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SUBJECT: INCREASED FACILITIES FOR VISUAL DISPLAY IN THE WWI INPUT-OUTPUT SYSTEM

To: Those Listed

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Abstract: The visual display facilities described in Engineering Note E-469, "Visual Display Facilities in the Final WWI Input-Output System," have been increased by the addition of a vector generator, a number generator, and many more switches for selecting parts of the information being displayed by the computer. These additions have necessitated some changes in the logic of the system, and an entirely different means has been used to mechanize the selection of displays at the individual display scopes. This note therefore will supersede Engineering Note E-469.

1.0 INTRODUCTION

The purpose of this report is to describe the operation and programming requirements for the visual display facilities which are available in the WWI computer. This report supersedes E-Note E-469, "Visual Display Facilities in the Final WWI Input-Output System," by J.W. Forgie which has been obsoleted by recent changes and additions. Many of the parts of E-469 which have not been affected by changes, and parts of Memorandum M-1999, "Display Categories and Assigned Scope Displays" by H. Benington, which discusses the use of the display system for a particular group of problems, have been included verbatim.

It has been assumed that the reader is familiar with the basic logic and operation of the in-out element as described in Engineering Note E-466, "The Operation of the In-Out Element." Reference is made to the drawings attached to E-466 as well as drawings C-37447, B-37448, and B-37449 attached to this memorandum.

The organization of this note is similar to that of E-469 which it replaces. In Section 2.0 the visual display facilities available are described in general terms. The actions of the operator and programmer necessary to utilize these facilities are set forth in Section 3.0, and the logical operation of the equipment and computer instructions involved are explained in Section 4.0.

2.0 VISUAL DISPLAY FACILITIES AVAILABLE

2.1 Display Oscilloscope

The display oscilloscope, often referred to as scope, is basically a cathode ray tube which gets its horizontal and vertical deflection voltages and intensification signals from the computer. Two digital to analogue converters serve to decode two 11-digit binary numbers representing respectively the horizontal and vertical Cartesian coordinates of a point. Two such numbers and an intensification pulse are supplied to plot a point on the face of a display scope.

In addition to plotting points, from which any type of curve or figure may be formed, it is possible to plot vectors and some characters or symbols. To plot a vector the x and y deflections are supplied just as if a point were to be plotted; in addition, two 6-digit numbers are supplied which serves as the Δx and Δy of the vector. If the vector generator has been selected, it will cause the beam of the display scope to move across the face of the scope in a line determined by the two 6-digit numbers supplied to it.

To plot characters, a numbergenerator is available which will move the beam of the display scope through a rectangular figure eight. The position of the character on the face of the scope is determined by the two 11-digit numbers supplied to the x and y decoders, and a 7-digit number contained in IOR determines when the scope is intensified as the seven lines of the figure eight are traced. Thus, any character which may be formed from the seven lines of a rectangular figure eight may be plotted automatically by using the number generator.

The use of a long-persistence phosphor on the scope's face permits a graph or other picture, although plotted on a point by point basis, to be viewed as an integrated picture. Facilities are also available for photographing scope displays.

The deflection of the display scopes by the x-and y-decoders and the vector and number generators is a parallel action. All scopes, therefore, receive the same deflections and move through the same pattern, but the same picture need not be displayed on all scopes because the intensification of the individual scopes for any point, vector, or character depends upon coincidence between the display selected by the computer program and the display selected by the scope observer. The computer program may select any of 256 display categories. The display category therefore is the finest degree of selection possible. Each display category contains only points, vectors, or symbols. At each scope there are a number of switches which determine what is displayed on the scope. Each switch controls one or more display categories and is said to control a category set. When the computer performs a display, it will also select a display category and the display will appear on all scopes at which the same display category has been selected. It should be pointed out that at any time a scope may have a number of display categories selected, and that a number of scopes may have selected display categories which overlap.

In the final system there is no logical limit to the number of display oscilloscopes which may be connected to the computer, or to the number of switches controlling category sets at a particular scope, but each switch requires a three-input crystal gate and each scope requires an intensification amplifier and gating circuit besides providing an increased load to the equipment for selection, deflecting, and intensifying. Initially, facilities are provided for 40 logically distinct scopes. A logically distinct scope is a scope which has an individual set of switches for selecting displays. Several scopes could be connected in parallel all seeing the same display selected by a single set of switches and still be considered as one logically distinct scope. Initially a maximum of 352 category switches may be divided among the scopes.

In Test Control there are two 16-inch magnetically deflected and focused scopes and one 5-inch electrostatically deflected and focused scope. One of the 16-inch scopes is primarily intended for photographic purposes, and normally will have a Fairchild 35mm automatic scope camera attached. These three scopes have a common set of switches for selecting displays. One of these switches selects all 256 categories.

2.2 Display Control

From the above discussion it may be seen that three types of controls are necessary in the display system: A selection control, which indicates which scopes will see the display; a deflection control, which determines where the display is to be seen on the scope face; and an intensification control which provides the intensification for the selected scopes at the proper points in the display cycle. These controls are discussed in the following paragraphs.

2.21 Display Selection

As stated previously, the computer program may select any one of 256 display categories for a particular display. The category selected is determined by IOS which is set to the position indicated by the address section of the si instruction. Two matrices are connected to IOS for category selection. The first matrix, Matrix #1, is connected to digits 12, 13, 14, and 15 of IOS while the second matrix, Matrix #2, is connected to digits 5,6, 10, and 11 of IOS. One line in each of these matrices is activated whenever digits 7,8, and 9 are set to 6 (110), i.e., whenever the display system is selected. Thus two lines, called a matrix pair, are required to select any one category. It may be noted that there is a one-to-one correspondence between the matrix pairs and the address section of the si instruction selecting the display system. Matrix pairs present a convenient means of mixing categories into category sets.

