. ON TYPEWRITER
PIN NO.
KEY SOLENOIDS
SEE BELOW
SEE BELOW
-48V
-48V
86 CC RED CC. RED 20
46 → 32 5
26 Q 1 65
16 G 18 44
06 8 27 8
87 CC BLACK C.C. BLACK 19
47 ? 36 3
27 R 13 62
17 H 22 41
07 9 31 7
88 CARR RET CARR RET 15
48 X 40 34
28 S 6 50
18 I 29 58
(C17-25) 8'
(C17-26) 4'
(C17-27) 2'
(C17-28) 1'
(C17-29) 0'
(C20-26) 6"
(C20-27) 7"
(C8-9) 8"
(C8-5) 9"
(C19-25)8'(C17-6)
(C19-26)4'(C17-7)



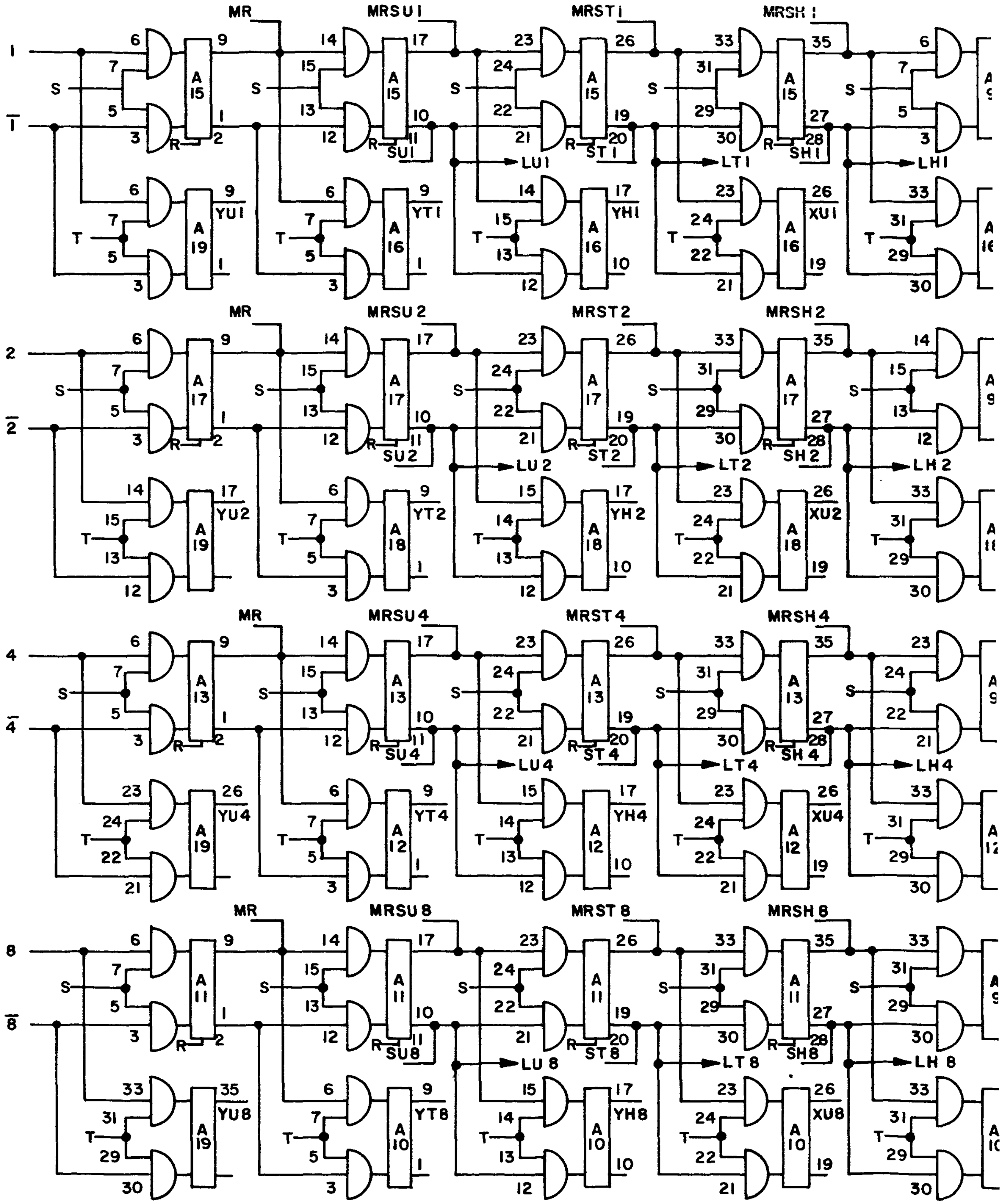
C6(PART 3). TYPEWRITER DECODING REGISTER