Whether a display is shown at a particular scope requires coincidence between the category selected by IOS and the category set selected by the switches at the scope. Selection is controlled by three-input crystal gates or "and" circuits. Two of the inputs to these gates are from the two matrices in IOS while the third input is from the switches at the consoles. Several IOS lines may be mixed to provide one input to the gates. Also several switches at a console may control one gate and several gates may be controlled by one switch. These mixings provide the category sets for each switch. The mixing is done at a large "junction box" which facilitates changes in the category sets. The category sets are listed in Memorandum M-1999.

The output of all of the "and" gates associated with one scope are mixed and provide one input to a gate in intensification control. Thus a display will appear on a scope only if the category selected by the computer program is in the category sets selected by the switches for the scope.

2.22 Display Intensification Control (515)

Intensification control contains a flip-flop which provides the intensification for the display scopes selected. As stated above there is one gate tube in intensification control for each logical display scope in the system. One input to these gates is from selection control; the other input is from the intensification flip-flop. Thus a scope is intensified whenever selected by selection control and the intensification flip-flop is set. The position of this flip-flop is controlled by IOC and IOR. Whenever the intensification flip-flop is set, a delay is counted in the IO delay counter. The intensification flip-flop will be cleared after the completion of this delay count. Thus this flip-flop is always cleared shortly after being set, effectively providing a gate for intensification purposes. The duration of this gate varies from 32 microseconds for each segment of a character to about 70 microseconds for a point or vector display.

2.23 Display Deflection

Four units have been provided to control the deflection in the display system, the horizontal decoder, the vertical decoder, the vector generator, and the numerical generator. As stated above, all display scopes are deflected in parallel by these units.

The horizontal and vertical decoders provide the initial deflection for the scopes and determine where on the face of the scope a particular point, vector, or character display is to appear. They receive their input directly from digits 0-10 of the computer bus and convert the 11-digit numbers supplied to them into analogue voltages suitable for deflection. Further deflection for vectors and characters are provided by the vector generator (517) and character generator (516), respectively.

2.231 Vector Generator (517) The vector generator makes possible the tracing of a straight line or "vector" whose origin is the point selected by the deflection decoders. The length and direction of the vector is specified by two 6-digit numbers, $\triangle x$ and $\triangle y$.

The vectors are formed by varying the x and y deflections of the scope while the scope is being intensified. The vector generator converts the digital quantities $\triangle x$ and $\triangle y$ furnished by the computer into two analogue voltages. These voltages are both multiplied by a time-varying voltage and used to provide the two deflections required. The time-varying voltage has a fixed duration and is nearly linear with time in order to provide a constant intensification on the scope. Thus a vector is formed in the direction specified by $(\triangle x, \triangle y)$ whose magnitude is proportional to the magnitude of $(\triangle x, \triangle y)$.

The decoder for Δ x is connected to digits 0-5 of IOR while the decoder for Δ y is connected to digits 8-13 of IOR. Digits 0 and 8 are the sign digits. The vector generator requires an initiation pulse to start the deflection and a completion pulse to terminate the deflection. The duration of the sweep is counted in IO delay counter.

2.232 <u>Character Generator (516)</u> The character generator allows the deflection beam of the display scope to be deflected through a rectangular figure eight at the point selected by the horizontal and vertical decoders. The sequence which is followed in tracing the complete pattern as well as the position of the pattern with respect to the point selected by the decoders is shown in Figure 1. A 7-digit code is required to indicate which segments of the figure should be intensified. The segments of the pattern shown in Figure 1 are numbered showing both the

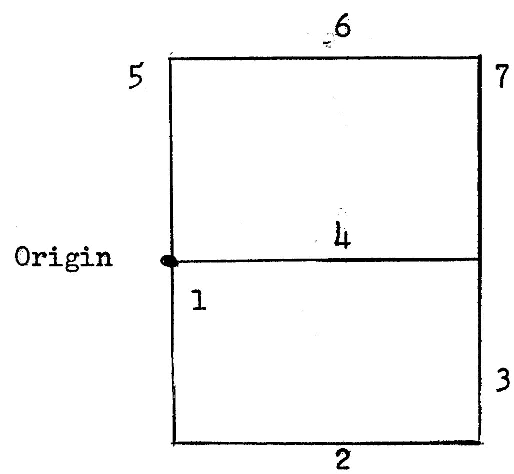

Figure 1

sequence in which the pattern is traced as well as the positions in the code which control particular segments. That is, a "one" in the first digit position of the code intensifies the segment numberd "1", etc. As an example, to form the number 2 from the figure eight, segments 1,2,4,6, and 7 must be intensified. Therefore, the code for the number 2 is 1101011. This code is placed in digits 1-7 of IOR. The figure eight for a numerical display is generated by a waveform generator and a counter. The content of the counter determines which segment is being formed and therefore must be changed at the beginning of each segment. The interval between these change pulses as well as the number of change pulses are determined by IO delay counter. The segment-change pulses are carried from digit 10 of the IO delay counter and will add to the numerical display counter only if the unit has been turned on (i.e., if FF01 is set, see drawing C-37447). The intensification flip-flop is always set by these segment-change pulses. A gate attached to the zero side of IOR digit 1 is then sensed to see if the segment should be blanked. If so, the intensification flip-flop is cleared. IOR is then shifted left one so that digit 1 of IOR will be used to determine whether the next segment should be blanked. The number generator will repeat the center segment of the figure eight. However, a Sync Completion pulse from IOC will clear the intensification flip-flop at the start of this segment so that this segment will always be blanked.

2.3 Light Guns

The light gun offers a simple means by which the computer can rapidly interrogate a human operator. The light gun is a photocell device which can generate a pulse if it sees sudden change in light intensity such as occurs when a spot is intensified on a display scope. The device contains a trigger switch and is built in such a manner that only one pulse can be generated for each depression of the trigger, and this pulse can be generated only during a time that the in-out switch is set to display points. The pulse is sent to the computer, which can be programmed to check after each intensification of a point to see if a light gun pulse has been returned. This facility enables the human operator to direct the attention of the computer to information represented by certain points on a display scope.

The final in-out system will be capable of handling up to 15 light guns. Each light gun will insert a "one" in the sign digit and one of the other 15 digits of the in-out register when it generates a pulse indicating that a point has been detected. After displaying a point the contents of the in-out register may be brought into the accumulator and inspected to see if any light guns picked up the point. The location of the light guns and their connection to digits of the in-out register is specified in Memorandum M-2180, Light Gun Connections to In-Out Register.

One oscilloscope, called the "area discriminator" has a photocell permanently mounted above it. The cell operates like the light guns except that no trigger is necessary to activate the photocell. The photocell will generate a pulse for any point displayed on the scope unless a filter or mask is placed between the point and the photocell. Thus points displayed in certain areas may be given special significance by placing a filter or mask over these areas on the scope surface.

2.4 Scope Cameras

Two types of cameras are usable with the final in-out display system. The first of these is the Polaroid Land type of scope camera which gives immediate pictures of a scope display. Cameras of this type are used on the 5-inch display scopes and are operated manually in complete independence of the computer. The operation of these cameras will not be discussed in this report. The interested reader is referred to the instructions supplied with cameras of this type.

The second type of camera is the Fairchild 35mm automatic scope camera. One camera of this type is planned for the final system. It is mounted to photograph one of the 16-inch display scopes in Test Control although it could be used on a 5-inch scope. This camera has its focus and aperture setting controlled manually, but its film may be indexed and an exposure cycle controlled by computer orders. It gives picutes only after darkroom development. Operation of this camera with the computer is discussed in Section 3.3.

3.0 PROGRAMMING REQUIREMENTS

All instruction addresses in this section are given in their octal representation. Table I at the end of this report gives the octal, decimal, and binary representation of these addresses as well as the length of the delays counted for the various displays.

3.1 Instructions Necessary to Plot a Point, a Vector, or a Symbol

Two instructions are normally necessary to plot a point, a vector, or a symbol on the display scopes. The address section of the si instruction selects the display scopes as the desired mode of in-out operation, specifies whether a point, vector, or character is desired, and specifies the display category so that the correct scopes will be intensified. The contents of the accumulator when the si instruction is given specifies the vertical coordinate of the point, vector, or character. If an rc instruction is given after the si, the contents of the accumulator when the rc is given will determine the horizontal coordinate of the point or origin of the vector or character. The contents of the register specified by the address section of the rc instruction will furnish the additional information necessary if either a vector or a character is to be displayed. The rc instruction performs the actual display by providing an intensification signal.

Two hundred and fifty-six si addresses refer to display scopes. Addresses from 0600 to 0677 (octal) select the 64 point display categories. Addresses from 1600 to 1677 (octal) select the 64 vector display categories and addresses from 2600 to 2677 and 3600 to 3677 (octal) specify the 128 character display categories.

3.11 To Display a Point

An si 0600 + w ($0 \leq w \leq 77$) octal) will select scopes as the desired mode of in-out operation, specify that a point is to be displayed, enable the light guns so that they may generate pulses in response to changes in light intensity, select the point display category w, and transfer the vertical coordinate of the point from the accumulator (left 11 digits) to the vertical decoder.

Following the si instruction the scopes will remain selected and the vertical deflection will be remembered until another si instruction is given. After the horizontal coordinate has been brought into the accumulator an rc instruction will transfer the left 11 digits of the accumulator to the horizontal decoder and display a point. The address section of the rc instruction is not used and may assumed any value.

A horizontal line may be displayed by giving one si instruction to set the vertical position of the line and a series of rc instructions each with a new horizontal coordinate. To display a series of random points a new si 0600+w followed by an rc instruction must be given for each point.

The previously described combination of si and rc instructions will display points on all scopes at which the display category specified by the si instruction has been selected. It should not be inferred that every scope will have the ability to select every display because this would require a prohibitive amount of equipment.

3.12 To Display a Vector

An si 1600+w ($0 \leq w \leq 77$ octal) will select scopes as the desired mode of in-out operation, specify that a vector is to be displayed, select the vector display category w, and transfer the vertical coordinates of the origin of the vector from the left 11 digits of the accumulator to the vertical decoder. The selections and settings made on the si instruction will be stored and remembered until another si is given.

After placing the desired horizontal coordinate in the accumulator, an rc z instruction will transfer the most significant 11 digits (including the sign digit) from the accumulator to the horizontal decoder, transfer the contents of register z to the in-out register so they may be used by the vector generator, and display the vector by starting the vector generator.

The vector generator interprets the six most significant digits of the in-out register (digits 0-5) as $\triangle x$ where digit 0 is considered as the sign digit of the vector along the x axis. In-out register digits 8-13 are interpreted as $\triangle y$ and digit 8 is the sign digit of the vector along the y axis. Therefore, this information must be in the corresponding digits of register z when an rc z is given. The x and y decoders are both 11-digit decoders and will resolve numbers from $-1023 x 2^{-10}$ to $+1023 x 2^{-10}$. The vector generator has been calibrated so that the least significant digits of the two 6-digit numbers placed in the in-out register to specify $\triangle x$ and $\triangle y$ will cause a change in vector length along the x or y axis equal to four times the distance the origin is shifted by the least significant digits of the x or y decoders. Thus a vector of maximum length along either the x or the y axis will cover just slightly less than one-sixteenth of the maximum change in deflection which can be obtained with either the x or y decoders. Relative to the x and y decoders the vector generator may be thought of as handling two numbers which vary from $-31 x 2^{-8}$ to $+31 x 2^{-8}$.

If the numbers transferred to the vector generator are plus or minus zero, a zero length vector is plotted which appears on the scope exactly like a point except that light guns will not respond to these zero length vectors.