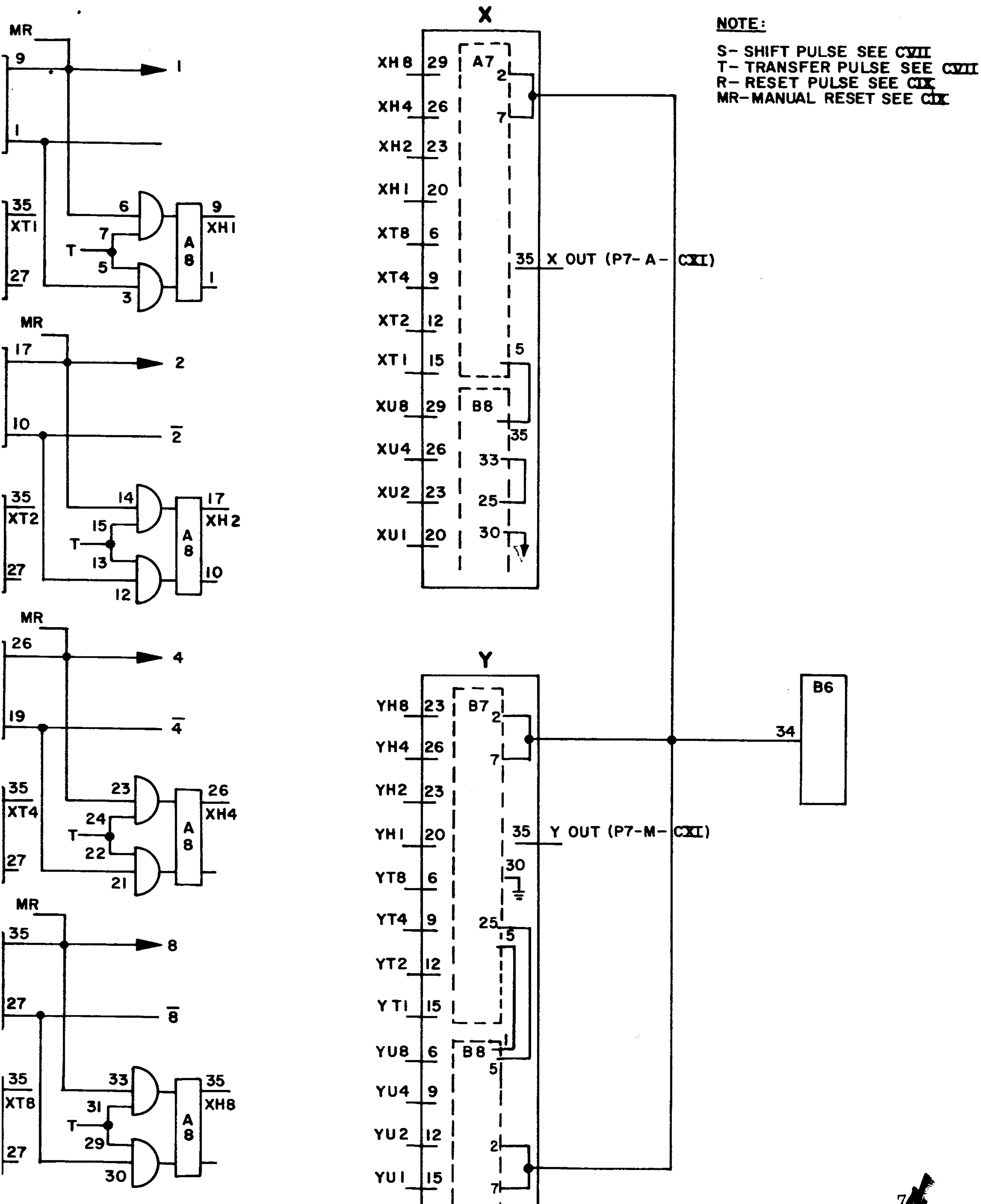


C7. KEYBOARD A

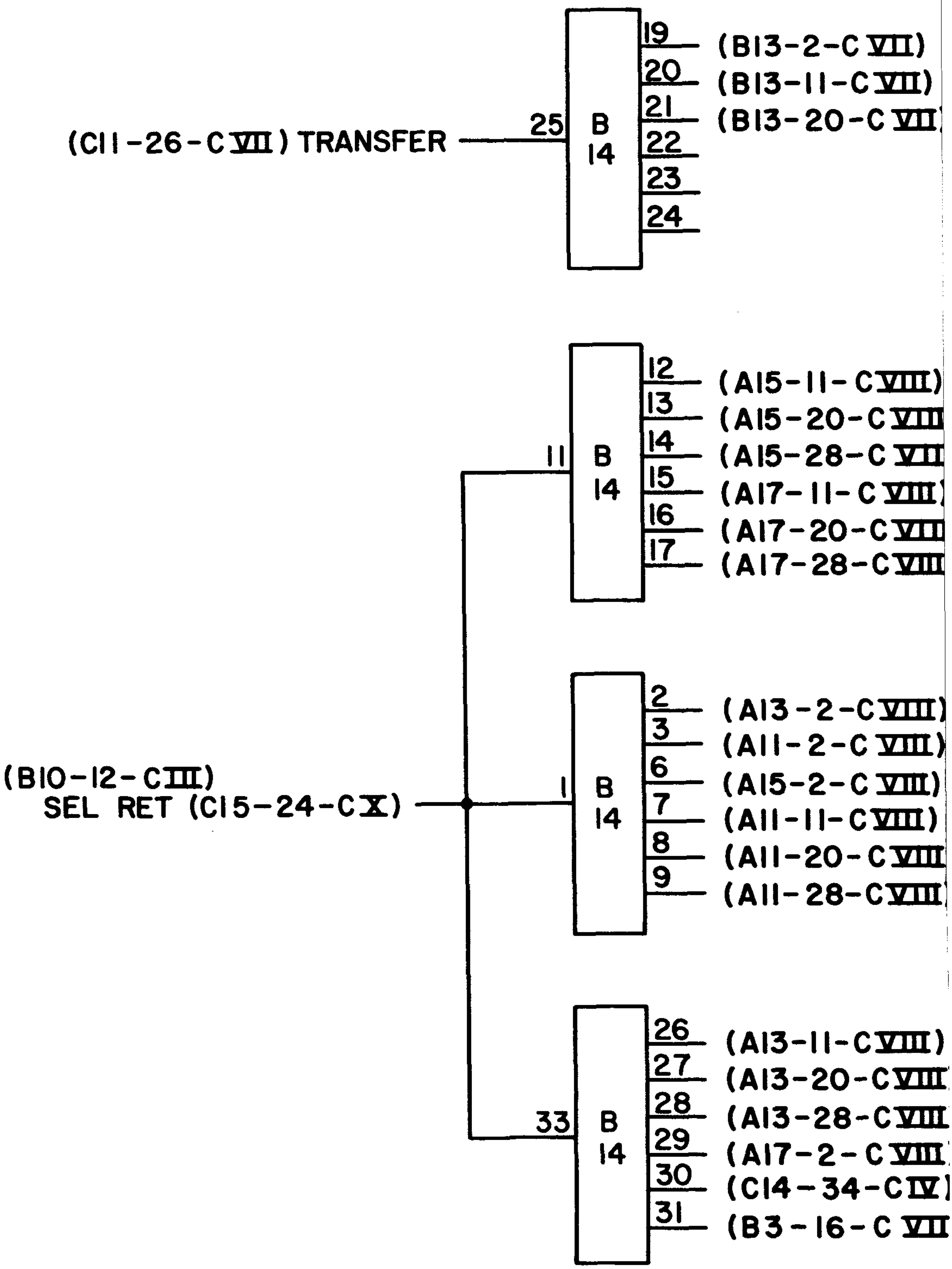


ND CRT CONTROL


MR
MRSU1
MRST1
MRSH1
SU1
ST1
SH1
LU1
LT1
LH1
YU1
YT1
YH1
XU1
MRSU2
MRST2
MRSH2
SU2
ST2
SH2
LU2
LT2
LH2
YU2
YT2
YH2
XU2
MRSU4
MRST4
MRSH4
SU4
ST4
SH4
LU4
LT4
LH4
YU4
YT4
YH4
XU4
MRSU8
MRST8
MRSH8
SU8
ST8
SH8
LU8
LT8
LH8
YU8
YT8
YH8
XU8


NOTE:
S- SHIFT PULSE SEE CVII
T- TRANSFER PULSE SEE CVII
R- RESET PULSE SEE CIX
MR-MANUAL RESET SEE CIX
X
A7
B8
35 X OUT (P7-A-CXI)
Y
B7
B8
35 Y OUT (P7-M-CXI)
B6
34
XH8 29
XH4 26
XH2 23
XH1 20
XT8 6
XT4 9
XT2 12
XT1 15
XU8 29
XU4 26
XU2 23
XU1 20
YH8 23
YH4 26
YH2 23
YH1 20
YT8 6
YT4 9
YT2 12
YT1 15
YU8 6
YU4 9
YU2 12
YU1 15
MR
T
XT1
XH1
XT2
XH2
XT4
XH4
XT8
XH8
A8