Example

Suppose it is desired to plot a vector whose origin is specified by $x = +12x2^{-10}$, $y = -14x2^{-10}$ and which is to move to a second point specified by $x = -8x2^{-10}$, $y = +18x2^{-10}$. The vector is to appear on all scopes which have selected the vector display category 5. The change in deflection from the origin of the vector to the end in the x direction is $-20x2^{-10}$ or $-5x2^{-8}$ and the change in the y direction is $+32x2^{-10}$ or $+8x2^{-8}$. Thus the binary number in register z when rc z is given to display the vector should be

$$\overbrace{\;11010\;}^{\Delta x}\quad\overbrace{\;001000\;}^{\Delta y}$$

1.11010xx001000xx

where an x indicates that the contents are immaterial. A sequence to display the vector would be:

1. Place $-14x2^{-10}$ in accumulator.
2. Perform si 1605: This selects the vector display category 5 and transfers contents of accumulator to vertical decoder.
3. Place $+12x2^{-10}$ in accumulator.
4. Perform rc RC 1.11010XX001000XX: This transfers contents of accumulator to horizontal decoder, transfers 1.11010XX001000XX to vector generator, and displays vector.

Additional rc instructions would plot vectors in vector display category 5 with a constant vertical deflection; the horizontal deflection depending upon the contents of the accumulator which may or may not be changed between rc instructions.

3.13 To Display a Character

There are 128 character display categories; these are selected by si 2600+w or si 3600+w where $0 \leq w \leq 77$ octal. The characters are displayed by intensifying the desired lines in a rectangular figure eight as illustrated in Figure 1.

The origin of the character is specified by the contents of the accumulator on the si and rc instructions exactly as it is specified for a point or a vector, and the origin is at the left center of the figure eight.

Which lines in the rectangular figure eight are to be intensified is specified by digits 1 to 7 of the register specified by the address of the rc instruction. Each of these seven digits corresponds to one of the seven lines as shown in Figure 1. A one indicates that the line should be intensified, a zero that it should not be intensified. The four shown in Figure 2 is formed from lines, 3, 4, 5, and 7 and is specified by having the binary number X0011101XXXXXXXX in the register specified by the rc instruction. Table II gives the constants which will form some of the other more obvious characters. If the change in deflection determined by the least significant digit of the x or y decoders is taken as a unit on the display scope face, the rectangular figure eight generated by number generator is 8 1/2 units high and 7 units wide.

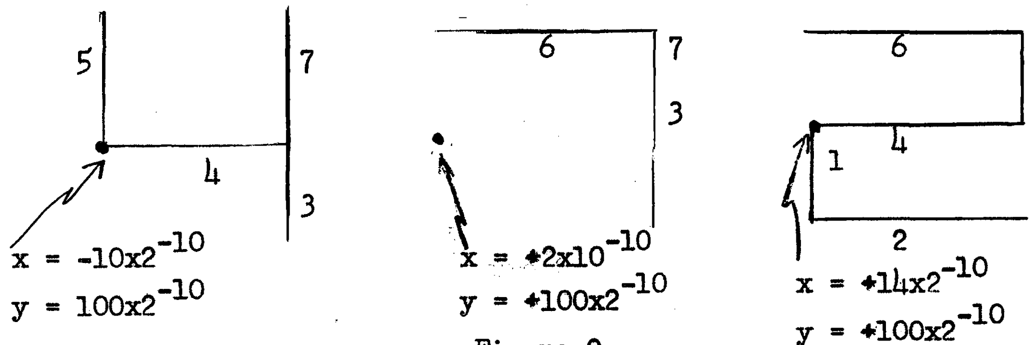

Figure 2

Example

The problem is to display on all scopes selecting character display category number five the number 472. The characters are to be centered on a horizontal line which has a y coordinate of $+100x2^{-10}$, and the x coordinate of the left side of the 4 is to be $-10x2^{-10}$. The space between numbers is to be 5 units (approximately 2/3 the width of the figure eight). The general procedure is as follows:

Instruction	Action
ca B1	1. Place the desired vertical deflection, $+100x2^{-10}$ in accumulator.
si 2605	2. Transfer vertical deflection from accumulator to vertical decoder and select character display by category 5.
ca B2	3. Place desired horizontal deflection of first character, $-10x2^{-10}$, in accumulator.
rc B4	4. Transfer horizontal deflection from accumulator to horizontal decoder, transfer contents of storage register B4 which specifies the character 4 to IOR, and display.
ad B3	5. Place new horizontal deflection in accumulator.
rc B5	6. Transfer horizontal deflection from accumulator to horizontal decoder, transfer contents of storage register B5 which specifies the character 7 to IOR and display.

Instruction	Action
ad B3	7. Place new horizontal deflection in accumulator.
rc B6	8. Transfer horizontal deflection from accumulator to horizontal decoder, transfers contents of storage register B6 which specifies the character 2 to IOR, and display.

				Binary	Decimal
where register	B1	contains		0.0001100100XXXXX	+100x2^{-10}
"	B2	"		1.111111010XXXXX	-10x2^{-10}
"	B3	"		0.0000001100XXXXX	+12x2^{-10}
"	B4	"		X.0011101XXXXXXXX	
"	B5	"		X.0010011XXXXXXXX	
"	B6	"		X.1101011XXXXXXXX	

3.2 Instructions Necessary to Use a Light Gun

No special instructions are necessary to operate a light gun. A given light gun will be connected to one digit of IOR, and all light guns will be connected in parallel to the sign digit of IOR. When scopes have been selected by an si 0600+w instruction, the rc instruction will clear IOR so that a light gun return can put a one in the appropriate digit of that register. If it is desired to find out if a light gun return has occurred with the plotting of a given point, it is necessary to order an rd after an rc has plotted the point in question and before another rc or si is ordered. The rd instruction will bring the contents of IOR into the accumulator. Since returns from several light guns may be received for a given point, it is possible that more than one digit of IOR (other than the sign digit) could contain ones after the plotting of the point. This situation causes no difficulty as far as the in-out system is concerned. It merely results in a more complicated programming problem. The location of the 15 light guns, and the digit to which each gun is connected is specified in Memorandum M-2180, "Light Gun Connections to In-Out Register."