T BUFFER



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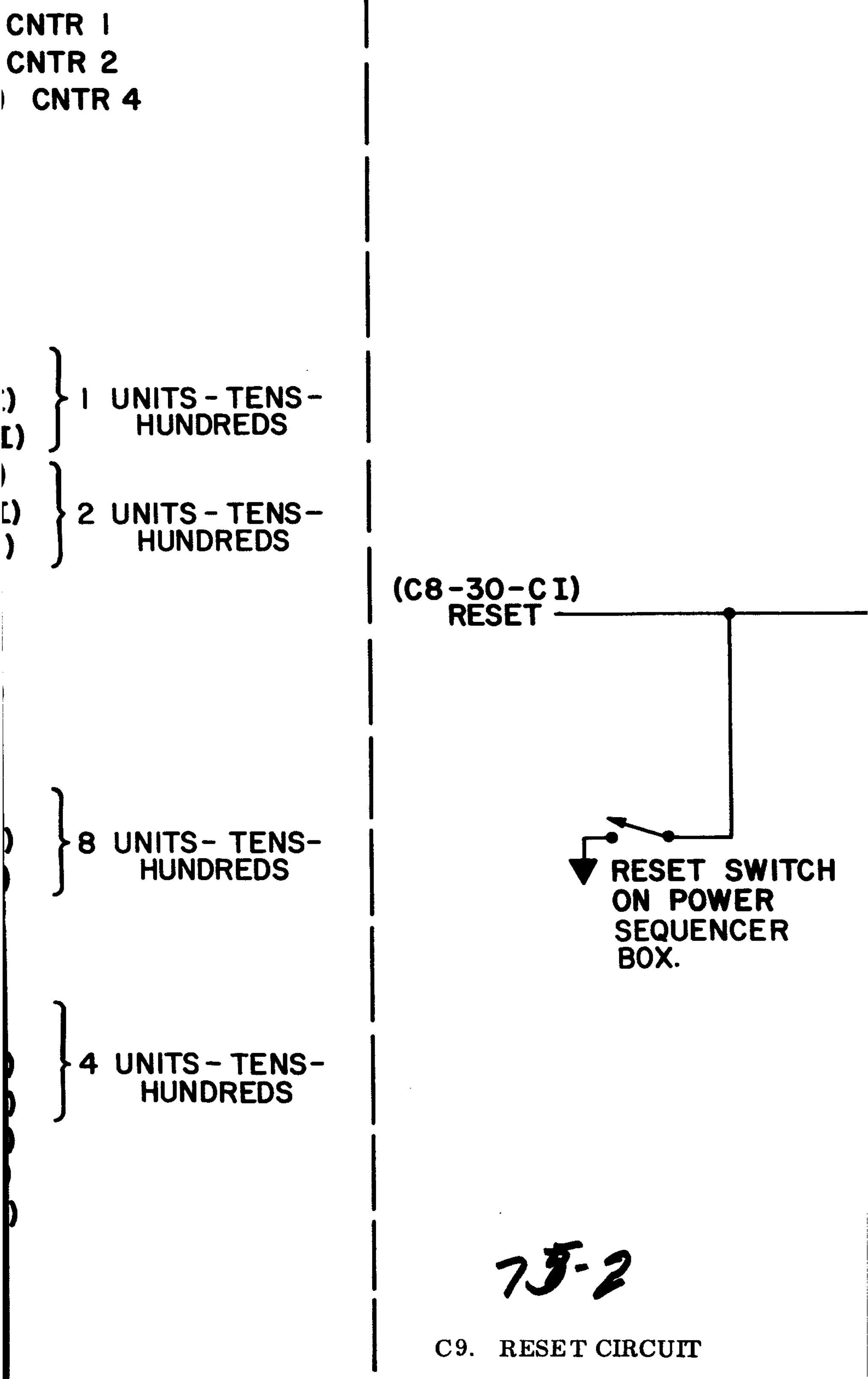
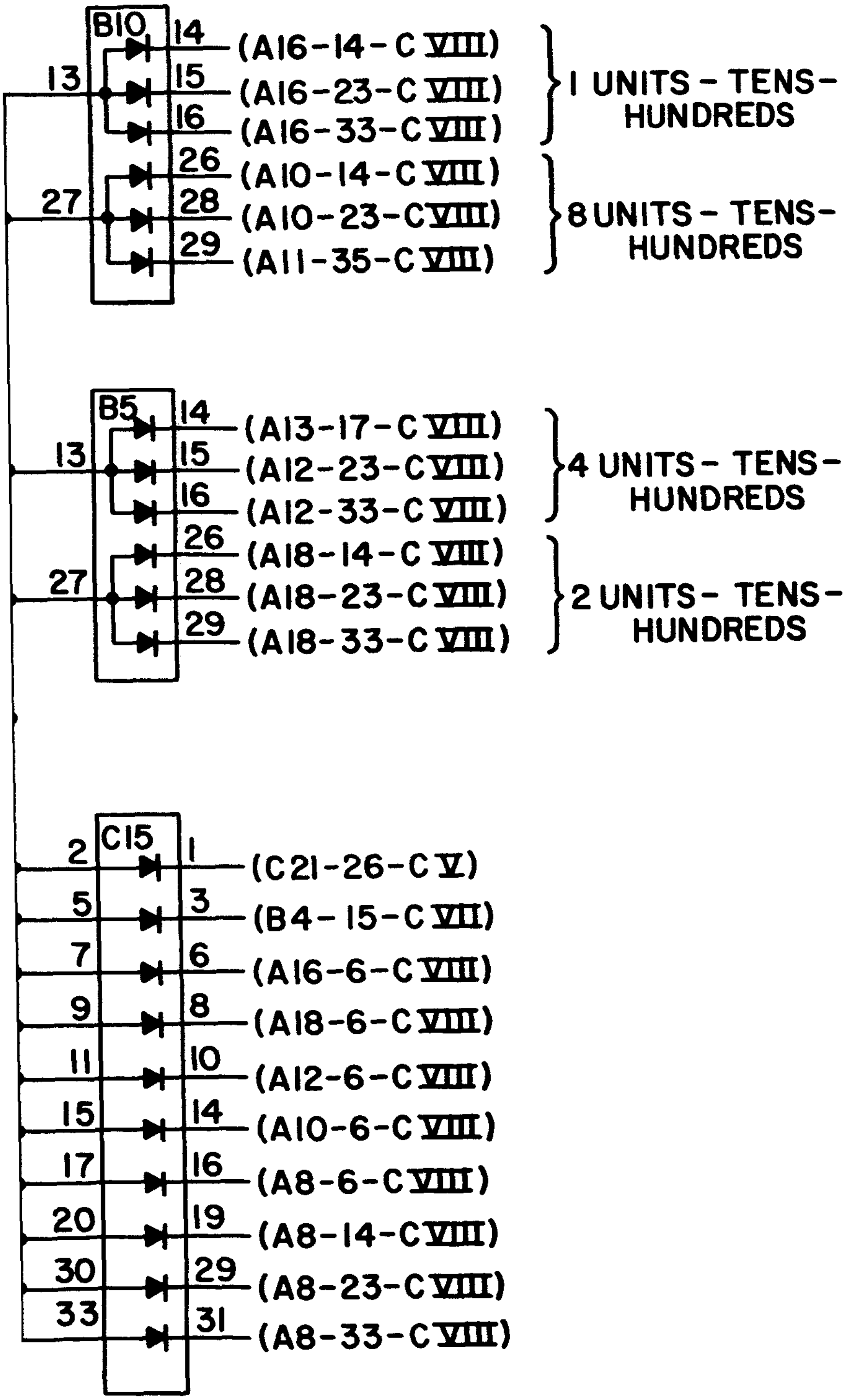
RESET GATE CIRCUIT

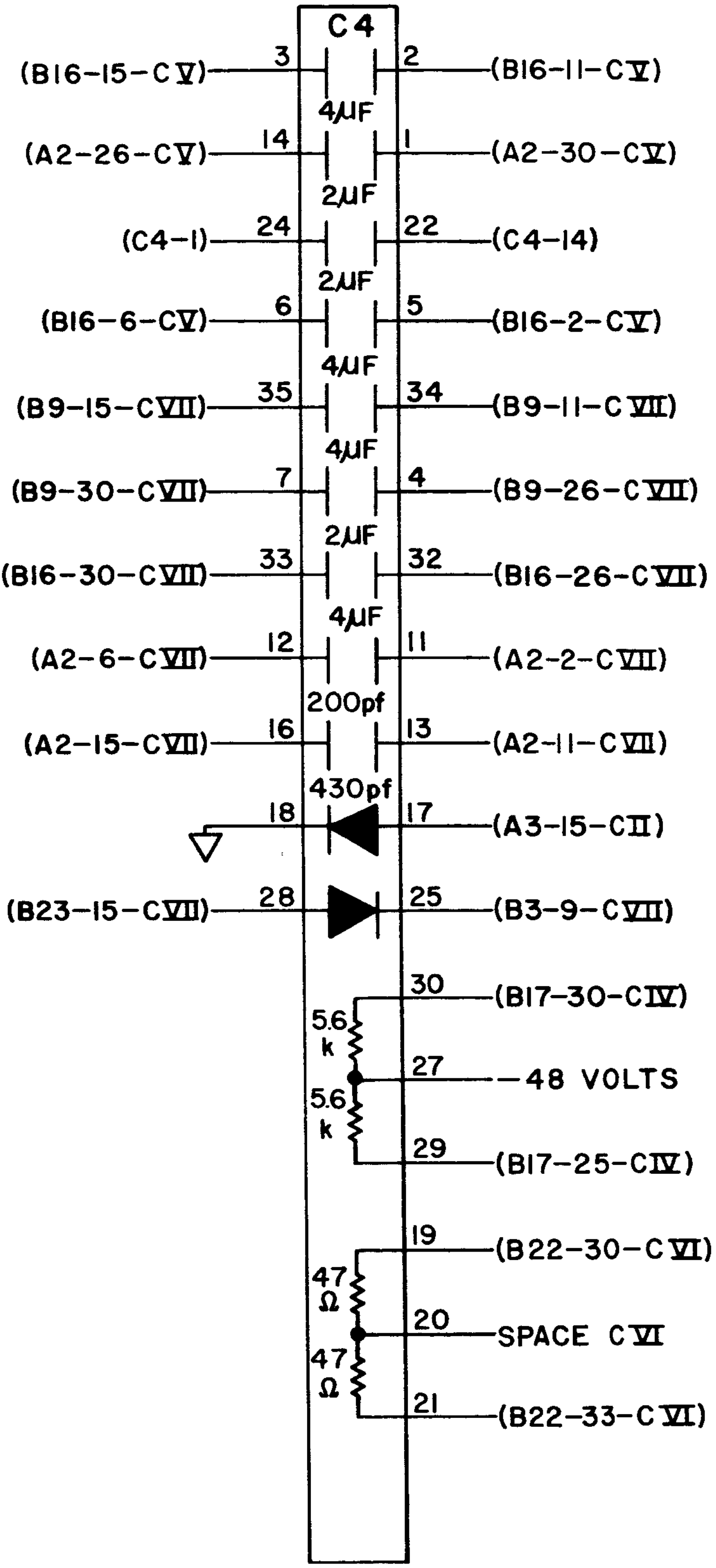


75-2

C9. RESET CIRCUIT

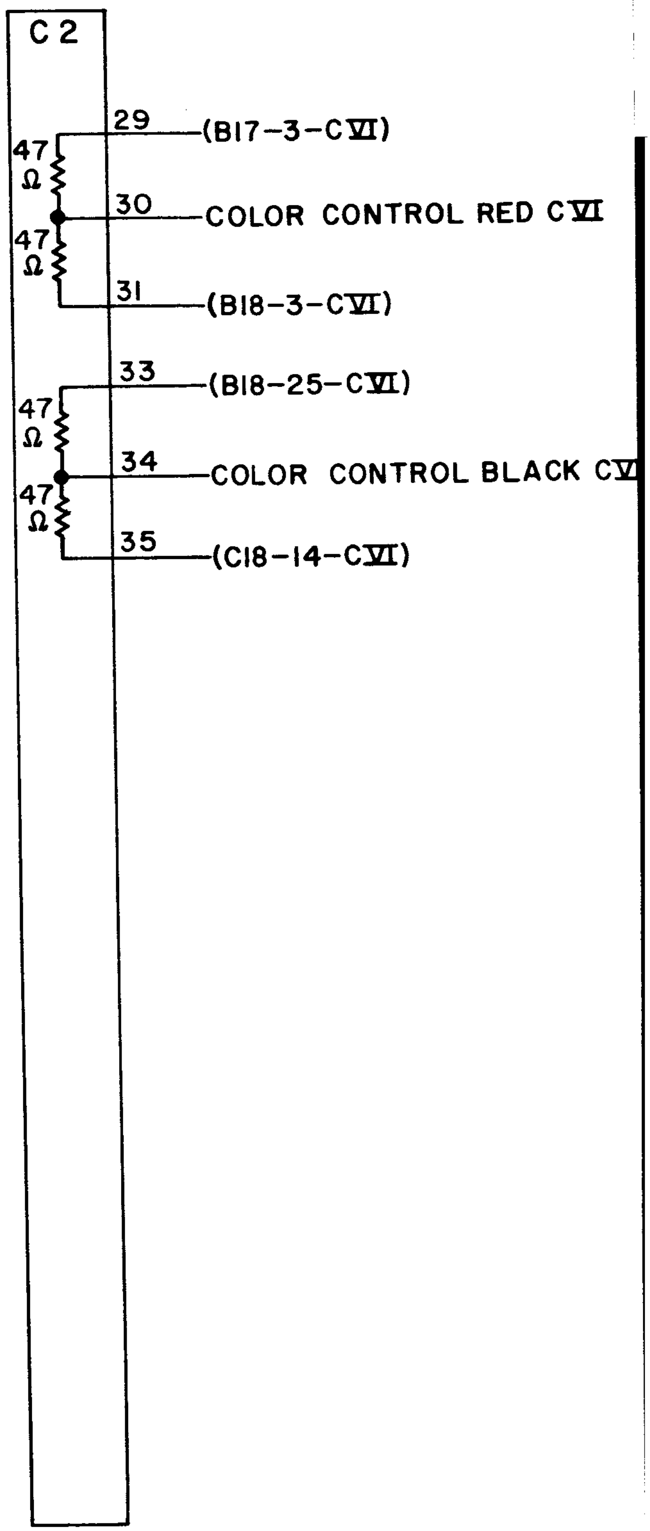


MANUAL RESET



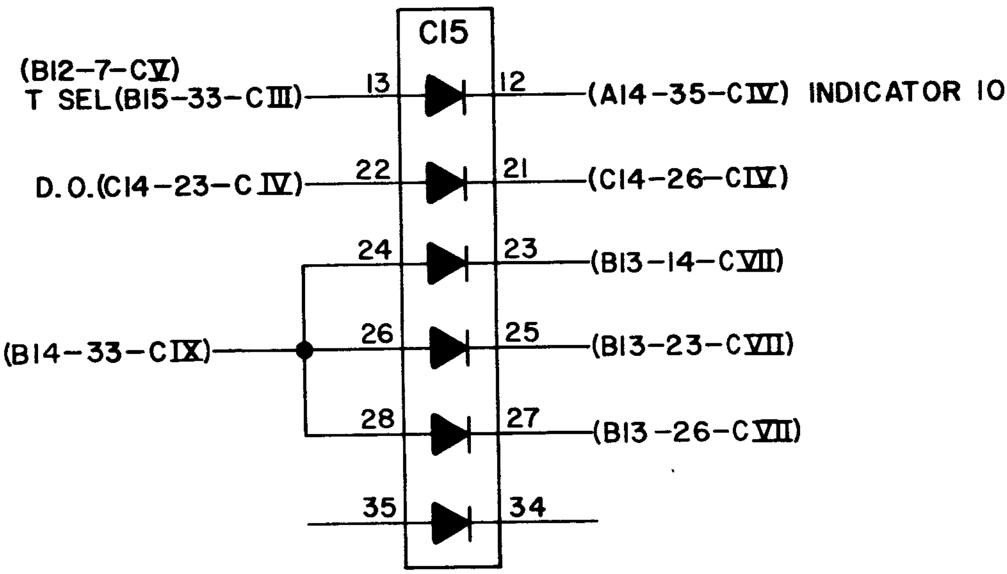
UTILITY BOARD NO I

77-1



UTILITY BOARD NO 2

C10. UTILITY BOARDS AND ISOLATION DIODES



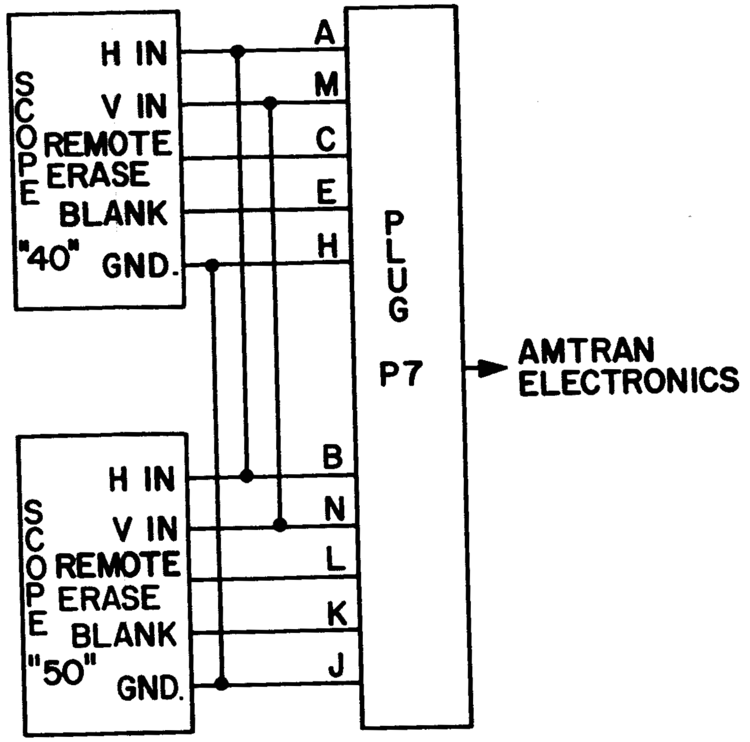
ISOLATION DIODES

SIGNAL	IBM PLUG SIGNAL	IBM PLUG GND PAIR REF.	AMP PLUG P5	KI
0 INTO COMP. (A24-1-CII)	9	10	E	UNITS
1 INTO COMP. (A24-3-CII)	1	2	A	
2 INTO COMP. (A24-9-CII)	3	4	B	
4 INTO COMP. (A24-14-CII)	5	6	C	
8 INTO COMP. (A24-19-CII)	7	8	D	
C INTO COMP. (A24-24-CII)	13	14	F	
SRQ (A24-28-CII)	17	18	H	
D.I. (A24-34-CII)	15	16	d	
I/O SEL (A21-1-CII)	21	22	J	
0 FROM COMP. (C24-5-CI)	31	32	P	
1 FROM COMP. (C24-9-CI)	23	34	K	TENS
2 FROM COMP. (C24-11-CI)	25	26	L	
4 FROM COMP. (C24-17-CI)	27	28	M	
8 FROM COMP. (C24-19-CI)	29	30	N	
C FROM COMP.	NOT USED			
X FROM COMP. (C24-27-CI)	33	34	R	