3.3 Instructions Necessary to Index the Scope Camera

The Fairchild scope camera may be operated both manually and by the computer. A push button on the camera-control panel may be used to manually index the film. The shutter is normally open so that a display can be plotted at leisure with each spot registering on the film as it appears. Pushing the index-film button will close the shutter, index the film, and open the shutter.

When the camera is to be operated by the computer, an si 004 instruction must be given. This instruction sends a pulse to the camera control panel which performs the same function as pushing the index button. Approximately 1/5 second is required for the camera to complete its action. During this time the interlock is set so that no other in-out operation may take place.

4.0 LOGICAL OPERATION OF THE VISUAL DISPLAY EQUIPMENT

The logical operation of the display system on the si, rc, and rd instructions is discussed in this section. Certain details of operation are presented in E-466 and are only outlined in this report. However, the rc instruction has a unique method of operation for the display system and therefore certain details will be repeated.

4.1 Action Occurring on the si Instruction

As explained in Section 3.1 of E-466, the first action on an si instruction is the sensing of IOC interlock on TP6. This sensing is gated by gate tube GT01 of IOC interlock which is on only if the previous unit selected by IOS had been an output unit. TP7 will thus wait until the previous reading has been completed.

On TP7 the flip-flops driving the IOS crystal matrix are cleared and a stop pulse is sent to any external units requiring such a pulse. At the same time an IOS Delay Start pulse is sent to IOC which starts the counting of a delay of about 15 microseconds and stops the computer clock. This delay is necessary to allow the new setting of IOS to take effect. This new setting of IOS is read from the program register into the IOS flip-flops on TP7.5. The output lines selected by IOS depend on whether points, vectors or characters are selected. Since these lines do not affect the operation of the si instruction, their listing is deferred to the next section. The line which selects the category is not included in this listing.

Following the completion of the IOS set-up-delay count, the computer clock is restarted and TP8 appears. The only action of this time-pulse of interest to scope display is the clearing of the vertical decoder flip-flops.

On TP1 the left 11 digits of the accumulator are read into the vertical decoder. The IOC Reset and Start EU pulses have no effect when scopes have been selected.

4.2 Actions Occurring on the rc Instruction

The first action of the rc instruction is the sensing of IOC Interlock on TP6. This sensing forces TP7 to wait until a previous operation has been completed. Also on TP6 a Core Memory Read is initiated which transfers the content of the core memory register specified by the address section of the rc instruction to PAR.

IOR is cleared on TP7.5 and the content of storage is transferred to IOR on TP8. Thus the content of the register specified by the address section of the rc instruction is transferred to IOR. This information is only used on vector and character displays.

The horizontal decoder is cleared on TP8 and the content of the left 11 digits of the accumulator are transferred to the decoder on TP1.

The next action pertinent to displays is the IOC Reset (rc) pulse which occurs on TP3. The action initiated will depend on the type of display selected and is discussed below. The gate tubes in IOC reset control through which the pulses must pass are given in parentheses in the text. One action common to all three types of displays is the counting of a deflection delay of about 100 microseconds to allow transients in the decoders to die out before intensifying the scopes. The IOC Reset (rc) pulse will always set IO interlock and clear IO alarm control. IOS line C01 is selected for all displays so that no other in-out process may be started until the display has been completed.

4.21 Point Displays

The scopes are intensified for about 70 microseconds for point displays. This period is counted in two steps by the IO delay counter. In the middle of this delay count the light guns and area discriminator are sensed to see if any returns have been received. If a return has been received, the appropriate digits of IOR are set. The sensing is done at this time to make certain that phototube output signals have reached full amplitude. The following IOS lines are selected for point displays:

LG01 - Enable light guns and area discriminator activate GT's 26, 20, and 25 of IO reset control

C01 - Activate GT01 of IO interlock

C03 - Activate GT's 9 and 22 of IO reset control

C11 - Activate GT17 of IO reset control

If a point display is selected, the IOC reset pulse will set (GT09) and start (GT22) a scope deflection delay in the IO delay counter. It will also set IO control counter for three cycles of operation and clear IOR (GT26), preparing IOR to receive light gun returns.

After the completion of the deflection delay, an odd cycle pulse will be received from IO control counter which will send an intensify pulse to intensification control (GT17) and set (GT20) and start (GT22) the first half of intensification delay for points.

After the completion of this delay an even cycle pulse will be received from IO control counter which will again set and start the intensification delay. This pulse will also sense (GT25) the light guns and area discriminator and if a return has been received, will set the appropriate digits of IOR.

After the completion of the second half of the intensification delay a Sync Completion pulse will be received from IO control counter which will clear intensification control. This pulse will also clear the interlock (or start the clock if the interlock had previously been sensed) indicating the completion of the operation.

4.22 Vector Displays

As stated previously, digits 0-5 of IOR will contain $\triangle$x and digits 8-13 of IOR will contain $\triangle$y if a vector is to be displayed. After the completion of the deflection delay, the vector generator must be started and the selected scopes intensified for about 67 microseconds.

The following IOS lines are selected for point displays:

C01 - activate GT01 of IO interlock

C03 - activate GT's 9 and 22 of IO reset control

C11 - activate GT17 of IO reset control

C09 - activate GT21 of IO reset control

C12 - activate GT10 of IO reset control

If a vector display is selected, the IOC reset pulse will set (GT09) and start (GT22) a scope deflection delay in the IO delay counter. It will also set IO control counter for two cycles of operation (GT10).

After the completion of the deflection delay, an Even-Cycle pulse will be sent as an intensification pulse to intensification control (GT17) and an initiate pulse to the vector generator (GT21). This pulse will also set (GT21) and start (GT22) an intensification delay for vector displays.