SRP (C24-31-CI)	39	40	T	
D.O. (B24-5-CI)	37	38	c	
SEL 0 DB (UNITS) (B24-31-CI)	59	60	b	
SEL 1 DB (TENS) (B24-9-CI)	51	52	U	
SEL 2 (B24-11-CI)	53	54	V	HUNDR
SEL 4 (B24-17-CI)	55	56	W	
SEL 8 (B24-19-CI)	57	58	X	
R/W CALL (B24-25-CI)	65	66	a	
CONT-HOLD OUT (A25-31-CI)	67	68	Z	
I/O CHECK (C24-25-CI)	75	76	S	GND
+24 V	169-171	170-172	Y	
GND.		ALL EVEN NO'S.		
RESET (B24-27-CI)		79		

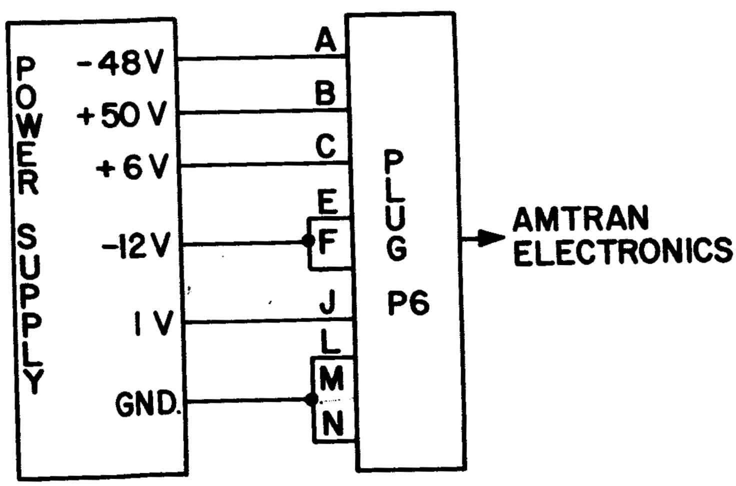
COMPUTER PLUG P5

EYBOARD		AMP PLUG P4
0	(A5-26-A I)	A
1	(A5-15-A I)	B
2	(A5-10-A I)	C
3	(A5-13-A I)	D
4	(A5-21-A I)	E
5	(A5-19-A I)	F
6	(A5-7-A I)	d
7	(A5-24-A I)	H
8	(A5-1-A I)	J
9	(A5-5-A I)	K
0	(A4-26-A II)	L
1	(A4-15-A II)	M
2	(A4-10-A II)	N
3	(A4-13-A II)	P
4	(A4-21-A II)	R
5	(A4-19-A II)	S
6	(A4- 7-A II)	T
7	(A4-24-A II)	U
8	(A4-1-A II)	V
9	(A4-5-A II)	W
EDS		
0	(NOT USED)	a
1	(A4-33-A II)	X
2	(A17-27-C VIII	b
4	(A13-27-C VIII	c
		Y