After the completion of the deflection delay, a Sync Completion pulse will be received from IO delay counter which will clear intensification control, stop the vector generator, and clear the interlock (or start the clock if the interlock had previously been sensed) indicating the completion of the operation.

4.23 Character Displays

The pulses necessary for controlling the numerical display generator are obtained from the IO delay counter. These pulses are also used for sensing and shifting IOR once the numerical display has been initiated.

The following IOS lines are selected for character displays:

C01 - activate GT01 of IO interlock

C03 - activate GT's 9 and 22 of IO reset control

C10 - activate GT23 of IO reset control

C12 - activate GT10 of IO reset control.

If a character display is selected, the IOC reset pulse will set (GT09) and start (GT22) a scope deflection delay in the IO delay counter. It will also set IO control counter for two cycles of operation (GT10). After the completion of the deflection delay, an even-cycle pulse from IO delay counter will set (GT23) and start (GT22) the IO delay counter to count the cycles and the interval between cycles for the character display. It will also initiate (GT23) the number display by setting FF01 of number display control. This will allow the carrys from digit 10 of the IO delay counter to control the character display as discussed in Section 2.232.

An end-carry from IO delay counter will signify completion of the display and will pass through IO control counter as a Sync Initiation pulse. This pulse will clear the intensification flip-flop and FF01 of number display control. It will also clear the interlock (or start the clock if the interlock has previously been sensed) indicating the completion of the operation.

4.3 Actions Occurring on the rd Instruction

An rd instruction may be used when the display system is selected to transfer the content of IOR to AC. The action on the rd instruction is described in E-466. Therefore, the only action which will be discussed here is the action initiated by the IOC Reset (rd) pulse.

IOS line C01 is selected for all displays so that a subsequent si instruction will sense IO interlock. Since the IOC Reset (rd) pulse will always set the interlock, the interlock must also be cleared for an rd instruction used with displays. Therefore, the IOC Reset (rd) pulse also starts (GT22) the IO delay counter. Since both IO delay counter and IO control counter will contain all ones, a Sync Completion pulse will be generated in a few microseconds which will clear the interlock.

Signed Guy A. Young
Guy A. Young

Approved E S Rich
E. S. Rich

GAY/mrs
Drawings: C-37447
B-37448
B-37449

TABLE I

si Addresses for Display Scopes

Type of Display	Octal	Decimal	Binary
Point (170µs)*	0600 to 0677	384 to 477	0.0000 00 110 000 000 to 0.0000 00 110 111 111
Vector (167µs)	1600 to 1677	896 to 959	0.0000 01 110 000 000 to 0.0000 01 110 111 111
Character (327µs)	2600 to 2677	1408 to 1471	0.0000 10 110 000 000 to 0.0000 10 110 111 111
	and	and	and
	3600 to 3677	1920 to 1983	0.0000 11 110 000 000 0.0000 11 110 111 111

*Times indicate duration of display and include a 100 microsecond deflection delay.

TABLE II

Code for Some Common Characters

Character	Binary Code	Octal Computer Word*
1	0010001	0.10400
2	1101011	0.65400
3	0111011	0.35400
4	0011101	0.16400
5	0111110	0.37000
6	1111110	0.77000
7	0010011	0.11400
8	1111111	0.77400
9	0111111	0.67400
0	1110111	0.73400
A	1011111	0.57400
C	1100110	0.63000
E	1101110	0.67000
F	1001110	0.47000
H	1011101	0.56400
J	1110001	0.70400
L	1100100	0.62000
P	1001111	0.47400
U	1110101	0.72400

*Digits 0, 8-15 may contain anything but are assumed to be zero in the table.

Distribution List:

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R. Gould
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F. Irish
D. Israel
H. Kirshner
R. Mayer
K. McVicar
B. Morriss
J. Newitt
L. Norcott
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A. Shortell
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S. L. Thompson

W. D. Walker

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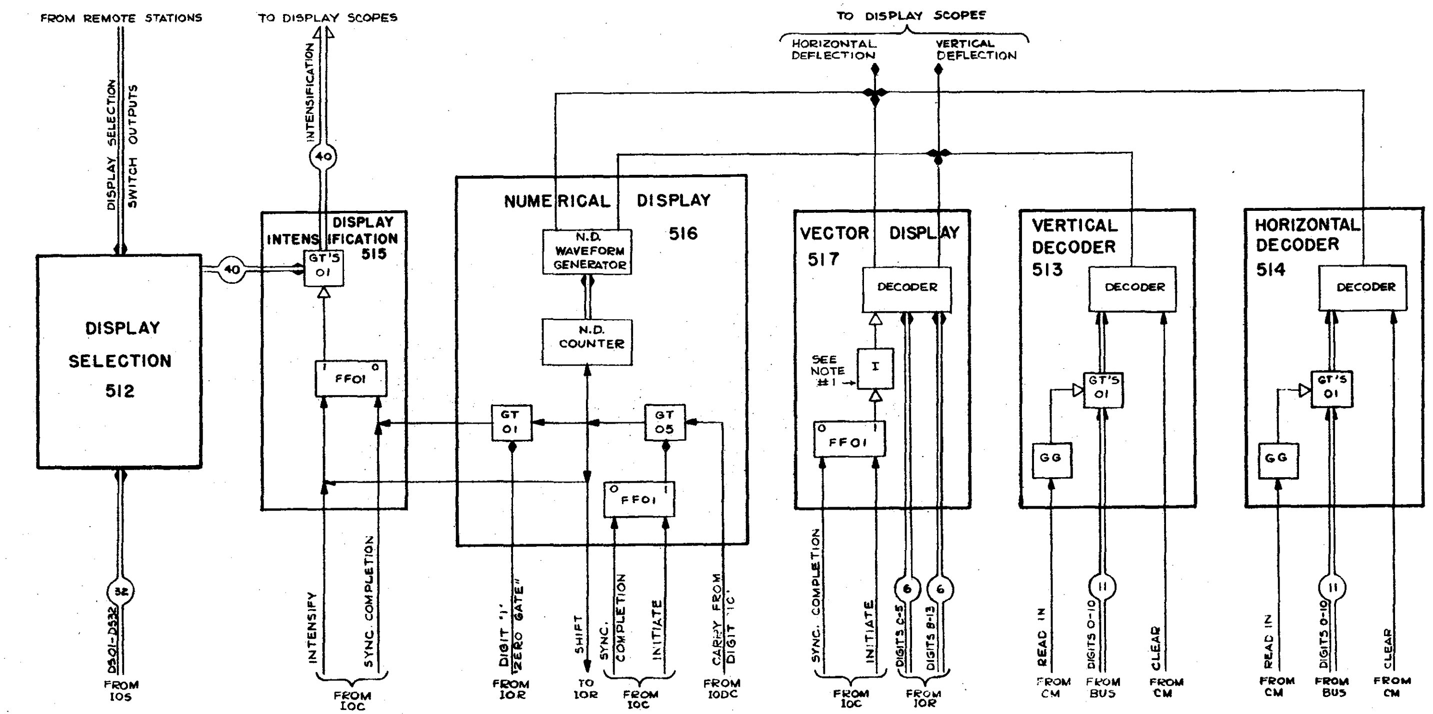
P. B. White