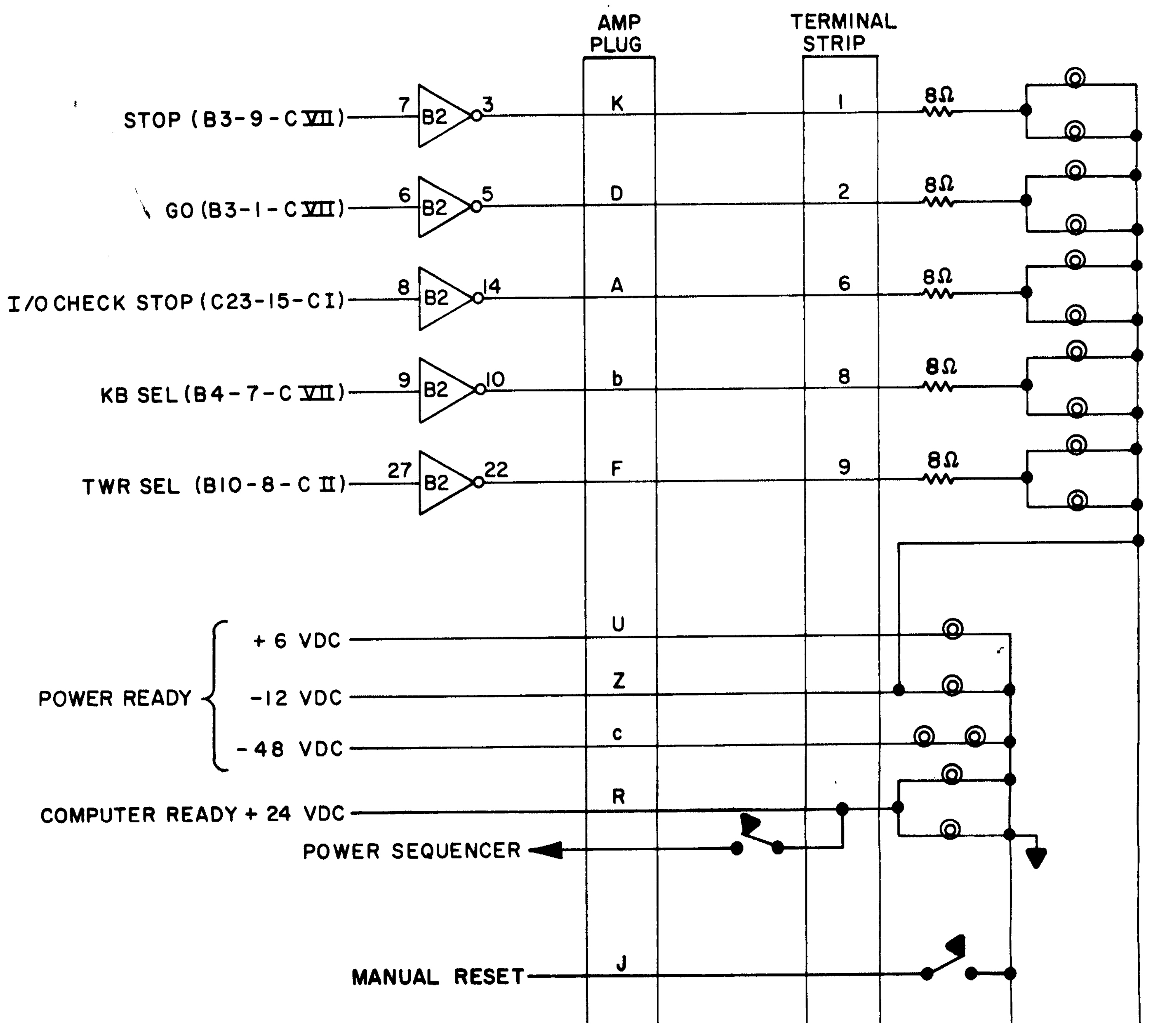
KEYBOARD PLUG P4



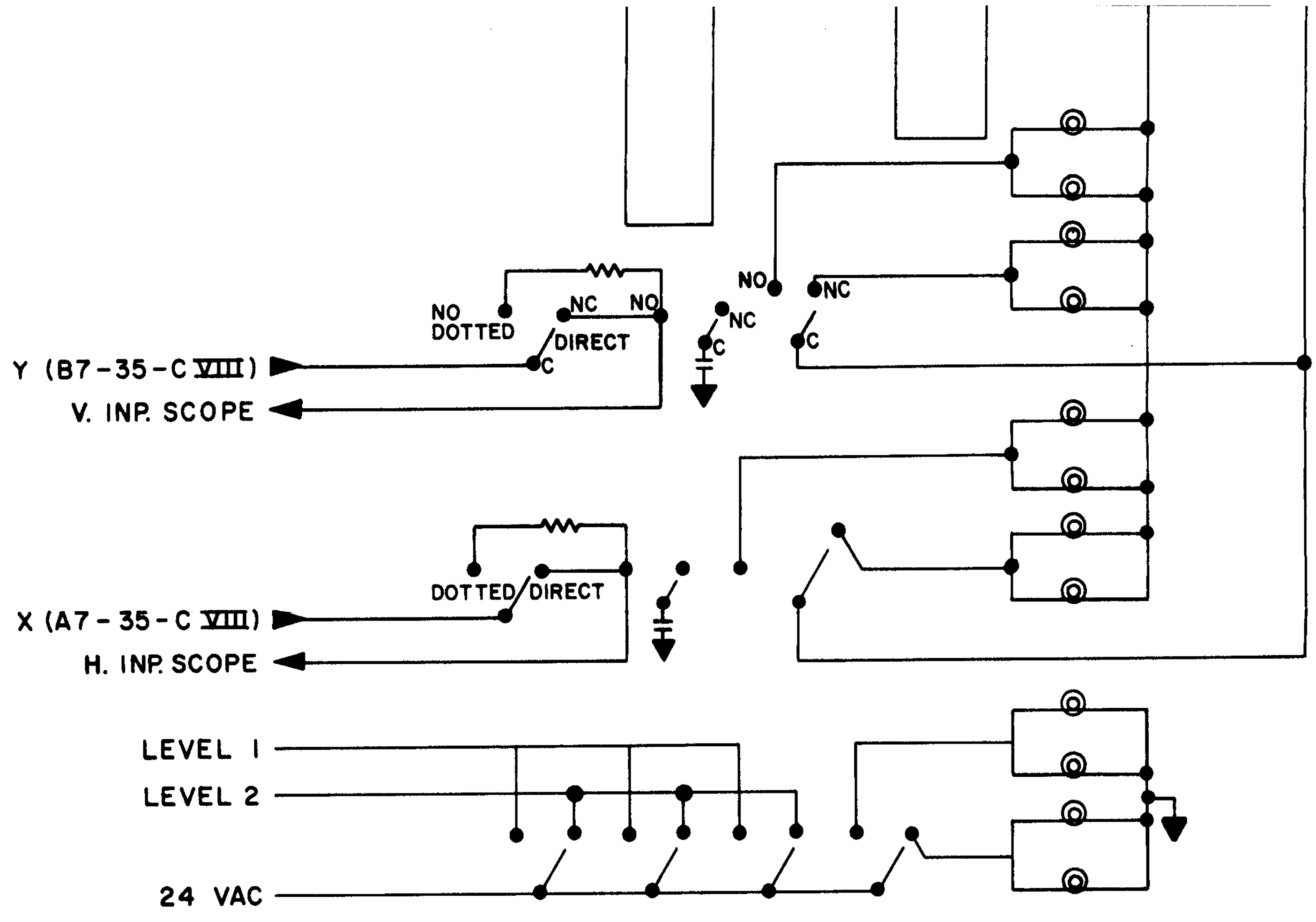
CRT PLUG P7



POWER SUPPLY PLUG P6

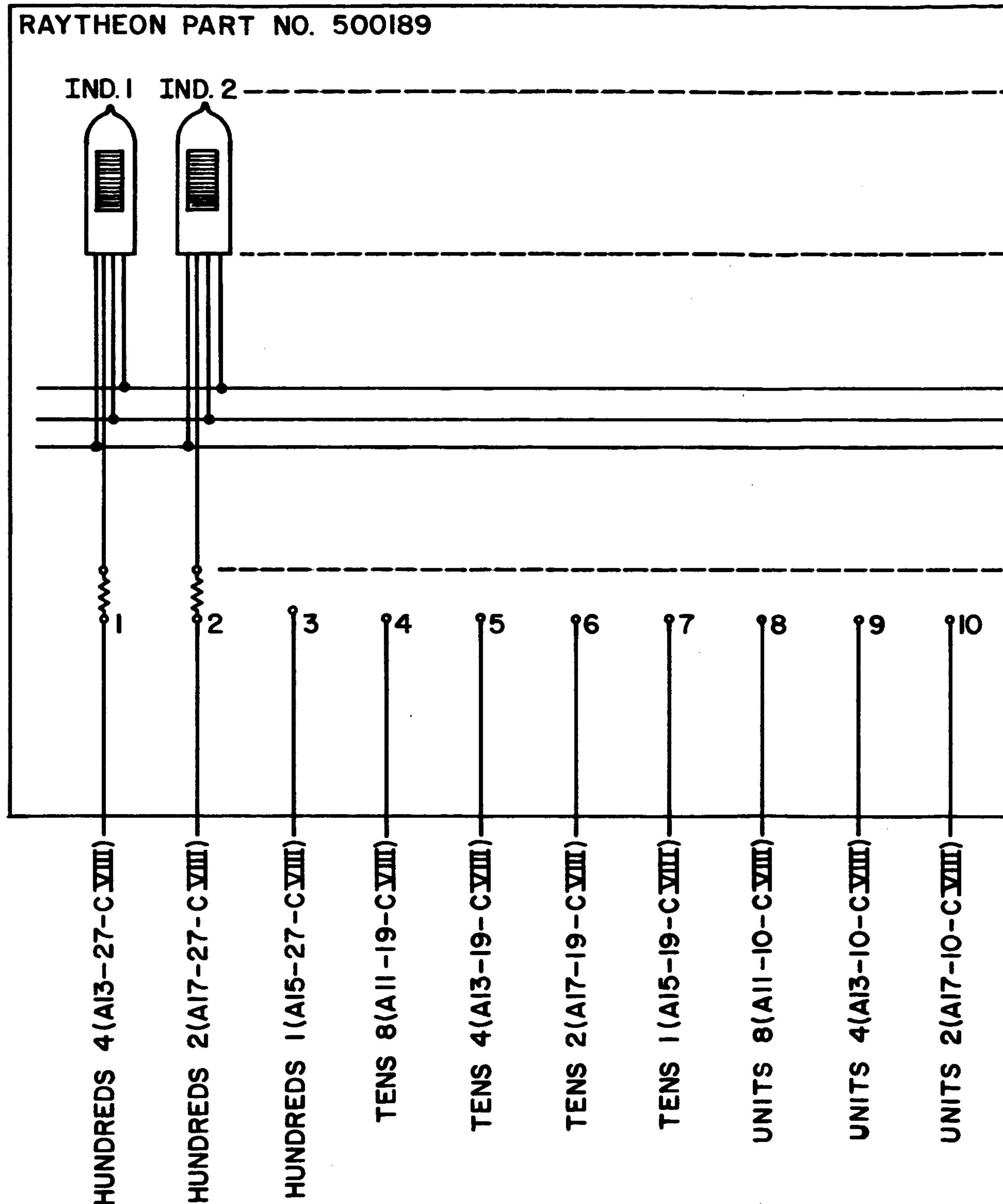

AMP PLUG
TERMINAL STRIP
STOP (B3-9-C VII)
GO (B3-1-C VII)
I/O CHECK STOP (C23-15-C I)
KB SEL (B4-7-C VII)
TWR SEL (B10-8-C II)
7
3
6
5
8
14
9
10
27
22
B2
K
D
A
b
F
U
Z
c
R
J
1
2
6
8
9
8Ω
POWER READY
+ 6 VDC
-12 VDC
-48 VDC
COMPUTER READY + 24 VDC
POWER SEQUENCER
MANUAL RESET