H. Atlas

J. Doyle

C-37447



NOTES:
1. [I] DENOTES AN INTEGRATOR, CLAMPED SO IT WILL NOT EXCEED FIXED UPPER AND LOWER LIMITS.

DRAWING REFERENCES:
1. BLOCK SCHEMATIC: D-54393

GRADED BY: DATE: THIS IS A GRADED DRAWING OF HIGHEST GRADE APPROVED BELOW:
GRADE I FOR REFERENCE ONLY
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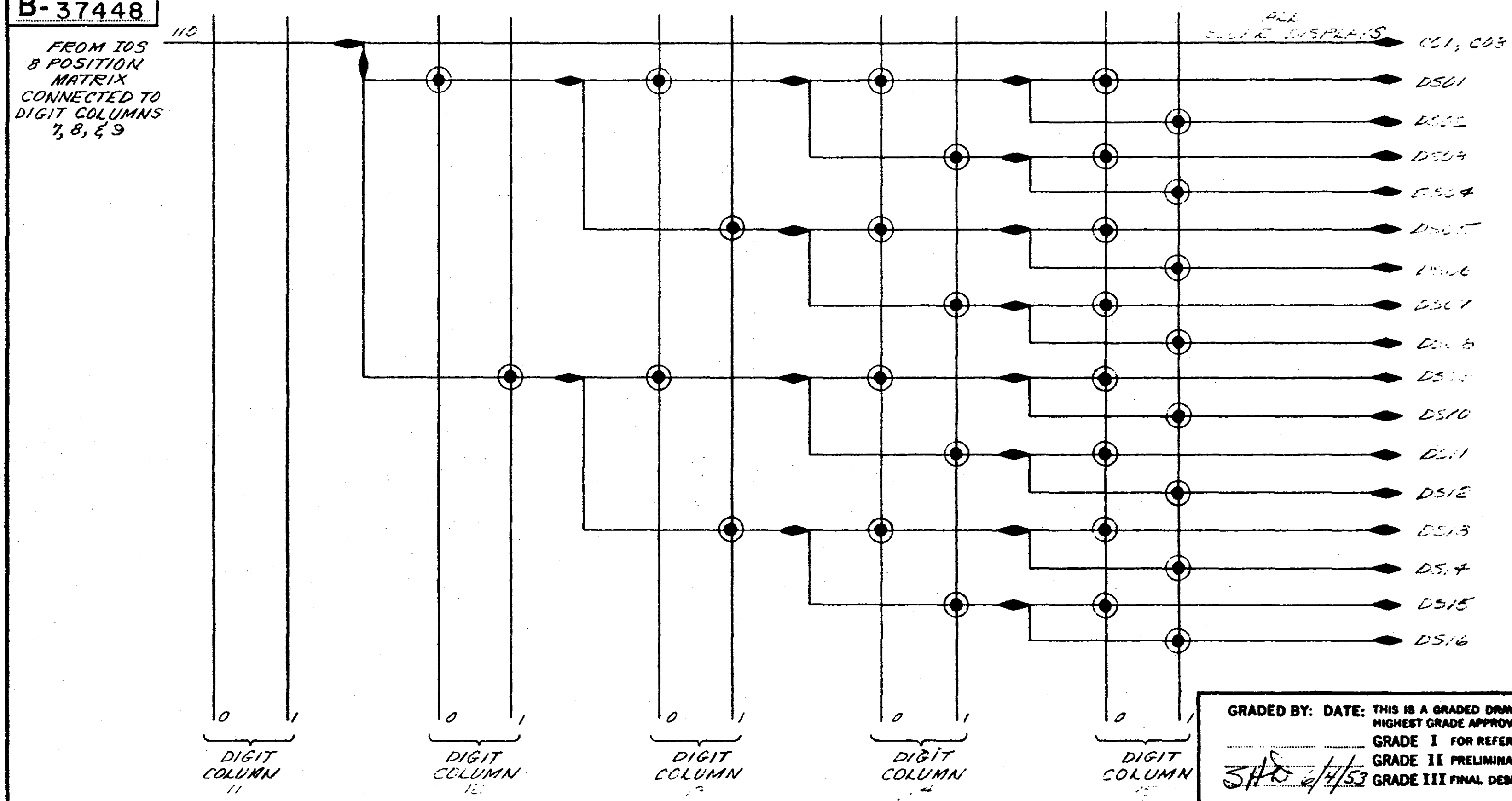
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
DIGITAL COMPUTER LABORATORY
DEPT. OF ELECTRICAL ENGINEERING—D. I. C. PROJECT NO. 6869

BLOCK DIAGRAM,
510, DISPLAY SYSTEM, WWI.

SCALE: —	DR. JJG 3-2-54	C-37447
ENG. 3/10/54	CK. 3/11/54	APPD. 3-15 54

B-37448



NOTE: MATRIX CONNECTIONS ⊕ ALLOW ANY "OFF" INPUT LINE TO TURN OFF ALL CONNECTED OUTPUT LINES. "OFF" SIGNALS PASS ALONG HORIZONTAL LINES FROM LEFT TO RIGHT ONLY.

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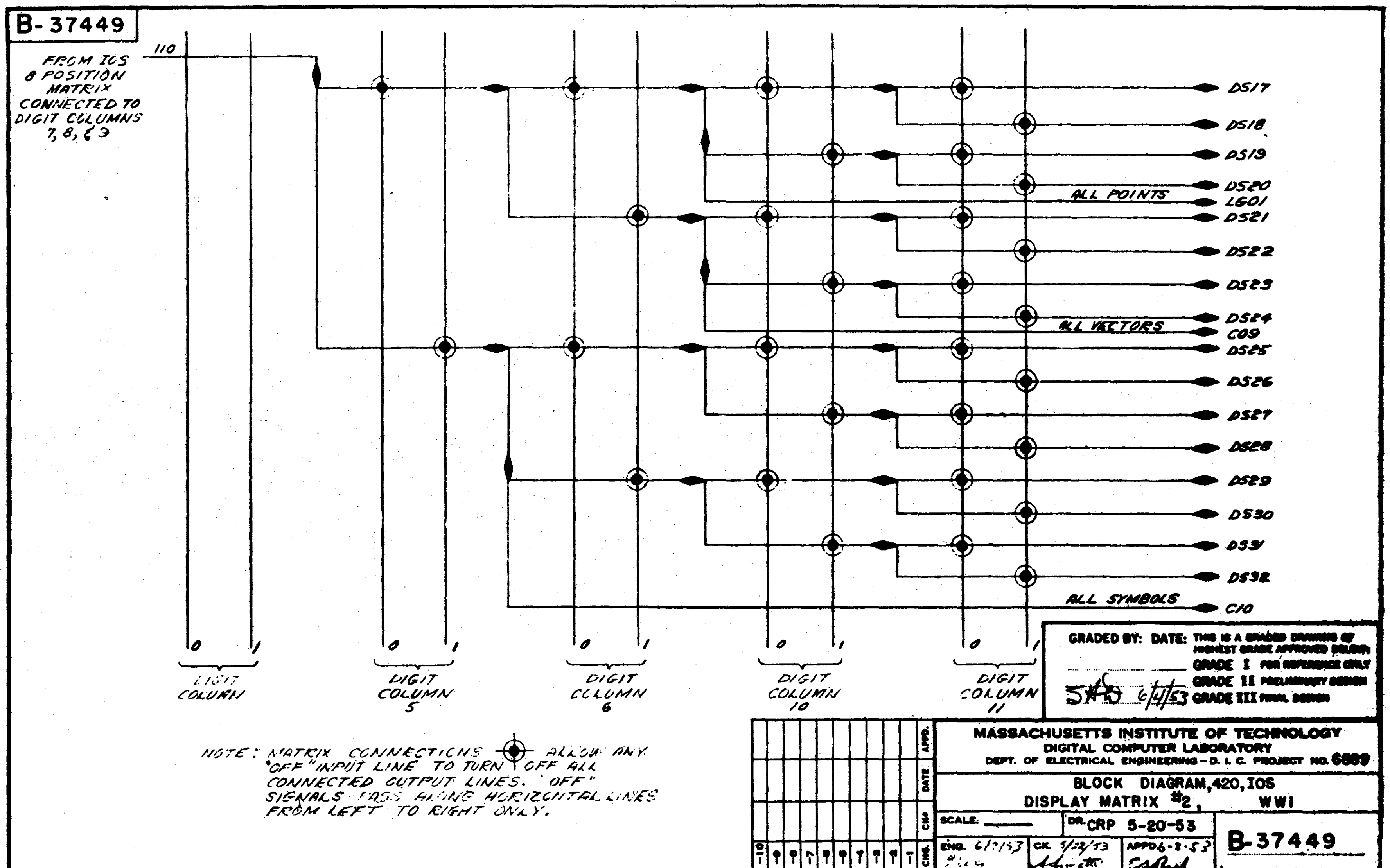
BLOCK DIAGRAM, 420, IOS
DISPLAY MATRIX #1, WWI

SCALE: | DR. CRP 5-20-53
ENG. | CK. | APPD. 6-2-53

B-37448
MN

CHG. APPD. DATE CN#

K+E ALBANENE 196L TRACING PAPER


B-37449
110
FROM IOS 8 POSITION MATRIX CONNECTED TO DIGIT COLUMNS 7, 8, & 9
DS17
DS18
DS19
DS20
ALL POINTS
LG01
DS21
DS22
DS23
DS24
ALL VECTORS
C09
DS25
DS26
DS27
DS28
DS29
DS30
DS31
DS32
ALL SYMBOLS
C10
0 1 DIGIT COLUMN
0 1 DIGIT COLUMN 5
0 1 DIGIT COLUMN 6
0 1 DIGIT COLUMN 10
0 1 DIGIT COLUMN 11
NOTE: MATRIX CONNECTIONS ALLOW ANY "OFF" INPUT LINE TO TURN OFF ALL CONNECTED OUTPUT LINES. "OFF" SIGNALS PASS ALONG HORIZONTAL LINES FROM LEFT TO RIGHT ONLY.
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6/4/53
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DEPT. OF ELECTRICAL ENGINEERING - D. I. C. PROJECT NO. 6889
BLOCK DIAGRAM, 420, IOS
DISPLAY MATRIX #2, WWI
SCALE:
DR. CRP 5-20-53
ENG. 6/2/53
CK. 5/22/53
APPD. 6-3-53
B-37449