81

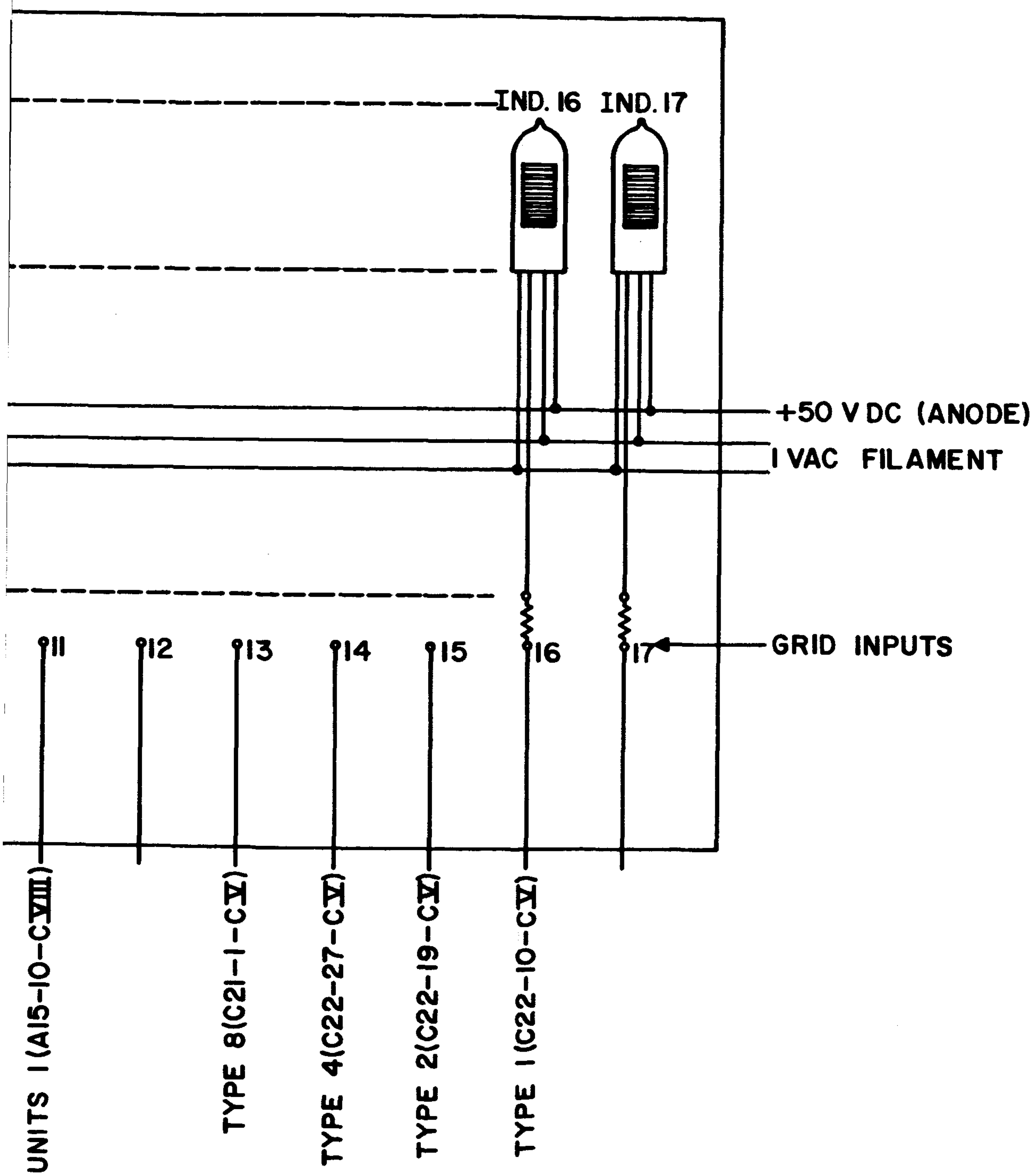


NOTE : ALL 12 VOLT LAMPS # 330
6 VOLT LAMP # 345
24 VOLT LAMPS # 327

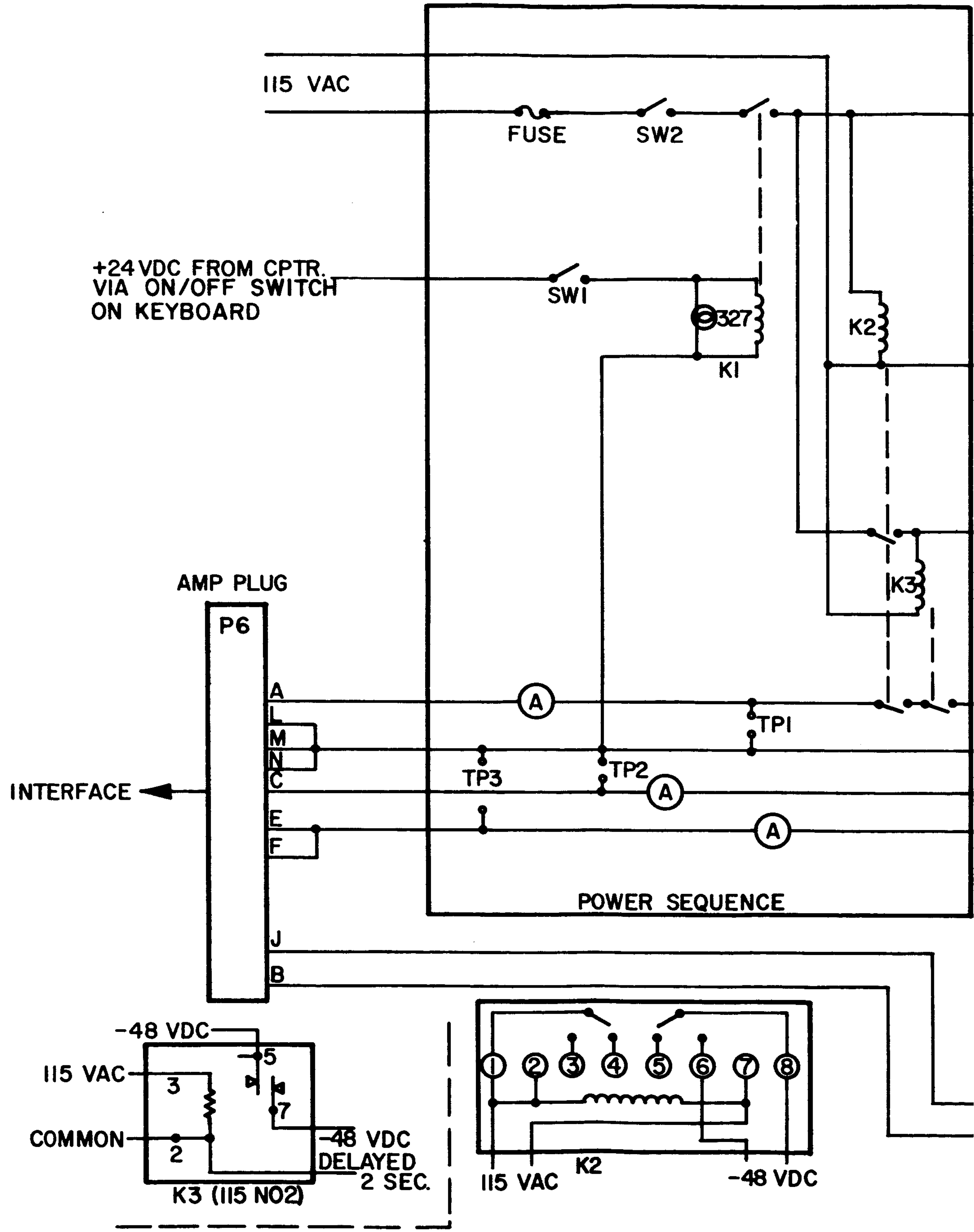
C12. STATION INDICATOR LAMPS



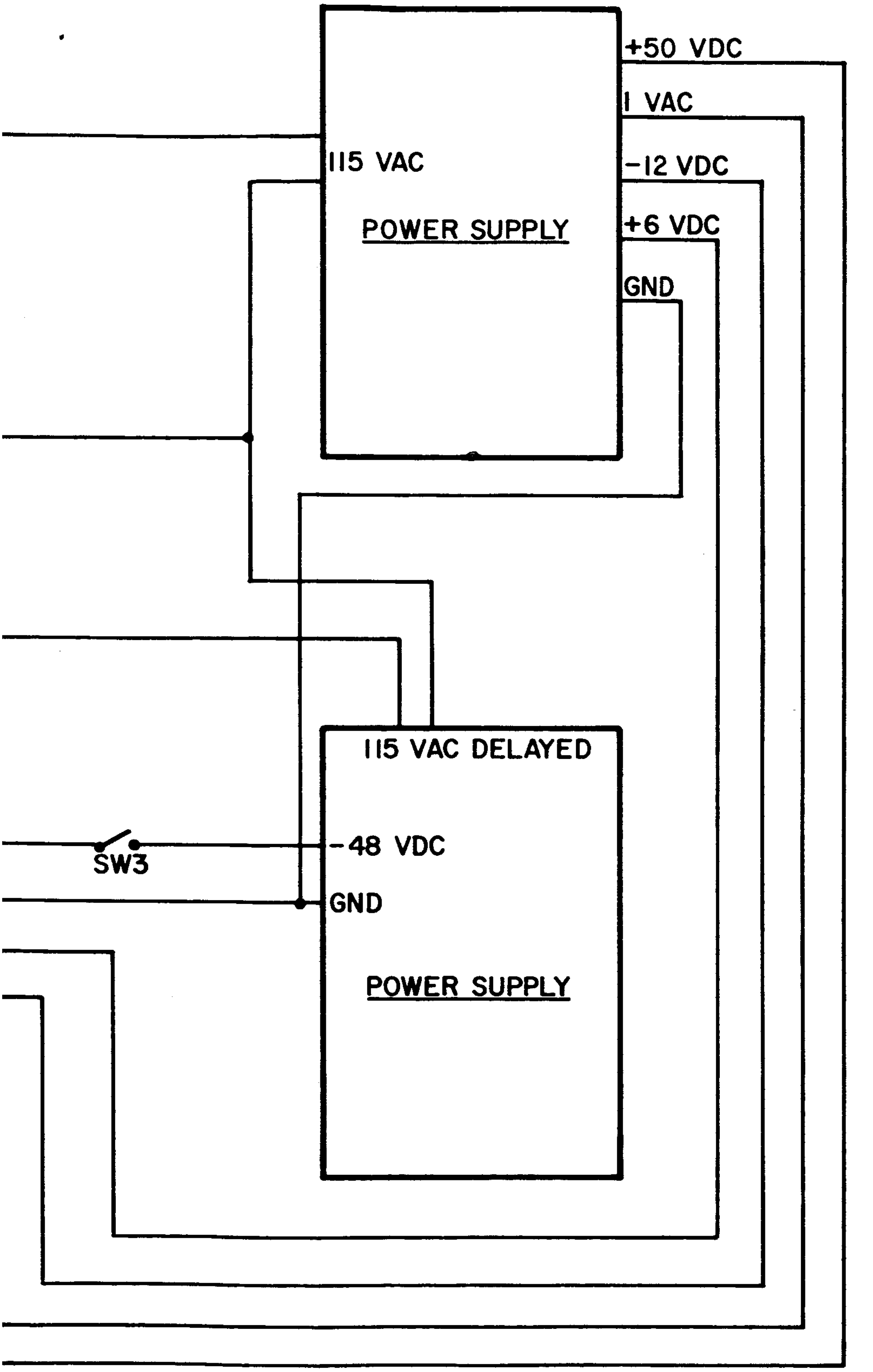
C13. MULTIPLEXER



MONITOR LIGHTS



C14. POWER SUPPLY


+50 VDC
1 VAC
115 VAC
-12 VDC
POWER SUPPLY
+6 VDC
GND
115 VAC DELAYED
-48 VDC
SW3
GND
POWER SUPPLY

REFERENCES

1. Seitz, R. N., "AMTRAN, Do-It-Yourself Computing," Astronautics and Aeronautics, June 1965.

2. Clem, P. L., Jr., Reinfelds, J., Seitz, R. N. , Wood, L. H., "AMTRAN, A Conversational Mode Computer System for Scientists and Engineers," Proceedings of the IBM Symposium on Computer Aided Experimentation, Yorketown Heights, October 1965.

3. Seitz, R. N., Reinfelds, Juris, Wood, L. H., Clem, P. L., Jr., "AMTRAN - Pushbutton Route to Instant Mathematics," Datamation, (to be published October 1966)

4. Albert, M. R., Clem, P. L., Jr., Flenker, L. A., Reinfelds, Juris, Seitz, R. N., and Wood, L. H., "The AMTRAN Sampler System," NASA Technical Memorandum X-53342, May 1966.

AMTRAN HARDWARE - AN ELECTRONIC INTERFACE TO SIMPLIFY AND SPEED UP MAN MACHINE COMMUNICATION

By Juris Reinfelds, R. N. Seitz, L. H. Wood and C. A. Ely

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This report has also been reviewed and approved for technical accuracy.

Ernst Stuhlinger

ERNST STUHLINGER
Director, Research Projects Laboratory

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